Clean Development Mechanism Project Opportunities in Bangladesh

Appendix to Main Report

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Contents

Tables

Abbreviations and Acronyms

AIJ	Activity Implemented Jointly
ALGAS	Asia Least-Cost Greenhouse Gas Abatement Strategy
Auto	Automobiles
BBS	Bangladesh Bureau of Statistics
BMRE	Balancing, Modernization, Rehabilitation and Expansion
BTK	Bull's Trench Kiln
CC	Combined Cycle
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CNG	Compressed Natural Gas
COP	Conference of Parties
GDP	Gross Domestic Product
GJ	Gigajoules
GOB	Government of Bangladesh
GEF	Global Environment Facility
GT	Gas Turbine
IGCC	Integrated Gasification and Combined Cycle
IPCC	Intergovernmental Panel on Climate Change
IOC	International Oil Company
IPP	Independent Power Producer
JI	Joint Implementation
kgoe	Kilograms Oil Equivalent
MSCF	Thousand Standard Cubic Feet
Mt	Megatonne
NEP	National Energy Policy
NG	Natural Gas
NGO	Non Government Organization
O&M	Operation and Maintenance
PDB	Power Development Board
REB	Rural Electrification Board
ST	Steam Thermal
T&D	Transmission and Distribution
TCF	Trillion Cubic Feet
TJ	Terajoules
TOR	Tonnes of Refrigeration
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
VSBK	Vertical Shaft Brick Kiln

Preface

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

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

The following publications have been produced by the project partners:

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

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

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

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

The participants are working in collaboration with: The Bangladesh University of Engineering and Technology; The Global Climate Change Institute at Tsinghua University (China); and the Centre for Research on Material and Energy at the Technology University in Bandung, Indonesia.

The case study **Clean Development Mechanism Opportunities in Bangladesh** was produced by the Chemical Engineering and Petroleum and Mineral Resources Engineering Departments of the Bangladesh University of Engineering and Technology, Dhaka, Bangladesh. The views expressed in the report and this appendix are entirely those of the authors.

1 Industrial Energy Efficiency

1.1 Iron and Steel – Efficiency in Re-rolling Mills

National Sustainable Development Objectives

The demand for steel (rods and angled bars) for the construction industry is largely met by about 150 re-rolling mills. These mills employ extremely crude and inefficient technology to process mainly waste steel from ship breaking. The closure of the only steel mill of the country and the expansion of the construction industry has seen the mushrooming of these small-scale industries. A few of the re-rolling mills are equipped with modern equipment, but the majority rely on crude indigenous technology.

Over 90% of the hand re-rolling mills use box-type furnaces along with two locally manufactured burners. The daily capacities of these mills are 10-15 tonnes and operate on a single 8-hour shift. A burner consumes 500 m^3 of natural gas per day and the natural gas cost per tonne of production is about US$ 6. The energy efficiency of these mills can be improved by using good efficient burners, better insulation, a better firing system and longer shifts. The energy efficiency of these mills is between 6% and 8%, which can be raised to 35%. Some relevant details about the steel industry are provided below:

- The total yearly consumption is 161,139 tonnes (1997-98)
- There is one large-capacity fully automatic steel mill (now closed due to recurring losses)
- There are four 1,000-2,000 tonnes monthly capacity automatic/semi-automatic re-rolling mills
- One automatic re-rolling mill achieved a natural gas reduction of 20 m^3/tonne by applying advanced technology

Description of Baseline and Mitigation Technologies

The baseline for the project is a 10-tonnes/day hand re-rolling mill. The baseline technology details are given below:

- Two crude burners which are essentially perforated pipes
- No premix of air
- Gas consumption - 100 m^3 per tonne of product
- High rate of scaling (oxidation from lack of control of air-fuel mixture) that causes production loss of 5% to 8%
- 8% thermal efficiency

The details of the mitigation proposal are as follows:

- Replacement of the burners with instigator-type burners (this will eliminate the need for one of the blowers)
- Improved insulation
- Installation of pressure gauge and thermocouple
- Replacement of curved roof of furnace with refractory type flat panels

- Gas consumption - 70 m^3 per tonne of product
- Scaling loss to be reduced to 3%
- Replacement of oil-fired systems with gas-fired systems (in the newly connected areas to the gas grid in the Western zone of the country)

Description of the Project

The retrofit technology would be relatively easy to implement in this project. The challenge is to coordinate the owners of the 150 re-rolling mills. As all these re-rolling mills are privately owned, there is no single body either in the private or public sector to monitor the activities of these mills. For this reason, the project would require an inspection, monitoring and coordinating agency. This agency would require about US$ 250,000 per year for this purpose.

Measurable Reduction

The CO_2 emissions reduction can be established from the fuel consumption and the production. This project could face some difficulties in this regard because most small-scale industries do not pay their gas bills properly. In addition, to evade duties and value-added tax (VAT) these industries do not report their outputs correctly.

Financial Aspects of the Project

The investment requirement per re-rolling mill is approximately US$ 15,000. The total cost for the 150 mills is therefore US$ 2.25 million. This project would require a good implementation scheme. The transaction and monitoring cost of this low-cost option will be significant and can even go up to 100% of the investment cost.

Benefits

The expected benefits from the proposed modification are:

- Cleaner and more complete combustion
- Increase in productivity by 2% to 5%
- Improvement in the working environment of the mills

Barriers to Implementation

- Difficulties in convincing the owners to accept the proposed retrofit
- Re-training of technicians
- Fear of unknown technology and government interference

Emission Additionality

The appropriate project boundary is the 150 re-rolling mills. An average mill operates on a daily eight-hour shift for twenty days a month. The CO_2 reduction has been calculated using average specific fuel consumption and the production for 1997-98.

It is expected that the efficiency improvements would reduce the specific fuel consumption by 30 m^3/tonne (Energy Auditing Cell, Ministry of Energy, GOB). The CO_2 reduction was calculated in the following manner:

Yearly production = 160,000 tonnes (BBS, 1998)

Heating value of Natural Gas (NG) = 35 MJ/m^3

CO_2 emission factor = 56.1 tCO_2/TJ = 0.0019635 tCO_2/m^3

NG savings per year = 30 × 160,000 = 4,800,000 m^3/yr

Total CO_2 savings = 0.0019635 × 4,800,000 = 9,425 tonnes/yr

Potential for Reduction

The full potential in the re-rolling mills has been considered in this CDM project. If the Chittagong Steel Mill resumes production, then a good CDM project can be developed for it.

1.2 Pulp and Paper – Continuous Digester

National Sustainable Development Objectives

Bangladesh has four very old public-sector mills that produce pulp from indigenously available virgin fibrous raw materials (i.e. bamboo, wood, reed, bagasse, etc.). Some relevant information about these mills are given in the table below:

Table 1.1 Pulp Mills

Name	Raw Materials	Products	Capacity tonnes/year
Kharnaphuli Paper Mills, Ltd.	Bamboo, wood	Writing and printing paper	30,000
Khulna Newsprint Mills, Ltd.	Wood	Newsprint	48,000
North Bengal Paper Mills, Ltd.	Bagasse	Writing and printing paper	15,000
Sylhet Pulp & Paper Mills, Ltd.	Reed, bamboo, jute cuttings	Pulp	30,000

There are also a number of paper mills in the private sector of capacities ranging between 3,000 and 30,000 tonnes/year. These mills do not produce pulp from virgin raw materials and are dependent on imported or locally produced pulp and recycled paper. More than 50% of the country's demand for paper is met by imports, and the demand is increasing by 5% per year. The number of paper mills in the private sector are increasing, but due to the lack of pulp in the country all new mills are being planned on the basis of imported pulp and recycled paper.

All the four pulp and paper mills mentioned above are over thirty years old, and as a result, their process and machinery are extremely backdated. These mills are still in operation because they have undergone a number of BMRE programs and the government is subsidizing their products. For example, the Karnaphuli Pulp and Paper Mills (KPM), located in the Chittagong Hill Tracts on the banks of the Karnaphuli river was constructed in 1953. Since then it has undergone several BMRE programs to keep it operational, but the basic technology has remained the same. The government of Bangladesh is keen to keep it running because it is a major industry producing white paper in the country. Paper produced by KPM is unable to compete with imported and other locally made paper (from recycled paper). Thus to keep KPM running it is critically important to increase its productivity, hence profitability.

The pulp and paper industry is a well-known polluting industry. It is one of the highest water consuming industries. However, the state-of-the-art pulp and paper mills (those in Canada, USA, Norway, Sweden) have become environment friendly in the last decade. At present for every tonne of paper, KPM uses 3 to 4 times more water compared to the world standard and consumes double the amount of energy. Upgrading the pulp and paper technology will not only make it more energy efficient, it will also aid in making the industry less polluting. The discharge of liquid effluent is a major environmental problem in the locality. On several occasions the government has made attempts to control the pollution from KPM, but very little has been achieved. The government's sustainable development objectives with regard to KPM are to make it less polluting and more productive.

Description of Baseline and Mitigation Technologies

The present energy consumption of KPM is 18 GJ of power and 70 GJ of heat per tonne of paper. State-of-the-art plants consume less than 5 GJ of power and 28 GJ of heat per tonne of paper. The water consumption of newer plants is also less than half. Since many things in the existing plant cannot be altered or discarded easily, the reduction potential will probably be much less than the full potential.

The baseline technology is the following:

- Batch Digesters
- Low use of cogeneration power

The mitigation technology aims to retrofit the existing mills by:

- Continuous Digester
- More complete use of cogeneration power

The continuous digester will reduce the present heat requirement by 50% and power requirement by 40% for pulp making.

Description of the Project

This is a retrofit operation of the KPM. A continuous digester will replace the existing batch digester. At present cogeneration is used in KPM to a very small extent. The full potential is quite large. Since the plant is quite old, substantial modification and process integration will be needed to achieve the full cogeneration potential. The items discussed would be implemented selectively by replacing old equipment and necessary modifications would be made to accommodate the changes. The KPM is under Bangladesh Chemical Industries Corporation (BCIC), which has extensive capabilities in project formulation and implementation. Thus, if funds are available, BCIC personnel can handle the retrofit operation.

Measurable Reduction

These mills are all large public sector entities where fuel consumption data are accurately maintained, and therefore, the emission reduction can be easily calculated.

Financial Aspects of the Project

The replacement cost of the batch digesters by the continuous digesters would be US$ 20 million. The cogeneration unit will cost an additional US$ 20 million. This project will require US$ 500,000 as operation and maintenance cost every year.

Benefits

There are other several benefits of using continuous digestion in place of batch digestion. The water requirement for digestion is lower which results in better recovery of black liquor and less liquid effluent is discharged. It is also claimed that pulp made by continuous digestion need reduced quantities of bleaching chemicals and consequently lesser quantity of effluent. The other benefits of this CDM project are:

- Increase in productivity hence profitability
- Health benefits to the local community by virtue of cleaner air and river water

Barriers to Implementation

- These are public sector mills
- Old equipment has to be scraped
- At present all public sector pulp and paper mills are losing money

Emission Additionality

Plant capacity = 30000 tonnes/yr of pulp

Energy consumption per tonne of paper = 70 GJ (heat) + 18 GJ (electricity)

Grid power plant efficiency = 35%

Cogeneration power plant efficiency = 30%

Transmission loss = 4.2% (95.8% efficiency)

CO_2 emission factor for natural gas = 56.1 tCO_2/TJ

18 GJ/tonne of grid electricity = 18/0.35/0.958 GJ/tonne = 53.7 GJ/tonne of heat

Total energy consumption per year = 30,000 × (70 +53.7) = 3711 TJ/yr

Total CO_2 emission due to the plant = 3711 × 56.1 = 208187 tonnes/yr

CO_2 emission from 20 MW cogeneration (300 days, 24 hours)

$= 20 \times 10^6 \times 3{,}600 \times 24 \times 300 \times 56.1 / 0.3 = 96941$ tonnes/yr

CO_2 emission from 25 GJ/tonne heat used at the retrofitted plant (by burning NG)

$= 30{,}000 \times 25 \times 56.1/1{,}000 = 42{,}075$ tonnes/yr

CO_2 savings = 20,8187 – 96,941 – 42,075 = 69,171 tonnes/yr

Potential for Reduction

The mitigation scheme discussed for the KPM can be extended to three other mills. The full potential in the country of reducing CO_2 emission by this mitigation technology is approximately 250,000 tonnes/year.

1.3 Brick Manufacturing - Vertical Shaft Brick Kilns

National Sustainable Development Objectives

In Bangladesh, brick is the predominant building material in urban areas. It has become a significant building material even in the rural areas. High prices and scarcity of alternate building material such as, wood, bamboo, straw, iron sheets, etc. are increasing the demand for bricks. To meet the increasing demand, many new brickfields are mushrooming at the outskirts of urban areas as well as in the countryside.

Most of the bricks in Bangladesh are manufactured in conventional Bull's Trench Kilns (BTK) which are highly energy inefficient. Low-grade coal, firewood and even tires are used as fuels in brick kilns. In areas around urban centers where natural gas pipeline exists, the brickfields use natural gas. Firewood constitute approximately 35% to 40% of the total energy used in the brick industry. This very high fuelwood use is causing deforestation in many areas and is a major concern for the country. Inefficient and partial burning of fuels in the conventional kilns is causing severe environmental problems in the surrounding areas. Firing bricks in conventional BTKs also result in high percentage of wastes (10 to 15%) thereby increasing the overall fuel consumption and cost of production. With increasing demand for bricks, more and more paddy fields are being converted to brickfields thus putting tremendous pressure on the already scarce agricultural land. The haphazard growth of the brick industry is completely unsustainable. There is an urgent need for making it more efficient in terms of fuel and land usage.

Description of Baseline and Mitigation Technologies

The conventional Bull's Trench Kiln is an annular shaped space dug out in the open field. 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. The bricks are fired from the top and the fire moves forward toward 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 kiln is dug out in open field and gets destroyed by rain and floodwater every year. Every year new kilns need to be constructed almost from scratch.

Low-grade coal (rock coal) and firewood are the main fuels of the brickfields. The average fuel mix is: 55% to 60% coal and 35% to 40% firewood. A small amount of furnace oil is used to initiate the fire. On an average about 30 tonnes of fuel is needed per 100,000 bricks. Assuming an average weight of a brick to be 1.75 kg, the fuel requirement turns out to be 3.0 MJ/kg of fired bricks. The quality of the bricks mainly depends on the quality of the firing, which in turn depends on the expertise of the fireman, who is the person responsible for firing the bricks. Usually the firemen have no formal training and acquire expertise through experience. Good firemen are in heavy demand during the season and are paid quite handsomely. The firemen control the fire mainly by visual inspection. Coal and firewood are loaded from the top for firing. Furnace oil is used in places where the fire needs to be invigorated during the firing process. Apart from the skills of the firemen, the quality of the bricks also depends on the quality of the clay used. Too sandy a clay is not good for bricks and usually yields low strength bricks.

The mitigation option proposed is the replacement of BTKs by Vertical Shaft Brick Kilns (VSBK) which are compact continuous kilns developed in China. A VSBK is very fuel-efficient and saves approximately 35% to 40% fuel compared to the BTK. In addition, the kiln is simple to construct and operate, making it ideal for rural areas. The VSBK requires 1 hectare of land compared to 3 hectare for the BTK. The VSBK has been tested and proved to be very successful in China, India and Nepal. In a VSBK, bricks are stacked in a shaft measuring $1x1m^2$ up to a height of 6.0m. Green bricks are loaded from the top in batches of 224 bricks arranged in four layers. At the bottom, bricks are taken out using a special unloading device. On the average one batch of 224 bricks is unloaded every 1.5 hours. The firing occurs around the middle of the shaft. The kiln has been tested only with coal dust, which is loaded from the top along with the green bricks. The combustion air enters at the bottom of the shaft and moves up through the bricks already fired. The combustion air gets preheated to about 750^{o}C by taking up heat from the fired bricks. After combustion the hot flue gases move up through the unfired bricks and in the process preheat the bricks to be fired. The VSBK is a permanent structure and can easily last for 8 to 10 years with minimum maintenance.

Description of the Project

No reliable statistics are available on the number of BTKs and their output. One study estimates that about 5,500 million bricks are produced annually from 3,200 kilns. This project proposes that 25% of the total bricks will be produced using the VSBK technology. A 6 shaft VSBK can produce 24,000 bricks per day. Assuming 8 months operation per year, a VSBK can produce (24,000x30x8) = 5,760,000 bricks per year. To produce 25% of the present demand, a total of 240 VSBKs will be required. The technology is available in China, India and Nepal. Average cost of construction of a VSBK is about US$ 25,000 per kiln and it takes about 2 months to construct a kiln.

Measurable Reduction

The emission calculation will be based on the fuel use and the outputs of the VSBKs.

Financial Aspects of the Project

The construction cost of a 6 shaft VSBK is US$ 25,000

Therefore, to construct 240 VSBKs, the cost would be US$ 6.0×10^6

The life of a VSBK is assumed to be 5 years

Fuel Cost: Cost of coal = US$ 45/tonne

Fuel cost = 412,500 tonnes x US$ 45/tonne = US$ 18.75×10^6

Benefits

The use of the VSBK technology instead of the BTK technology for brick manufacturing will result in the following benefits:

- Reduced fuel consumption and improved combustion will cut emissions of noxious gases by less than half
- Since VSBK only uses powdered or fine-grained coal, this technology will cause biomass use in brick manufacturing to stop. Thus, VSBK will contribute to sustainable development
- Reduced consumption of coal will save foreign exchange
- A VSBK requires 1 hectare of land compared to 3 hectare for BTK. Therefore, the project will reduce land used by the brick industry
- Lower production cost will eventually benefit the consumer and the national economy
- A VSBK does not need to be re-constructed every year unlike the BTK

Barriers to Implementation

- New technology - a marketing strategy will be needed to disseminate the technology and brick workers will need to be trained
- The kiln operates only with powdered or small grained coal and thus, the shift will cause less flexibility on fuel choice

Emission Additionality

Brick to be manufactured by VSBK = 1375×10^6 (25% of present demand)

CO_2 emission factor from coal = 94.6 tCO_2/TJ

Heating value of coal = 2,0.93 GJ/tonne

Energy: FOR BTK

Specific coal consumption = .3kg/brick

Coal consumption = $.3 \times 1{,}375 \times 10^6$ /1000 = 412,500 tonnes

Energy = 412,500 tonne $\times$ 20.93 GJ/tonne = 8634 TJ

FOR VSBK

VSBK - 50% fuel efficient

CO_2 emission: 8,634 TJ $\times$ 94.6 tCO_2/TJ= 816,776 tonnes/yr (BTK)

Potential for Reduction

In Bangladesh about 3,200 brick kilns are in operation producing about 5,500 million bricks per year and consuming fuel equivalent to about 1.5 million tonnes of coal. Fuel consumption can be reduced significantly using improved kilns like the Vertical Shaft Brick Kilns (VSBK) which consume approximately half the amount of fuel of BTKs. Therefore, by replacing all BTKs by VSBKs, the present CO_2 emissions from the brick industry can be halved, i.e., 1.6 million tonnes of CO_2 can be abated annually. The full potential may be difficult to achieve given the numerous barriers and a more realistic, though still ambitious, target is one-fourth the full potential, i.e., 400,000 tonnes annually.

1.4 Cement Manufacture – Wet to Dry Process

National Sustainable Development Objectives

Cement production is an energy intensive activity. The energy cost of Portland cement production is 20% to 30% of the total production cost. Consequently, efforts have been made to reduce energy consumption in cement production through improvements in the process and other auxiliary facilities. Since the energy crisis of 1973, the dry process has replaced many of the wet processes for clinker production. The dry process uses up to 50% less energy than a wet process.

Annual demand of cement in 2000 is estimated at 4.5×10^6 tonnes. Installed capacity of one integrated cement plant based on the wet-process and sixteen clinker grinding plants is 4.3×10^6 tonnes/yr. The nominal capacity of the wet-process plant is 0.233×10^6 tonnes/yr, which comprises only 5.4% of the national demand for cement. Clinker is imported from several countries and processed in finish mills using electric power.

A cement production plant consists of the following three steps:

- Raw material preparation
- Clinker burning
- Finish grinding

The raw material preparation and the clinker burning process are each classified into the wet process and the dry process. The finish grinding involves the dry grinding of a mixture of clinker and 4% gypsum to produce cement.

In the **wet process**, a crusher crushes the principal raw material limestone. Then crushed limestone and clay are mixed, and ground wet in a tube mill to produce a slurry containing 35% to 40% water. The slurry is fed to a long rotary kiln for clinker burning. The wet process ensures good homogenization of the raw materials and production of good quality cement. However, a large quantity of fuel is consumed in the clinker burning process due to water evaporation.

In the **dry process**, clay and crushed limestone are dried in separate cylindrical rotary dryers, blended together, ground and stored in silos. The blended raw materials enter into a suspension preheater, where hot gases from the kiln heat the raw feed and provide partial calcination of limestone before the feed enters the short rotary kiln for clinker burning. The advantages of the wet process are that the plant construction cost is low and high quality cement is produced easily. On the other hand, in the dry process energy consumption and operating cost are lower. Technological advances are eliminating the differences in quality between the products from the above processes, while needs for energy savings are becoming increasingly important.

Description of Baseline and Mitigation Technologies

The Chattak Cement Company Limited (CCCL), which is a wet-process cement plant having an annual capacity of 233,000 tonnes, has the following major equipment and facilities:

- Ropeway for limestone transport from quarry in India.
- Jaw crusher and hammer crusher for crushing limestone.
- Wash mill for clay.
- Two raw mills (ball mills) for wet grinding of a mixture of crushed limestone and clay; capacity of each mill is 35 tonnes/hr.
- Slurry silos.

- Two long rotary kilns for clinker production; capacity of each kiln is 350 tonnes/day.
- Clinker storage hall.
- Gypsum dryer.
- Four cement mills (ball mills) for grinding clinker and gypsum to cement.
    - Two cement mills of 10 tonnes/hr each
    - Two cement mills of 15 tonnes/hr each
- Cement silos.
- Packing machine for cement.

Natural gas consumption as fuel for rotary kiln = 200 m^3/tonne clinker.

The conversion of the existing Chattak wet-process to dry-process would require the following modifications or installation of new equipment:

- Raw material preparation based on the dry-process. This will require installation of clay dryer and limestone dryer. Furthermore, the existing raw mills need to be adapted for dry grinding of a mixture of clay and crushed limestone.
- Installation of new blending silos for the storage of powder raw material.
- Cutting the existing rotary kilns to reduce their length and installation of suspension preheater. The exit gas from the rotary kilns may be used as a heating medium in the suspension preheater.
- Replacing the existing planetary coolers by conventional coolers in order to recover heat from the hot clinkers (400-500°C), which the planetary coolers now cool, but no heat is recovered.

Natural gas consumption as fuel for rotary kiln = 100 m^3/tonne clinker

The clinker grinding process equipment does not require substantial modification.

Description of the Project

In Bangladesh, there is a 233,000 tonne wet-process cement plant (CCCL). The historical growth of this plant's capacity is shown below:

Table 1.2 Historical Cement Plant Capacity

Year	Installed capacity (tonnes/yr)
1941	60,000
1958	90,000
1979 (Before the last phase of capacity expansion)	135,000
2000	233,000

The last phase of expansion program was initiated in 1979 and completed in 1987 from 135,000 tonnes to 233,000 tonnes. The owner of the plant (Bangladesh Chemical Industries Corporation (BCIC)) has considered conversion of the existing wet-process kilns to semi-dry or dry-process kilns but the Report for the CCCL BMRE Project by the Storch Corporation of U.S.A. (1984) expressed the view that the conversion from wet-process to dry-process was not technically and economically viable based on world experience at that time. Since then a rapid switchover from wet-process to dry-process has taken place in many countries. For example, in Japan almost all the wet-process kilns have been transformed into the dry-process kilns. In 1993, Japan's cement production based on the dry-process was 97 million tonnes.

In the backdrop of this worldwide trend for energy conservation in cement industry, the Energy Monitoring and Conservation Center of the Ministry of Energy, GOB in 1994 hosted a one-day seminar on "Energy conservation in cement industry" organized by the Energy Conservation Center of Japan. Although the Government of Bangladesh has shown interest in the conversion of the Chhatak wet-process cement plant to a dry-process one, it has not been possible to achieve the conversion due to lack of proper policies and financial support.

Measurable Reduction

The CCCL is a large plant with well-equipped measuring devices. Any reduction in fuel consumption can easily be monitored.

Financial Aspects of the Project

Conversion of the wet-process to dry-process would require US$ 40 million. The operation and maintenance cost in the existing plant is about US$ 2 million. This would be reduced to about US$ 1 million in the new dry-process plant. Fuel savings will amount to an additional US$ 2.05 million per year.

Benefits

- Reduction in water use
- Will make the product competitive with imported cement

Barriers to Implementation

- The CCCL and BCIC are public sector organizations
- Will require government cooperation

Emission Additionality

Natural gas as fuel for rotary kilns (wet) = 200 m^3/tonne clinker

Natural gas as fuel for rotary kilns (dry) = 100 m^3/tonne clinker

Specific fuel savings = 100 m^3/tonne

Plant capacity = 233,000 tonnes

Annual NG requirement = $100 \times 233{,}000 = 23.3 \times 10^6\ m^3$

CO_2 emission factor = 56.1 tCO_2/TJ = 0.0019635 tCO_2/m^3

CO_2 reduction = $0.0019635 \times 23.3 \times 10^6$ = 45,750 tonnes/yr

Potential for Reduction

Since this is the only cement manufacturing plant in the country, the scope of converting wet-process cement plant to the dry-process is limited to this one. However, large number of clinker grinding plants are being set up where energy efficiency schemes can be implemented.

1.5 Urea Fertilizer Plants

National Sustainable Development Objectives

As a source of nitrogen, urea fertilizer made from natural gas is extensively used for rice cultivation. The increase in rice production in the past three decades has been made possible to a large extent by the availability of urea fertilizer. If self-sufficiency in cereal production is considered a matter of national security, then urea is a strategically important commodity for Bangladesh. This situation is expected to prevail at least up to 2020. Fertilizer plants contribute towards sustainable growth of the economy through increased food production. Although the contribution of natural gas towards the cost of production of urea is not large (approximately 20-25%), in Bangladesh fertilizer production is one of the accepted options for value addition to natural gas. For the growth and sustenance of the natural gas sector, urea production is vital. If CDM projects were constructed for urea plants, then it would be in line with the Government's initiative to attract joint venture capital in this sector and would also address the donor agencies repeated requests for privatization of the public sector industries.

The installed capacity of the seven urea plants currently in operation is 2,895,685 tonnes per annum, while the actual production capacity of these plants is 1,860,910 tonnes per annum. All fertilizer plants are of the grass-roots type with captive power generation. The seventh plant came on-stream in 1994. Natural gas is used both as feedstock and fuel. The seven plants consume about 35 percent of the total natural gas used in Bangladesh. By 2010, Bangladesh is likely to have two more urea plants, while one of the smaller capacity plants will be retired. The installed capacity of urea plants by 2010 will be close to 4 million tonnes per annum.

The portion of the natural gas used as feed does not lead to emission of CO_2 in the plant but does so later when the urea is used. The portion of natural gas used as fuel (process furnace, auxiliary boilers and electric generators) produce CO_2. A state-of-the-art urea fertilizer plant operating in Bangladesh produces about 0.6 tonne of CO_2 per tonne of urea.

Description of Baseline and Mitigation Technologies

The baseline is an existing ammonia-urea plant having the process technology of the late seventies. The project baseline assumes a grass-roots ammonia-urea complex having a specific natural gas consumption of 35 MSCF per tonne of urea.

State-of-the-art urea plants maximizes the use of waste energy available in different forms such as flue gas and process steam and consume less than 24 MSCF of natural gas per tonne of urea. The mitigation project will utilize the state-of the-art process technology and plant machinery. Some of the options considered are:

- Improved conversion per pass due to improved catalysts thereby reducing recycle volume resulting in reduction in compressor power
- Improved reformers with improved catalysts will require a lower steam to carbon ratio for reforming thereby reducing steam requirement
- Electric cooling water pumps, boiler feed water pumps, ID and FD fans for reformers to be replaced by steam turbines
- Waste heat boilers plus process heat exchangers would reduce the steam generation requirement by the auxiliary boilers
- Recovering hydrogen from the purge gas will result in savings in process gas and additional ammonia
- Balanced operation of urea and ammonia plants at a plant load close to 100% will result in lesser waste in process and fuel natural gas

- Generation of steam at the highest possible pressure and temperature will allow production of additional electricity for export to the national grid after meeting the plant's requirement for prime movers. Use of more efficient STG for power generation
- Use of excess low-pressure steam (5 and 15 kg/cm^{2}g) in absorption refrigeration system thereby replacing the existing vapor-compression refrigeration system for the plant buildings and urea storage areas. The savings per tonne of urea produced are equivalent to 0.24 tonne of steam at a pressure of 15 kg/cm^2. In terms of CO_2 emission this is 0.0279 tonne per tonne of urea
- Compression of process natural gas from the available inlet pressure (>20 kg/cm^{2}g) to the reforming pressure instead of reduction of inlet gas to 7 kg/cm^{2}g through let-down valve. This would result in net savings of compression power equivalent to 2 MW and result in reduction of CO_2 emission by about 0.019 tonne per tonne of urea if this power were delivered to the national grid

Description of the Project

The project proposes to retrofit an existing ammonia-urea complex built in the late seventies. The fertilizer complexes are under a big corporation called the Bangladesh Chemical Industries Corporation (BCIC) which has extensive capabilities to execute large projects. Therefore, BCIC can handle the full retrofit operation if the required investment funds are made available to it. The project will require 24-28 months for implementation after the scope of work is fully defined.

Measurable Reduction

The emission measurement will be based on the actual plant performance. However, the CO_2 reduction can be calculated from the technical literature and suppliers of technology. The measurement of CO_2 emission should pose no problem because these fertilizer plants are highly automated facilities.

Financial Aspects of the Project

US$ 90 million would be required to accommodate all the modifications and retrofitting to improve the energy efficiency of the urea fertilizer plant. An average yearly operation and maintenance cost of US$ 2.5 million would be required during the project life. This improvement would save US$ 12.5 million each year in reduced fuel bills. In addition to that a yearly income of US$ 0.8 million would be generated from selling 2 MW power to the national grid. There will also be financial benefits from increased production.

Benefits

The expected benefits from the proposed mitigation option are:

- Significant reduction in natural gas consumption hence conservation of a natural resource
- Increased production of urea for the next fifteen years
- Reduction in operating cost due to less maintenance requirement
- Higher capacity factor – less shutdowns

Barriers to Implementation

- Plant operators will be required to appreciate the underlying concepts and principles of the technological options being proposed

- The investor will have to deal with a public sector organization and may find that there is a lack of interest in such projects

Emission Additionality

Plant capacity = 448,000 tonnes/year

Specific NG consumption

Baseline = 991 m^3/tonne

Mitigation = 680 m^3/tonne

CO_2 emission factor

= 56.1 tCO_2/TJ = 0.0019635 tCO_2/m^3 = 28.512 tCO_2/MW

Power plant efficiency = 35%

CO_2 emission from 2 MW power (24hr, 330 days) =

$2 \times 3{,}600 \times 24 \times 330 / 10^6 \times 56.1 / 0.35 = 9{,}140$ tonnes/yr

Natural gas savings = $(991-680) \times 448{,}000 = 139.33 \times 10^6$ m^3/yr

CO_2 savings from fuel reduction = $139.33 \times 10^6 \times 0.0019635 = 273{,}575$ tonnes/year

Total CO_2 savings = 273,575 + 9,140 = 282,715 tonnes/yr

Potential for Reduction

The potential for emission reduction exists in three urea plants. The emission of these plants can be brought down from the present 1.97 to 1.335 tonne of CO_2 per tonne of urea. The total potential by this project opportunity is estimated to be approximately 500,000 tonnes of CO_2 annually.

2 Renewable Energy

2.1 Water Pumping (wind)

National Sustainable Development Objectives

For a country of 120 million people, the energy resource base is tiny. Natural gas is the only significant energy resource. Compared to its present consumption, however, the natural gas reserve is large, but with economic growth and prosperity, the present surplus will disappear. The need to search for newer and more sustainable energy resources will gain prominence as natural gas begins to deplete. The use of renewable energy in whatever form and in whatever quantity must be given priority.

Bangladesh has large coastal areas along the Bay of Bengal (725 km coastline). The average wind speed is 2-4 m/s at the height of 5 to 10 meters above the ground level. The available wind power is seasonal and diurnal. There exists potential for developing wind power in the coastal areas.

The potential area for lifting water for irrigation is in the coastal districts, especially Chittagong, where diesel/electric pumps are used to lift water from canals and rivers. Suitably designed windpumps can be widely used for vegetable growing during the winter months (November-February) in all coastal areas.

The total irrigation area serviced by power pumps in the coastal districts (Chittagong, Noakhali, Khulna, Barisal, Patuakhali) is about 46,508 acres (Bangladesh Statistical Handbook, 1996-97). The total number of power pumps is 455. About 100 of these pumps would be suitable for replacement by windpumps.

Description of Baseline and Mitigation Technologies

Typical shallow-water pumps are run by 5 kW diesel engines with a pump output of 3 kW. Average fuel consumption is about 200 gm/kWh.

The mitigation proposal is the replacement of the diesel pumps by windpumps. The following are the specifications for the windmill and pump.

- Windmill
  - Diameter 5m
  - Number of Blades 12
  - Coefficient of Performance 0.25
  - Optimum tip speed ratio 2.0
  - Rated wind speed 3 m/s
- Pump
  - Positive displacement pump
  - Water head 5m
  - Flow at full capacity 1.5 l/s

Description of the Project

The project would involve installing 100 windpumps at appropriate sites to displace an equivalent number of diesel pumps serving the same irrigation area. Thus, to initiate this project the appropriate sites have to be located. A small company would have to be set up to implement the project. This company will not only provide the technical services, but will also interact with the current owners of the 100 existing diesel pumps to convince them to make the changeover.

Measurable Reduction

Once the baseline emission is established from the average fuel consumption of the diesel pump sets, the only thing that needs to be established is whether the windpumps are being able to provide the same service in terms of water flow.

Financial Aspects of the Project

The cost of the proposed windpump set would be about US$ 3,000. The implementation of this project would require a good scheme, the cost of which is estimated to be US$ 1,000 per windpump. The total investment for 100 windpump sets would be US$ 400,000. Assuming the cost of diesel to be US$ 0.4166/kg, a total of US$ 0.1 million can be saved in fuel bills each year.

Benefits

The expected benefits from the proposed modification are:

- Reduction of pollutants from diesel combustion at the pump site
- Reduction of noise pollution
- Truly sustainable energy

Barriers to Implementation

- It may be difficult to convince the diesel pump owners to make the change
- High initial investment for the small time businessmen
- Introduction of unfamiliar technology

Emission Additionality

The project boundary will be slightly larger than the existing 100 diesel pump set locations because of the extra space required for the windmills. It is assumed that an engine (5 kW) is operated for twelve hours a day for 200 days a year and consumes diesel at the rate of 200 gm/kWh.

Total diesel consumption = 240,000 kg/yr

Heating value of Diesel = 0.0000433 TJ/kg

CO_2 emission factor = 74.06 tCO_2/TJ

Total CO_2 savings = $0.0000433 \times 240{,}000 \times 74.06$= 770 tonnes/yr

Potential for Reduction

From the average wind speed data of the probable sites, it may be suggested that some hybrid wind power generation may be achieved in the Kuakata, Kutubdia and Char Fashion areas. The most prospective option for wind energy utilization is however lifting water for drinking and irrigation purposes, which has been considered in this CDM project. For special needs (i.e. telecommunication), some wind-PV generators (100 W to 2 kW) at remote locations may be installed. Without good data on the wind potential of the country, the potential for CO_2 reduction cannot be determined.

3 Transportation Sector

3.1 CNG Vehicles – Gas Engines

National Sustainable Development Objectives

Vehicle emissions contain a large number of harmful gases, and the major sources of CO, NO_x, SO_x and hydrocarbon emissions in urban areas. Diesel vehicles also emit large amounts of particulate matter. The use of old vehicles and lack of maintenance has aggravated the air pollution problems in the major city centers. Use of compressed natural gas (CNG) can lead to more sustainable urban transport by reducing air pollution in the major city centers.

Compared to its present demand Bangladesh has a large natural gas reserve. At present natural gas is the prime source of energy for the power, fertilizer and industry sectors. Since natural gas is an indigenous fuel, the Government of Bangladesh would like to maximize its use especially to substitute for liquid fuels in the transport sector. The burden of having to import liquid fuels using hard-earned foreign currency will continue to increase because the transport sector is one of the fastest growing sectors. The substitution of gasoline and diesel by compressed natural gas (CNG) will bring significant economic and environmental benefits to the country.

To reduce the dependency on imported fuels and to reduce air pollution in major city centers, the national oil and gas corporation called Petrobangla, in 1982 conducted a feasibility study and carried out a pilot project on CNG as a vehicle fuel. Under the project, undertaken by GDC International Inc., a subsidiary of the Institute of Gas Technology (IGT), Chicago, conversion and refueling facilities were installed at Joarshahara, Dhaka and a number of vehicles were converted to CNG. Encouraged by the success of the pilot project, a company called Compressed Natural Company Ltd. was launched in 1987. Later in 1991 the company was assigned the additional responsibility of producing liquefied natural gas (LPG) from natural gas liquids (NGL) and renamed as Rupantarita Prakritik Gas Co. Ltd. (RPGCL). RPGCL in joint venture with a private company now has CNG workshop at four locations including Joarshahara to convert vehicles to CNG and operates eight CNG refueling stations in different areas of Dhaka. From the beginning of 2001 a massive CNG program has started and the entire business has been opened up to the private sector. Four new refueling stations have been constructed and more than 5000 vehicles have been converted. However, the entire CNG program is based on converting oil-run vehicles to CNG. There is no program to promote CNG-engined vehicles.

Description of Baseline and Mitigation Technologies

In 1997 a total of 458,687 vehicles of different types were in use in the country (source: Bangladesh Road Transport Authority (BRTA)). Of the vehicles being used in the country, about 50% and 25% are based in the cities of Dhaka and Chittagong, respectively. In 1997, a total of 998,945 tonnes of gasoline and diesel were consumed by road transportation (BPC Annual Report, 1997). Dhaka, with a population of 10 million, is already considered to be one of the mega-cities of the world. The population of Dhaka is expected to rise to 15.5 million by 2016. The number of vehicles plying on the city roads is increasing at a rate faster than the population. Air pollution has become a major concern in the major city centers especially in the Dhaka and Chittagong metropolitan areas. Most vehicles run on standard gasoline and diesel engines. The baseline technologies are these engines.

The mitigation technology is cars with gas engines.

Description of the Project

The project proposes to import 20,000 relatively small vehicles (i.e., cars/jeeps/microbuses). A subsidy of US$ 2,000 will be provided to the vehicle owners. It is assumed that the government and the private sector will set up the required number of refueling stations in the business-as-usual scenario. Therefore no additional investment will be required for the refueling stations.

Measurable Reduction

Carbon dioxide emission can be directly calculated from the gas sales figures of the CNG refueling stations. The sales figures can be cross-checked from the gas sales figures of the gas utility company. Since converted CNG vehicles will use the same refueling stations as vehicles with gas engines, an account of the gas sales to the two types of vehicles must be maintained.

Financial Aspects of the Project

Subsidy to the cost of cars = US $ 2,000x20,000 = $40x10^6$

Initial investment: Cost of standard gasoline and diesel cars=$12,500/car

Cost of CNG car = $14,500/car

For CNG cars import and subsidy plans are 5% each

Investment for the standard gasoline and diesel cars=$12,500/car x 20,000 = $\$250x10^6$

Total investment for the CNG cars=$14,500/car x 20,000 x 1.1 = $ 319 x 10^6

Fuel Cost: Gasoline Tk. 25/litre, Diesel Tk. 15/litre, NG Tk. 10/m^3, 1 US$ = Tk. 55

Fuel consumption, gasoline 15,000 x 2,000/.8 = 37.5 $x10^6$ litters, diesel 5,000 x 2,200/.85 = 12.94 $x10^6$ litters. Therefore, fuel cost: (37.5 $x10^6$ x25 +12.94 $x10^6$ x 15)/55.0 = $ 20.53 $x10^6$, For NG = (1,800 x 20,000 x 10)/55= $ 6.55 $x10^6$

Benefits

The most significant benefit from the proposed project is reduction in atmospheric pollutants as shown in the table below:

Table 3.1 Reduction in Atmospheric Pollutants (gms/miles)

Pollutants	Diesel	Gasoline	CNG
CO_2	410	410	295
HC	0.79	0.19	0.03
CO	20.85	3.4	2.3
NO_x	20.36	0.51	0.05
PM	3.42	--	--

Other benefits of the proposed project are:

- Replacement of imported liquid fuels thereby saving hard-earned foreign currency needed for importing liquid fuels

- Increased domestic gas utilization is in line with government policy for energy use
- Health benefits from improved urban air quality
- NG is a cleaner fuel than gasoline/diesel and possesses higher knock resistance characteristic and therefore burns more completely compared to conventional liquid fuels
- Large savings for vehicle owners because the price of CNG is one third that of gasoline and one half that of diesel.

Barriers to Implementation

- People perceive use of CNG hazardous because of the high pressure cylinder on board
- Need to provide adequate number of CNG refueling stations
- CNG users may find the frequent refueling needs bothersome
- The present price differential between liquid fuels and CNG must be maintained
- Chances of hydrocarbon leakage if CNG is not handled properly
- Automobiles with gas engines are not standard. Therefore, these will have to be specially ordered

Emission Additionality

Project target: Assumption

Primary Energy: 2,000 kg/year/car (gasoline), 2,200 kg/year/car (diesel), 1800 m^3/year/car (CNG) (source: Expert judgement)

For gasoline, 15,000x2,000x44.88TJ/k-tonne x (1/1,000) x (1/1,000) = 1,346 TJ

For diesel, 5,000x2,200x43.33TJ/k-tonne x (1/1,000) x (1/1,000) = 477 TJ

For NG, 20,000x1,800x35MJ/m^3 x (1/1,000) x (1/1,000) = 1,260 TJ

CO_2 emission: For gasoline car, 1,346/15,000 x 69.3 T CO_2/TJ= 6.31 tonnes per car

For diesel car, 477/5,000 x 74.04 T CO_2/TJ = 7.06 tonnes per car

For NG, 1,260/20,000 x 56.1 T CO_2/TJ = 3.53 tonnes per car

Total CO_2 emission: 1,346 TJ x 69.3 T CO_2/TJ + 477 TJ x 74.04 T CO_2/TJ = 128,595 tonnes (from petrol and diesel) 1,260 TJ x 56.1 T CO_2/TJ = 70686 tonnes (from NG)

CO_2 reduction: 128,595 – 70686 = 57,909 tonnes

Potential for Reduction

According to the annual report of Bangladesh Petroleum Corporation (1997), the total amount of liquid petroleum fuels consumed in the road transport sector in 1996-97 was 998,945 tonnes, of which octane, petrol and diesel were 53,825 tonnes, 224,107 tonnes and 711,013 tonnes, respectively. According to Bangladesh Road Transport Authority (BRTA), in 1997 the total number of registered motor cars in Dhaka was 40,487 and that of jeep/pick-up/microbus was 24,666. Total CO_2 emission from the transport sector of the country is about $3.14x10^6$ tonnes/yr.

The potential is somewhat limited because the market for new cars is small. Most cars used in Bangladesh are re-conditioned ones, i.e., 4-5 year old cars from Japan, but the ownership of cars is increasing at a fast pace and therefore the potential will keep on increasing. If the Government provides adequate support then CNG-engined vehicles can be easily promoted. For example, there is 100% tax on vehicles. If this is lowered and the Government negotiates with automobile manufacturers for the supply of CNG vehicles, then the price differential between CNG and oil-run vehicles can be decreased to the extent that a CDM project can easily close the gap. Since CNG engines will only be available in new imported vehicles, the potential of this project must be judged from the demand growth for vehicles in the country. In that respect the potential for CO_2 reduction by this project can build up to 100,000 tonnes per year in 5 to 6 year's time.

4 Power Sector

4.1 Transmission Losses

National Sustainable Development Objectives

For the last eight years, the national power company has been unable to meet the demand for electricity. Moreover, 80 percent of the rural areas have no electricity. It is widely believed that meeting the unmet increasing demand for electricity in the rural areas would increase economic development. To achieve this objective, the GOB is considering separating generation, transmission and distribution of electricity. Private sector participation has already been allowed in the generation sub-sector and such participation is also being considered in the transmission and distribution sub-sectors.

The pitiable state of the transmission and distribution of electricity has already been mentioned in Sections 3 to 5. Even though the main problem is the non-technical system loss, the technical system loss is no less damaging. The extremely poor financial performance of the national power company is due to the large system loss. From a CO_2 emission point of view, the reduction of technical system loss can yield large dividends. During the peak hours, when transmission loss is at its highest and its management is more critical, all oil fired peak load generators are brought into the grid. Since oil fired power stations are predominantly used as peak load generators, any savings in technical loss of transmission and distribution at peak times will reduce carbon dioxide emission considerably. The savings will grow over time because 2,000 MW of additional capacity is expected to be added to the system by 2005.

Description of Baseline and Mitigation Technologies

Power evacuation is a serious problem in the existing transmission system in Bangladesh and new transmission lines are required to deliver electricity to areas not serviced by the grid. The Planning Division of the Bangladesh Power Development Board (BPDB) has submitted to the government a six-year plan to improve the situation as part of a long-term rehabilitation. This involves replacement of worn out items, capacity increase of existing lines and building new transmission infrastructure. If this expansion program were not undertaken the transmission losses would keep on increasing with increasing transmission of electricity.

Table 4.1 Summary of Transmission Development (up to 2005)

Description	Existing	Proposed	Total
New grid substations			
132/33 kV	75	10	85
230/130 kV	8	6	14
New Transmission Lines			
230 kV (km)	419	601	1,020
132 kV (km)	3,258	920	4,178
Augmentation and Rehabilitation of Old Substations			
132/33 kV		29	
Capacitor Bank Addition			
MVAR	340	200	540

Description of the Project

The transmission loss at present is 4.2% and the peak generation capacity is 2,700 MW (November 1999). Adding new capacitor banks, substations and transmission lines can reduce transmission losses to 2%. All these additions would improve power evacuation and hence decrease the loss. The proposed plan by BPDB requires significant investment and only about fifty percent of that is expected to be provided by the GOB and donor/financial agencies. The rehabilitation project is not progressing due to lack of any firm commitment. Therefore, if sufficient funds were made available, it would remove the current barrier towards implementing the project.

The peak transmission in 2005 is expected to be 4,700 MW. Considering the daily and seasonal load variations, the proposed expanded network would carry an average of 3,500 MW of electricity for the next 15 years (2005-20), although the total system capacity would be much more than that. All CO_2 saving has been calculated based on this figure.

Measurable Reduction

Transmission loss is easily calculated because electricity dispatched from power plants and received for distribution are both known accurately.

Financial Aspects of the Project

The total investment required to lower transmission losses is estimated to be US$ 761 million. The year-wise breakdown is as follows:

Table 4.2 Transmission Investment Plan 2000-2005 (million US$)

Year	Local	Foreign	Total	Peak Transmission Loss
2000	13.63	29.3	32.93	
2001	38.66	89.8	128.46	
2002	74.14	157.82	231.96	2.5%
2003	71.10	148.15	219.25	
2004	41.43	79.68	121.11	
2005	7.00	10.50	17.50	2.0%
Total	245.96	515.24	761.21	

Benefits

The expected benefits from the proposed modification are:

- Power savings of about 100 MW
- Expansion of the electricity network
- More availability of electricity hence less load shedding
- Economic development hence improved quality of life

Barriers to Implementation

- The investor will have to deal with a public sector corporation
- Difficulties exist in accurately defining the baseline
- The CO_2 abated may also be difficult to establish

Emission Additionality

The project boundary is the electricity transmission network of Bangladesh.

Gas-fired steam or combustion turbine generators are the baseload power plants in Bangladesh. The average efficiency of such plants is about 30%. Oil (diesel) fired generators manage the peak load with an average efficiency of 25%. In the future, however, the baseload will be met predominantly by combined cycle and gas combustion turbines will meet the intermediate and peak load. An average efficiency of 35% has been assumed to calculate CO_2 emission for the next 15 years.

Number of operating days = 365

Number of operating hours = 24

Power plant efficiency (average) = 35%

CO_2 emission factor = 56.1 tCO_2/TJ

Thermal energy required for producing 1MW electric power

$= 1\times10^6\times3{,}600\times24\times365/0.35$ J/yr = 90.1 TJ/yr

Total energy savings in MW = 77

Total CO_2 savings = 77 × 90.1 × 56.1 = 389,204 tonnes/yr

Natural gas required to produce 1 MW of electricity = 2.57×10^6 m^3/yr

Potential for Reduction

The full potential of reduction has been considered in this project.

4.2 Distribution Network Improvement

National Sustainable Development Objectives

The national sustainable development objectives have been discussed in the previous option. One may however add that the particular issue of non-technical system loss is connected with the distribution of power and this loss is particularly high in the city of Dhaka. The non-technical loss in the distribution system is officially recognized as 20% although the unofficial figure is as high as 40% in some areas.

The technical distribution loss in Bangladesh varies between 4.5% and 11%, the weighted average being 10%. Even in the case when power is available, full demand cannot be met in some areas due to line overload. To protect the system, load shedding is practiced. Inferior quality wire, inefficient transformers, conductors, insulation, joints etc create the bottleneck in the distribution lines. It is possible to reduce the losses to 8% thus saving about 30 MW of power by 2005.

It is only the technical loss that can be targeted in a CDM project. The non-technical losses in the opinion of economists are unpaid for demand. However, it may be argued that those who consume electricity without paying would consume far less if they were forced to pay for their full consumption. In that sense, one can invest in reducing non-technical losses and mitigate CO_2 emission, but the emission reduction cannot be quantified easily.

Description of Baseline and Mitigation Technologies

The largest electricity distribution network in the country is the one for the city of Dhaka. This distribution network is also one of the worst. Therefore, it is a logical choice for a CDM project. In this distribution network, 20 to 30 percent of the existing distribution lines need to be replaced with higher capacity and better quality wires and similar percentage of transformers needs to be replaced as well. Efficient amorphous metal transformers can be the replacement for the existing transformers. Partial replacement of old joints, insulation and conductors are also required. The investment requirement will naturally depend on the extent of replacement, quality of the new equipment, right of way (substation space) etc. The investment requirement considered in this study is a medium one.

Description of the Project

The local electricity distribution company known as the Dhaka Electric Supply Authority (DESA) will implement this CDM project in the city of Dhaka. DESA has the required skilled manpower and infrastructure support to implement the project, and therefore, no additional implementation cost would be required. A detailed project plan will have to be prepared, which can be done by DESA personnel or by consultants. The plan will i) find the locations where retrofit operations need to be conducted ii) determine the items that need to be replaced and iii) prepare a work schedule.

Measurable Reduction

This project suffers from a severe drawback in that its emission reduction cannot be readily measured. Therefore, to implement this project some standardized non-technical losses have to be assumed.

Financial Aspects of the Project

The cost of reducing the distribution loss at Dhaka by 3% would require an investment of US$ 150 million. The benefits of the project would accrue for at least 15 years. The cost data has been obtained from actual estimates made by the public sector power company known as the Bangladesh Power Development Board (BPDB).

Benefits

The expected benefits from the proposed modification are:

- Infrastructure improvement leading to less power outage
- Availability of more electricity leading to less load shedding
- Increased capability to distribute electricity
- Improvement in the financial position of the power company

Barriers to Implementation

Same as the 'Transmission Losses' project.

Emission Additionality

The project boundary is the electricity distribution system of Dhaka. The average distribution load at present is about 800 MW, which takes into consideration the daily and seasonal variations. The average load on the existing distribution infrastructure (the facilities being considered in the CDM project) during the next 15 years is assumed to be 1,000 MW. On the basis of this assumption the average savings is 30 MW, i.e., 3% efficiency improvement.

Number of operating days = 365

Number of operating hours = 24

Power plant efficiency (average) = 35%

Heating value of Natural Gas = 35 MJ/m^3

CO_2 emission factor for natural gas = 56.1 tCO_2/TJ

Primary energy required for 1 MW of electricity =

$$1 \times 10^6 \times 3{,}600 \times 24 \times 365 / 0.35 = 90.1 \text{ TJ/yr}$$

Total CO_2 savings = $30 \times 90.1 \times 56.1$ = 151,710 tonnes/yr

Potential for Reduction

The CDM project considered here dealt with only the distribution network of the city of Dhaka. Such CDM projects can be designed for many other distribution networks because all suffer from high system losses. The potential is probably about 300,000 tonnes per year up to the year 2012.

4.3 Aeroderivative Turbines

National Sustainable Development Objectives

The total installed power generation capacity in Bangladesh is 3,478 MW (October, 2000), of which, 79 percent is natural gas based and 93 percent is thermal based. The dependable capacity is much lower than 3,478 MW and is unable to meet the peak demand. Load shedding of 100-250 MW is practiced depending upon the season.

The demand for electricity has been growing at 10% per year in the domestic and industrial sectors. These two sectors consume about 80 percent of the total electricity. There exist several projections of the power demand in Bangladesh. According to one such very optimistic projection, an additional 1,460 MW of power will be required by 2005; and 7,000 MW of power will be required by 2010. On the other hand, according to a realistic projection (Quader, 2000) based on past trend, Bangladesh's power sector is likely to have the following addition to its generation capacity by 2010:

Hydro:	100 MW
Coal (STG):	300 MW
Natural gas (STG/combined cycle):	1,460 MW
Natural gas (GT for peak demand):	> 500 MW

Natural gas is the predominant fuel for power generation. Approximately 45 percent of the total gas consumed goes for power generation. The plant factor of the power plants is currently about 45 percent on the basis of installed capacity. The baseload is met from the natural gas steam turbine generators (STG). The fuel efficiencies for the natural gas plants range from 18% to 40% depending on whether the plant is GT, STG, or combined cycle.

The priorities for the power sector are:

- Adequate, reliable and quality electricity to all (a constitutional obligation).
- Accelerated electrification of rural areas
- Efficient power generation
- Reduction of emissions including thermal pollution of river water

The scope for carbon dioxide emission reduction lies in these areas:

- Replacing existing gas turbines (GT) by more efficient ones and opting for advanced turbines in the future
- Converting to combined cycle the old steam thermal generators (STG) which are not likely to be scraped in the next 10 years
- Opting for IGCC instead of STG for the proposed coal power plant can serve as an ideal demonstration project for CDM and sustainable development.

These projects are in line with GOB's initiative to attract joint venture capital or foreign direct investment (FDI) in the power sector. As CDM projects these options will also meet the requirements of the donor agencies for privatization of the power sector.

Description of Baseline and Mitigation Technologies

The project baseline is a 100 MW natural gas conventional combustion turbine generator having a net thermal efficiency of 28%.

The mitigation technology being proposed is a 100 MW state-of-the-art natural gas aeroderivative turbine generator having a net thermal efficiency of 42%.

Description of the Project

The project will involve opting for an aeroderivative turbine instead of a conventional turbine in any one of the sites where the power company (Bangladesh Power Development Company (BPDB)) intends to set up new facilities. Since all auxiliary facilities in the mitigation project will be the same as in the baseline, the investor will only have to provide the incremental investment. The BPDB possesses all the capabilities to execute this kind of projects, and therefore, the investor will need to provide very little supervision and monitoring. The project will require 15-18 months for implementation after the scope of work is fully defined.

Measurable Reduction

The emission measurement will be based on the actual plant performance. However, CO_2 reduction can be calculated from the technical literature of supplier of the technology.

Financial Aspects of the Project

The cost of a 100 MW power plant with a conventional turbine would be US$ 30 million. The additional cost for an aeroderivative turbine would be US$ 15 million making the total investment US$ 45 million.

Benefits

The expected benefits from the proposed mitigation option are:

- Introduction of an advanced technology
- Conservation of natural gas resource

Barriers to Implementation

The main barrier of the project is dealing with a public sector organization.

Emission Additionality

Conventional turbine efficiency = 28%

Aeroderivative turbine efficiency = 42%

CO_2 emission factor for NG = 56.1 tCO_2/TJ

Operating hours per day = 5

Operating days per year = 330

1 MW power plant operating for 5 hours per day for 330 days in the year =

$$1 \times 10^6 \times 3{,}600 \times 5 \times 330 / 10^{12} = 5.94 \text{ TJ/yr}$$

CO_2 savings for 100 MW (Conventional – Aeroderivative) =

$$100 \times 5.94 \times 56.1 \times (1/.28 - 1/.42) = 39{,}671 \text{ tonnes/yr}$$

Potential for Reduction

In the power sector the prospective option for reducing CO_2 emission is the aeroderivative turbine. In Bangladesh gas turbines would be predominantly used as peak load generators. The peak load occurs between 5 p.m. and 11 p.m. depending on the season. Assuming an average of 5 hours of peak, a 100 MW turbine operating for 330 days a year will mitigate 40 thousand tonnes of CO_2 every year. The total CO_2 reduction potential for peak load of 900 MW (average over 10 years, from around 600 MW in 2002 to 1,200 MW in 2012) is 350,000 tonnes per year.

4.4 Hotel Cogeneration

National Sustainable Development Objectives

With the active promotion of tourism in the country, especially after the peace deal on the Chittagong Hill Tracts and the fast pace of institutionalizing democracy in the society, the demand for luxury hotels are growing. Surveys have shown that the number of foreign tourists in Bangladesh is growing at a rate of 5% per year.

The daily average temperatures in Bangladesh are between 25°C and 35°C from March to October. Space cooling is therefore essential for hotels, large shopping complexes, hospitals and office blocks. Space cooling is conveniently provided by using the cogeneration technology - electricity is generated on the premises using either gas engine or turbine generators and the waste heat is utilized to run vapor absorption refrigeration chillers. Large 3-Star to 5-Star rating luxury hotels are ideal for this scheme because the cooling load is high and continuous. At the present time these hotels use electricity from the national grid to run the chillers and small air conditioners. Hotels also require steam and hot water for which they employ small boilers. This demand is also conveniently met from the waste heat of the turbine generators. Even though the owners and operators of luxury hotels appreciate the potential benefits of cogeneration, the high initial investment requirement remains a barrier for such projects.

The reasons for using cogeneration in hotels in the context of Bangladesh are the following:

- Electricity from the grid is highly unreliable and this has a big impact on the delicate nature of the business
- Clean, inexpensive natural gas is readily available in the cities
- The T&D losses are greater than 30%

The government of Bangladesh is encouraging private entrepreneurs to build small power plants in the country to reduce the load on the public power plants by waiving tax and excise duties on the imported plant items. In addition, the government welcomes any venture that utilizes natural gas with a view to enhancing gas-based industries in the country. It is therefore expected that getting approval from the Government for cogeneration projects would not be a problem.

Description of Baseline and Mitigation Technologies

The following describes the baseline and mitigation technologies for a 300 room 5-Star hotel in Dhaka:

<u>Baseline Technology</u>

Electricity demand for non-chilling purposes: 1.0 MW with a peak of 1.3 MW. Air conditioning load: 600 tonnes of refrigeration (TOR). Steam requirement: 4 tonnes/hr at low pressure

- Two chillers - each of 300 TOR (vapor compression system); power consumed from the national grid for the chillers: 0.526 MW
- Total demand for electricity: 1.6 MW with a peak of 2 MW
- Fuel for boiler: Natural gas

<u>Mitigation Technology</u>

- 1 MW gas turbine generator using natural gas

- Waste heat utilized to run two 300 TOR chillers (vapor absorption system) and to raise low pressure steam in the boiler
- Power consumed from the national grid for non air-conditioning purposes: 0.2 MW during peak hours only
- Total demand for electricity: 1.0 MW with a peak of 1.3 MW

Description of the Project

The gas turbine generator and absorption refrigeration system will replace the present vapor compression system. Consultants and contractors are readily available to accomplish this task. The investor and developer will only need to supervise the work.

Measurable Reduction

The project would be easy to monitor because tamper-proof monitors and recorders can be installed to measure all variables needed to compute the CO_2 emission from the hotel. In general, luxury hotels are establishments that pay their energy bills regularly and properly.

Financial Aspects of the Project

(All $ are US$)

Investment requirement: $810,000

[Gas turbine unit - $500,000

Electrical equipment - $20,000

Vapor absorption chillers - $240,000*

Services and installation - $50,000]

Operation and maintenance cost - $40,000/yr

Other cost - $100,000 (participation plan)

Total electricity consumed in baseline = 14.02 GWh/yr (see Emission Additionality)

Total electricity consumed in mitigation = 9.42 GWh/yr (see Emission Additionality)

Total electricity generated in mitigation = 8.76 GWh/yr (see Emission Additionality)

Electricity purchased in mitigation = (9.42 – 8.76) GWh/yr = 0.66 GWh/yr

Natural gas consumption in mitigation = 3,231,114 m^3/yr (see Emission Additionality)

Cost of energy (electricity) in baseline = (14.02 GWh/yr)×(10^6 kWh/GWh)×($0.09/kWh)

= $1,261,440/yr

Cost of energy (natural gas) in mitigation = (3,231,114 m^3/yr)×($0.09/$m^3$) = $290,630/yr

Cost of energy (electricity) in mitigation = (0.66 GWh/yr)×(10^6 kW/GW)×($0.09/kWh)

= $59,300/yr

Total cost of energy in mitigation = $290,630/yr + $59,300/yr = $349,930/yr

Net saving in operational costs over baseline

= Cost of energy in baseline – Cost of energy in mitigation

= $911,510/yr

* The entire cost of replacing the existing vapor compression chillers with vapor absorption chillers may not be charged to the CDM project because current chillers are already 20 years old and would need replacement in any case.

Benefits

- Reliable power supply from own source
- Considerable saving in operation costs
- Reduction of load on the national grid by 1 MW

Barriers to Implementation

- People have very little understanding of a cogeneration project. It is perceived to be a complicated system
- Qualified personnel will be required to operate the system
- Increased air and thermal pollution in the cities
- Possible increase in noise pollution
- Increase in land requirement to locate the cogeneration unit

Emission Additionality

Grid power efficiency = 35%

Transmission and distribution loss = 15.2% (baseline)

Cogeneration power plant efficiency = 30%

Heating value of natural gas = 35 MJ/m^3

CO_2 emission factor for natural gas = 56.1 tCO_2/TJ

Power consumed in baseline = 1.6 MW (Peak 2 MW)

Power generated in mitigation = 1.0 MW

Power consumed in mitigation = 1.0 MW (+0.3 MW for 6 hours a day during peak)

Total electricity consumed in baseline = 1.6 MW×(0.001 GW/MW)×(24 hr/d)×(365 d/yr)

= 14.02 GWh/yr

Total electricity consumed in mitigation = [1.0 MW×24 hr/d + 0.3 MW×6 hr/d] ×

[(0.001 GW/MW)×365 d/yr] = 9.42 GWh/yr

Total electricity generated in mitigation = 1.0 MW×(0.001 GW/MW)×(24 hr/d)×(365 d/yr)

= 8.76 GWh/yr

Natural gas consumption in baseline = 1.6 MW×(1 J/s/W)×(3,600 s/hr)

×(24 hr/d)×(365 d/yr)÷(35 MJ/m^3)÷.35÷(1-.152)

= 4,857,297 m^3/yr

Natural gas consumption in mitigation = 1.0 MW×(1 J/s/W)×(3,600 s/hr)

+ 0.25×0.3×3,035,810 m^3/yr

×(24 hr/d)×(365 d/yr)÷(35 MJ/m^3) ÷ .3

= 3,231,114 m^3/yr

Primary energy consumed in baseline = (4,857,297 m^3/yr)×(35 MJ/m^3)×(10^{-6} TJ/MJ)

= 170.01 TJ/yr

Primary energy consumed in mitigation = (3,231,114 m^3/yr)×(35 MJ/m^3)×(10^{-6} TJ/MJ)

= 113.09 TJ/yr

CO_2 emission in baseline = (170.01 TJ/yr)×(56.1 tCO_2/TJ) = 9,520 tonnes/yr

CO_2 emission in mitigation = (113.09 TJ/yr)×(56.1 tCO_2/TJ) = 6,332 tonnes/yr

Saving in CO_2 emission = (9,520 – 6,332) tonnes/yr = 3,188 tonnes/yr

Potential for Reduction

The CO_2 reduction potential is approximately 3.2 thousand tonnes in one hotel. Such CDM projects can probably be implemented in 10 large hotels by the year 2010. The total CO_2 reduction potential by this CDM project is therefore around 30,000 tonnes.

4.5 Sugar Cogeneration

National Sustainable Development Objectives

Bangladesh is an agricultural country. Its vast population is dependent on many cash crops, of which, sugar cane is one. In recent years sugar produced locally is unable to compete with imported sugar. One reason for this is the poor performance of the sugar mills. If the profitability of sugar mills can be increased, then the price of locally produced sugar will come down. The government attaches high priority to these sugar mills to the extent that it forces farmers in the vicinity of the sugar mills to sell sugar cane to the mills at controlled prices, which are typically low. If the sugar mills can be made more profitable, then the livelihood of the farmers can be made more secure contributing to a more sustainable situation.

The cane sugar factory has unique characteristics for the application of cogeneration technology. The principal advantages lie in the good fuel characteristics of bagasse and in the high uses of low-pressure steam within the plant. In conventional power plants, most of the heat that is obtained by burning fuel is thrown away in the form of low-pressure steam as the steam condenses and heats cooling water. In the sugar factory, the heat in low-pressure steam is used to perform useful work as it condenses in the process of juice heating, evaporation and sugar boiling.

A well-known option for sugar mills to increase their profitability is bagasse cogeneration. At present, bagasse is burnt inefficiently in low-pressure boilers to raise steam. Cogeneration has long been a standard practice in the cane sugar industry. With the application of efficient processing and energy management systems, energy from the bagasse, well above the factory needs, is available and can be exported conveniently in the form of electric power. Application of sugar cogeneration will displace a part of fossil-based electricity generation leading to a more sustainable mix in power generation.

Description of Baseline and Mitigation Technologies

The baseline is the existing situation, i.e., bagasse burned in low-pressure boilers to raise steam used as process heat and power for prime movers.

The mitigation technology is steam thermal power cogeneration unit. Bagasse will be burned in a high-pressure boiler to raise power steam. The high-pressure steam will be used in backpressure type turbines to generate electricity and produce low-pressure steam. The major part of the generated electricity (i.e. 90%) will be exported outside the mill and the balance will be consumed within the mill. The low-pressure steam from the turbines will meet all the process steam requirements of the sugar mill. The CO_2 reduction comes about from the fact that the cogenerated electricity exported outside the mill will replace natural gas based grid electricity.

Description of the Project

The project is a small steam power plant to be set up at the mill premises. Since the existing boiler is a low pressure one, it cannot be utilized in the new cogeneration facilities. A high-pressure efficient boiler will need to be constructed to derive the full benefits of the potential large CO_2 reduction. The existing demand for steam in the mill will be met from the low-pressure steam extracted from the steam turbines.

The sugar mills possess the capability to execute the proposed mitigation scheme. Therefore all that would be required of the investor is to supply the investment funds.

Measurable Reduction

Sugar mills are government owned large entities. All data like bagasse production, electricity generation, steam generation and sugar production will be accurately maintained in these mills. Since the mills are public sector industries there will be no incentive for the employees to manipulate these data. Thus, the outputs will be reliably known.

Financial Aspects of the Project

Even though the cogeneration technology for sugar mills is well established, the sugar mills are unable to finance it because of their poor credit worthiness. Thus despite the fact that bagasse cogeneration in sugar mills is a negative cost option, there is no prospect of these projects materializing. Therefore, CDM projects can be formulated for one or more sugar mills.

US$ 10 million would be required to set up the cogeneration unit for a 1,500 tonnes/day of bagasse (120 days) producing plant. It is expected that the present operation and maintenance expenses of US$ 0.5 million will also be needed for the new cogeneration plant. Selling 10 MW power to the national grid is expected to generate an income of US$ 1.44 million.

Benefits

The following are the benefits of the project:

- Electricity generation using a renewable resource
- Will help sugar cane farmers maintain their livelihood
- Increase profitability of sugar mills thereby helping in sustaining a local industry
- Conservation of a non-renewable energy resource (natural gas at power plant)

Barriers to Implementation

- Most of the large mills are all in the public sector
- Government subsidy is required to sustain the sugar mills

Emission Additionality

Plant capacity = 1,500 tonnes/day bagasse

Grid power plant efficiency = 35%

Number of days of operation in a year = 120

CO_2 emission factor for Natural Gas = 56.1 tCO_2/TJ

Primary energy required for producing 10 MW of electricity using NG

$$= 10 \times 10^6 \times 3{,}600 \times 24 \times 120 / 0.35 = 296 \text{ TJ/yr}$$

CO_2 savings = 296×56.1 = 16,619 tonnes/yr

Potential for Reduction

Bangladesh has 15 sugar mills having a total crushing capacity of 21,000 tonnes of cane per day. In a typical year these fifteen mills crush about 2,500,000 tonnes of sugar cane and produce 200,000 tonnes of sugar. The crushing operation produces 875,000 tonnes of bagasse (containing 50% moisture), 95% of which is burned to raise steam for the mill's own use. If the bagasse (i.e. 95% of total) is used for cogeneration, then 150 MW of electricity can be generated, out of which 135 MW of electricity can be exported to the grid. The exported electricity will displace predominantly natural gas based electricity generation. For one average size sugar mill the annual CO2 emission reduction is therefore 15,000 tonnes. Thus the total potential (15 mills) is 225,000 tonnes of CO2 assuming 35% generation efficiency at the grid power plants.