Clean Development Mechanism Project Opportunities in Bangladesh

Chemical Engineering Department
Petroleum and Mineral Resources Engineering Department
Bangladesh University of Engineering and Technology
Dhaka, Bangladesh

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Contents

Figures and 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
DoE	Department of Environment
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
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
UNDP	United Nations Development Program
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 following case study was produced by the Chemical Engineering Department and Petroleum and Mineral Resources Engineering Department of the Bangladesh University of Engineering and Technology, Dhaka, Bangladesh. The views expressed in this report are entirely those of the authors.

1 Introduction

The Clean Development Mechanism (CDM) as an instrument for reducing global emissions of carbon dioxide, as enunciated in the Kyoto Protocol, is endorsed by the Bangladesh government subject to certain conditions discussed later. As a particularly vulnerable country, Bangladesh is keen to see progress in global efforts at reducing greenhouse gas emissions. From the activities of the Government in the last two years including their active participation in the COP (Conference of Parties) 6 and 7, it has become clear that Bangladesh would like to benefit from CDM. However, Bangladesh is lagging behind in terms of preparedness to participate in CDM projects.

Commercial energy consumption is extremely low in Bangladesh, and as a result the total ultimate CO_2 mitigation potential is low. However, since the CDM is a project-based instrument, there exists a fair bit of scope to construct emission reduction projects. The primary reason why the prospect of CDM projects exists is that large inefficiencies prevail across most energy-consuming sub-sectors. The prospect of the baseline improving in the next decade in most sub-sectors is extremely remote because policy planners in Bangladesh consider, probably rightly so, that it is more productive to expand the economic activity base with the meager resources at its disposal than to improve energy efficiency in existing economic activities. The various reasons why developing country entrepreneurs and governments do not invest in energy efficiency projects are well known and documented. In the present energy consumption scenario, one can pick almost any significant sub-sector/end-use and construct a mitigation project.

The objectives of the present work are to present the status of CDM related activities in Bangladesh and to make preliminary identification of potential CDM projects. To achieve the latter objective, an energy-demand projection has been performed and is presented in Section 3. The energy demand projection sets the stage for identifying the CDM projects by allowing significant emission sources to be identified. Of particular importance is how the emissions of a particular source grow in the next decade. In Section 4 the potential mitigation areas are discussed in broad terms. Also included in this section is the status of Joint Implementation (JI), Activity Implemented Jointly (AIJ) and other emission-reduction instruments. Section 5 presents the priority CDM projects. It begins by listing the criteria used to select options and goes on to present details on the CDM projects in the form of templates. The main focus of the study was the calculation of the emission reduction.

The information provided in this report on costs and benefits is the result of a very preliminary study and errors as high as ±100% can exist in some cases. A considerable amount of difficulty was encountered in the estimation of the initial investment cost of the mitigation technology. In almost all cases it has been found that costs applicable to developed countries do not apply to Bangladesh because of high transfer costs. More detailed information will be collected for some projects and presented in Phase II of this study.

This report has deliberately avoided presenting the cost effectiveness of a project in terms of \$/tonne of CO_2 abated but all data used to compute it have been presented. The principal reason for doing so is that in a CDM project the incremental investment will be negotiated between the investor and the developer. In many cases, the developer may be willing to provide a portion of the incremental investment, especially if the fuel savings are substantial. In others, however, the developer may not be attracted to pursue the project unless the full incremental cost is provided. Thus, depending upon how a CDM project is structured, the cost effectiveness (\$/tonne of CO_2) will vary. In some instances removing a small barrier, achieved inexpensively, can cause an otherwise inactive and costly project to proceed. In general, it may be stated that unless the developers are assured of significant financial benefits and/or substantial improvement in their competitiveness due to an improvement in their outputs, they will be reluctant to participate in a CDM project.

2 Climate Change Policy and Government Stand on CDM

2.1 Climate Change Policy

Bangladesh is signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. It ratified the UNFCCC in February 1994 and ratified the Kyoto Protocol in 22/10/2001. National Environment Policy and National Energy Policy both promote energy efficiency, cleaner production, renewable energies for greenhouse gas reduction and massive afforestation for enhancement of sink. The Ministry of Environment and Forest (MOEF), which is the nodal ministry for all environment-related activities in the country, is responsible for coordinating the activities under the UNFCCC and the Kyoto Protocol. There exists a National Climate Committee, which was constituted in 1994 for policy guidance and to oversee the implementation of obligations under the UNFCCC process. The committee is headed by the Secretary, MOEF and is comprised of members from all relevant government and non-government organizations, including educational institutions, journalists' forums and chambers of trade and commerce.

The Government policy on Climate Change is based on the following broad principles:

- Common but differentiated responsibilities. Primary responsibility of reducing emissions is of the developed countries.
- The development needs of the developing countries and the needs for adaptation to the adverse effects of Climate Change, especially of vulnerable countries, are of prime importance.
- The developed world must show demonstrable progress in initiating actions toward emission reduction, technology transfer and providing new and additional funds to encourage and facilitate actions by the developing countries.

To fulfill its obligations under the convention and also to enhance information on the various aspects of Climate Change, some studies have been conducted. These include:

- Country Study on Climate Change – conducted during 1994 to 1996 with US assistance and included emission inventory, vulnerability and adaptation assessment and mitigation strategy analysis.
- Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS) – this was a much more detailed and comprehensive study in which the emissions inventory was disaggregated to the sub-sector level and a least-cost mitigation strategy that was used for the identification of suitable projects to mitigate greenhouse gas emissions was developed.

The Government is in the process of finalising its First National Communication through a Global Environment Facility (GEF) funded project. The First National Communication may be submitted during COP-8 in New Delhi. Recently Bangladesh hosted a LDC workshop on capacity building for preparation of National Adaptation Programmes of Action (NAPA) organized by LDC expert group under UNFCCC in association with CIDA, UNDP, DFID and other donor agencies. The Hon'ble Prime Minister, Begum Khaleda Zia, inaugurated the workshop. This reflects Government's political commitment on Climate Change issues at the highest level. All Climate Change-related studies in Bangladesh have been collaborative efforts between the Government and relevant NGOs, including universities and research institutes. The findings of the studies were disseminated through workshops, seminars and booklets.

2.2 Government View on CDM

There exists no written document reflecting the views of the Bangladesh government on CDM. Following are the views of the Bangladesh government on CDM as gathered from the Climate Change focal point at the Department of Environment, Government of Bangladesh:

- The Government of Bangladesh supports the CDM because it is targeted to meet the objective of the convention for sustainable development in the developing countries.
- To ensure a fair and just system, Bangladesh's position is that CDM projects be distributed regionally and sub-regionally, based on equity through a CDM equitable-distribution fund to ensure that CDM investments take place in parties that are often marginalized by purely market-based investments.
- A share of the proceeds from certified project activities under the CDM should be used to assist developing country parties that are particularly vulnerable, to cope with the adverse affects of Climate Change.
- CDM should be oriented towards improving the quality of life of the very poor from the environmental standpoint and funding for CDM project activities shall be additional to official development assistance (ODA).
- Activities under the CDM should give full consideration to the special needs of the least developed countries, in particular to the identification of their special technology needs and to capacity building.
- Technology transfer in CDM project activities shall be additional to the commitment of parties included in Annex I on technology transfer to developing country parties under the convention.
- CDM should give priority to renewable energy and energy-efficient technologies.
- CDM should give consideration to carbon sequestration for combating of desertification.
- For least developed countries, the least cost option may be considered as the baseline.
- Apart from having global benefits, CDM projects should also promote sustainable development in non-Annex I countries like Bangladesh. Bangladesh therefore views CDM as an opportunity in developing and achieving sustainable development.

2.3 Recent Initiatives on CDM

Even though the Department of Environment (DoE), under the ministry responsible for Climate Change related activities is fully aware of the CDM, not much in way of preparation for developing and executing a CDM project has been achieved. Awareness of the concept and scope of the CDM amongst the policy makers and the business community is still at a low level. A workshop on Bangladesh's perspective on the CDM was held in late 2000 to debate the contentious issues. In May 2002 as a part of this project a CDM workshop was held which focused both on capacity building and dissemination of the results of this study. It was attended by many stakeholders including the government department responsible for Climate Change activities in Bangladesh. This workshop may be considered to the first to directly address CDM issues and opportunities in Bangladesh including Government preparedness in this matter.

The government is currently undertaking a project titled "Capacity Development for Clean Development Mechanism (CDM) in Bangladesh" with support from UNDP, Dhaka. This project aims to assist relevant agencies in the country in developing capacity for hosting Clean Development Mechanism projects in Bangladesh. In particular, the project is expected to:

- Create a CDM cell involving the relevant Ministries (Environment and Forest, Trades, Commerce and Industry), the Investment Board, representatives from academia and the Chambers of Commerce and Industries.
- Develop sustainable development criteria for the country that may be applied to CDM projects.
- Promote awareness of Climate Change issues, particularly the CDM, through seminars and workshops.

- Build capacity to develop Climate Change mitigation projects.
- Develop suitable CDM projects based on the ALGAS and TERI-Canada Energy Efficiency Project (this study) studies and facilitate dialogue between Bangladesh and Annex-1 countries' business communities for collaboration on Clean Development Projects.
- Develop and implement pilot CDM projects for demonstration purpose. In one such effort by the UNDP a landfill project is being developed as a demonstration pilot. The project also intends to help DoE set up a CDM cell at the Climate Change Focal Point.

3 Emission Inventories and Projections

3.1 Current Emissions

3.1.1 Summary of Emissions Sources in Each Sector

The emissions of CO_2 from different sectors for the year 1999-2000 are presented in Table 3.1. As may be expected, the electricity generation sector is the largest emitting source. Emissions from this sector are mainly due to natural gas-based generating plants. Less than 10% of the emission comes from oil-based generation. The second and third largest emission sources are oil consumption in transport and natural gas consumption in urea fertilizer industry.

Emissions from the transport sector are mainly due to vehicles but the contribution of water transport is significant. Diesel is the main liquid fuel and is used by buses, trucks, microbuses/jeeps, locomotives and launches. Gasoline consumption at present is modest but its use has one of the largest potentials for growth.

Emissions from the residential sector are from two sources – natural gas used in urban centers for cooking and kerosene used in the rural areas for lighting and cooking. It is worth pointing out that over 80% of rural people cook with biomass which does not contribute to CO_2 emissions.

The sources of emissions in the industrial sector are as follows – coal used in brick kilns, oil used in standby/captive generators and natural gas used in furnaces and boilers in most mills and factories. The agriculture sector's main emissions category is diesel pumps used for irrigation.

The six largest categories having emissions above one megatonne are urea fertilizer plants, natural gas-based steam thermal electricity generation plants, transmission and distribution losses of electricity, vehicles, agricultural diesel pumps, and, natural gas-based combustion turbine electricity generation plants. It is clear that when a priority list of mitigation projects is being prepared, these emission sources must be considered first. In a later section the emissions from these important categories for the base year and terminal year for modeling (1995 and 2012) are presented and discussed.

3.1.2 Description of Primary Energy Sources

In the year 2000, Bangladesh's per capita commercial energy consumption was 87 kgoe, which is one of the lowest in the world. Table 3.2 shows the primary energy sources for the year 1999-2000. There is a heavy reliance upon traditional biomass fuels but the proportion of commercial fuels is gradually increasing, mainly due to the increased use of natural gas. Commercial energy accounts for only 46% of the total energy consumed in the year 1999-2000.

Traditional fuels consisting of crop waste, firewood and animal waste are the predominant fuels for rural cooking. Rural industries also consume a large amount of biomass. A rural activity that consumes a significant amount of biomass is paddy parboiling. Brick manufacturing also consumes a large amount of biomass fuels.

At present the only domestic energy resource of the country is natural gas. It is therefore not surprising that 68% of the commercial energy requirement is met by natural gas. The government has an active policy of substitution of oil and coal by natural gas. In fact, oil and coal are used only in activities where it is not convenient to use natural gas, such as the transport and agriculture sectors. As can be seen more than 40% of oil is consumed in the transport sector. The small amount of oil used in the power sector is due to the fact that the western part of the country has no gas. Since last year, gas through pipeline is available in the western zone of the country and it is expected that oil-based power generation will cease. The highly unreliable power supply forces many industrial units to generate their own electricity during outage. In areas not served by gas pipelines, oil is used for this purpose. A large amount of oil is used for running irrigation pumps. The high consumption of oil in the residential sector is kerosene used for lighting. This highlights the fact that a large portion of Bangladesh is not electrified.

The main use of coal is in the brick manufacturing industry. At present, all coal is imported but in a few years' time, coal will be supplied from a mine currently being developed. A small amount of coal is used in rural and semi-rural cooking and industries.

The only other energy source is hydro electricity. As can be seen from the footnote of Table 3.2, 1027 GWh, which is approximately 6% of the total generation for the year 1999-2000, was supplied from the 210 MW hydroelectric plant.

Table 3.1 CO_2 Emissions in the Year 1999-2000
(Magatonnes)

SECTOR	COAL	OIL	NATURAL GAS	TOTAL COMMERCIAL
Power Generation		0.90	7.94	8.84
Residential		1.76	1.67	3.43
Commercial	0.10	0.09	0.21	0.40
Industrial	0.89	0.52	2.20	3.61
Transport		3.83		3.83
Agriculture/Others		1.72		1.72
Emission from Urea Production Plants			3.22	3.22
Losses and Own Use		0.14	1.32	1.46
Total	0.99	8.96	16.56	26.51

Table 3.2 Energy Consumption in the year 1999-2000
(million GJ)

SECTOR	COAL	OIL	NATURAL GAS	TOTAL COMMERCIA	BIOMAS S
Power Generation		11.90	147.31	159.21	
Residential		26.02	29.36	55.38	440
Commercial	1.35	1.27	3.81	6.43	2
Industrial	12.15	11.43	40.62	64.20	118
Transport		62.35		62.35	
Agriculture/Others		24.57		24.57	

Non-energy Use (Urea Fertilizer			84.00	84.00	
Losses and Own Use		1.86	23.91	25.77	
Total	13.50	139.40	329.01	481.91	560

Note: In addition, 1027 GWh of hydro electricity was generated
Source: BBS, 2002. Statistical Pocketbook of Bangladesh 2000

3.2 Business-as-usual Projections

3.2.1 Introduction

The key elements of a good energy and emission projection are accurate and up-to-date disaggregated energy data and the use of an integrated approach. In Bangladesh, energy projections for the different sectors are usually performed fuel-wise by utilities from their own restricted perspectives. An integrated approach, as has been adopted in this study, is essential to avoid erroneous projections and misleading conclusions.

The software used in this study, called LEAP (Long-range Energy Alternative Planning system), is an accounting- and simulation-type model. This software uses three main modules to project energy requirements and emissions. The Demand Module projects the energy requirements of all demand sectors. The Transformation Module computes the energy requirements of the Demand Module to give the total energy demand in the form of an energy balance. The Environment Module uses the type and quantity of fuels from the Demand and Transformation modules to compute emissions.

As mentioned earlier, LEAP is an accounting-type model in which energy consumption data are entered sector-wise in disaggregated form for a particular year (base year). Energy demands are calculated by multiplying the activity (load) by the energy intensity for all end-uses. Future energy demand of an end-use is projected from the base-year data by using a driver or an anticipated growth rate. For the business-as-usual case, these drivers or growth rates are usually based on the previous performances of the end-uses, sub-sectors or sectors. The Transformation module calculates the primary energy required to satisfy the Demand module by considering electricity generation, oil and gas production, oil refining, other energy conversion processes and the transmission and distribution losses of all energy transformation processes. The Environment module is driven by the Demand and Transformation modules. LEAP provides a large database of emission coefficients for different processes including those of the Intergovernmental Panel on Climate Change (IPCC).

The energy and emission projection performed in this study is for the business-as-usual scenario, i.e., the future is a reflection of the past. Only those policy changes and efficiency improvements, which are known with certainty, have been considered in this exercise. The base year for this projection is 1995 and the terminal year is 2012. The energy data for the year 1995 have been taken from the Statistical Yearbook of Bangladesh (1998), Annual Report of Bangladesh Power Development Board (1996-97), Annual Report of Bangladesh Petroleum Corporation (1998) and from the relevant industries.

3.2.2 Underlying Assumptions for Demand Projections

The growth rates of population, households and GDP are given in Tables 3.3 and 3.4 while Table 3.5 presents the sectoral breakdown of GDP for different years. A 5.5% GDP growth rate, which increases to 6.0% in the year 2005, can be considered to be consistent with the business-as-usual scenario. The population growth rate has been taken from the National Energy Policy (1996). The sectoral GDP proportions have been estimated by expert judgement from the Perspective Plan (1995) and have been used to construct the drivers for the different sectors. For example, the industry GDP growth rate has been used to create the driver called “Industry GDP”.

This modeling work did not consider any elasticity, i.e., it was assumed to be 1 because reliable estimates of elasticities for different end-uses were not available. This may be an unacceptable assumption in many cases, especially for a growing economy where energy intensity is bound to change with time.

Table 3.3 Population and Household Growth Rates

	1995		2012
Population	121 million	Growth Rate = 1.7%	161 million
Households			
Rural	16.4 million	Growth Rate = 0.4%	17.0 million
Urban	4.4 million	Growth Rate = 6.8%	13.5 million

Source: *National Energy Policy*, 1996 for population. Households figures are estimates

Table 3.4 GDP Growth Rates

1995-2000	2000-05	2005-10
5.5%	5.5%	6.0%

Estimates based on present trend.

Table 3.5 Proportion of Different Sectors in GDP

(% of total GDP)

	1995	2000	2005	2012
Agriculture	34	30	26	21
Industry	11	12	13	16
Services	35	38	41	43
Others	20	20	20	20

Source: Adapted for ALGAS (1999) from the *Perspective Plan*, Planning Commission, Government of Bangladesh (1995)

The most important industrial activity in the country is urea fertilizer production. The demand for fertilizer is considered to be saturated at the present time. Only two fertilizer plants, having an estimated capacity of 500,000 tonnes per year each, are expected to be set up by 2010, while one of the older fertilizer plants, having a capacity of about 100,000 tonnes per year, is expected to be retired. The proposed two di-ammonium phosphate (DAP) plants of 800 tonnes/day to be completed by 2005 have been included in the plan. Energy intensive industries like cement factories, cold storage and steel re-rolling mills with their respective projected growth have been considered. Other industries are expected to follow the business-as-usual growth rate as no dramatic change in the trend for any particular industry is envisaged.

For the transport sector several different drivers, including income per capita, have been used. A driver, which combines both the agriculture and industry GDP, has been used for road freight. The growth rate of residential electricity connections has been estimated using expert judgement. The main consideration has been the capacity of the power companies (PDB – for urban and REB – for rural) to make new connections. The growth rate of residential natural gas connections has also been calculated on the basis of the maximum number of connections that the distribution companies can provide per year (which was found to be approximately 50,000). The demand for kerosene used for lighting can be calculated from the difference between the total number of households and the number of electrified households. The growth rate for kerosene used for cooking was estimated on the basis of expert judgement.

The commercial sector could not be satisfactorily disaggregated. The electricity demand was however disaggregated using expert judgement and the “Commercial GDP” driver was used for projection. The Others sector, which was not disaggregated, was projected using the driver called “Others GDP”.

3.2.3 Energy Balance

The electricity generation efficiency and transmission and distribution losses during the plan period are shown in Table 3.6. As can be seen from Table 3.6, the electricity generation efficiency has been assumed to increase from 29% to 35%. The predominant reason for this is the involvement of the IPPs (Independent Power Producers) in Bangladesh. The transmission and distribution losses have been assumed to improve over time and come down to 27.5% in 2012. There are two reasons behind this assumption. First, the government has become concerned about the issue and has instituted several measures to tackle the problem. Second, there exists the possibility that large portions of the transmission and distribution network may be privatized.

Table 3.6 Electricity Generation Efficiency and Transmission and Distribution Losses

	1995	2000	2012
Electricity Generation Efficiency	29%	30%	35%
Transmission and Distribution Losses (T & D)	35%	35%	27.5%

Energy resources information is critical in determining the fuel mix of the future. Table 3.7 shows resource information for Bangladesh. As can be seen, Bangladesh is not very well endowed with energy resources. Natural gas reserves are only 16 Tcf, but there does exist a resource potential of 32-42 Tcf. The country's coal resources are under development and by 2005 will supply coal for a 300 MW power plant. By 2010, annual production is projected to increase to be able to supply coal for 600 MW of power.

Table 3.7 Significant Energy Resources of Bangladesh

Natural Gas[1]	16 Tcf – Reserves 32-42 Tcf Resources (mean)
Coal[2]	300 Mt

1. Source - Hydrocarbon Unit, GOB
2. Source - NEP, 1996, GOB

3.2.4 Factors Affecting Projections

The factors which significantly affect the energy projection and consequently the emissions projection are: (i) GDP growth rate; (ii) Population growth rate; (iii) Availability of resources, especially natural gas; (iv) Growth rate of industry; and (v) Power generation efficiency and transmission and distribution losses.

According to published figures (BBS, 1998) Bangladesh has experienced a 4-5% growth in the last decade. Since 1990, Bangladesh has been following more open-door policies and is encouraging industrialization through foreign direct investment. It is therefore expected that the GDP growth rate in the next decades will be over 5%.

Natural gas reserves will significantly affect energy projection. In 1995, reserves were 10.44 TCF, which with increasing demand are projected to be exhausted by 2015. This will lead to the increased use of coal and/or oil, resulting in the need to import larger quantities of these fuels. The scenario is however unlikely because substantial areas of Bangladesh are still unexplored. Moreover, an increased number of foreign companies are showing keen interest in exploration as a result of open-door policies of the government. Already there has been a major discovery by one of the IOCs (International Oil Companies) operating in the country under a production-sharing contract. In this study, as can be seen in Table 3.7, reserves have been taken as 16 Tcf with additional potential of 32-42 Tcf (Monte Carlo simulation mean). These values are considered by many experts to be reasonable estimates. Another energy resource, though not as large as natural gas, is coal. High-quality coal has been discovered in two regions of Bangladesh (Boropukuria and Jamalgonj). The Boropukuria Coal Mine, which has an estimated reserve of 300 Mt, is under development and is expected to go into production in 2003-04.

The industrial sector is the largest user of commercial energy. The government is emphasizing rapid industrialization and pursuing investment-friendly policies. With the growth of the industrial and commercial sectors, energy requirements will increase. However, if we analyze the business-as-usual scenario presented by Quader (2000), it becomes evident that the increase in energy requirements for the industry sector will not be as large as predicted by some of the earlier projections (Quader, 2000).

Power generation efficiency and transmission and distribution losses will also significantly affect energy requirements. Table 3.6 shows the overall electricity generation efficiency and T&D losses assumed for the energy projection. As may be appreciated, these may or may not follow the expected trend. For example, the IPP participation may hit a snag, causing efficiencies to remain at the present level. On the other hand, the T & D losses may dramatically improve, causing lowering of energy requirements at power plants.

3.2.5 Emission Projections

Figure 2 presents the projection of primary commercial energy demand by fuel type for the business-as-usual scenario. The projection has been performed up to the year 2012, starting from the year 1995. During the projection period, primary commercial energy demand increases by 2.24 times. Compared to demand in 1995, demand for natural gas, petroleum products, and coal are expected to increase by 2.1, 2.1 and 7.4 times, respectively. The unusually large increase in demand for coal is due to the development of the Boropukuria Coal Mine, which is expected to commence production by 2003-04.

Figures 3 and 4 present CO_2 emissions from primary energy sources in the years 1995 and 2012, respectively. By 2012, total CO_2 emissions from primary energy sources are projected to increase from the 1995 level of 15.9 Mt to 41.4 Mt, which is a 2.6 times increase.

Figures 5 and 6 present CO_2 emissions from different sectors in the years 1995 and 2012, respectively. As expected, the largest CO_2 emitting source in the year 2012 remains the electricity generation sector. It is worth mentioning that whereas the total CO_2 emission increases by 2.6 times between the years 1995 and 2012, the emission from electricity generation increases by 3.6 times.

Figures 7 and 8 present CO_2 emissions from some key categories in the years 1995 and 2012, respectively. The total emission from these categories is expected to increase from 7.3 million tonnes in 1995 to 12.6 million tonnes in 2012, which is a 1.73 times increase. Among the categories shown, emission from automobile displays the highest growth and increases from 1.43 million tonnes in 1995 to 3.82 million tonnes in 2012. This increase is due not only to the expected increase in the number of vehicles, but also to the poor roadworthiness of vehicles.

Figures 9 and 10 present CO_2 emissions from different types of electricity generation plants in the years 1995 and 2012, respectively. Emissions due to transmission and distribution (T & D) losses are also shown in these figures. Total emissions from these power plants, including the transmission and distribution losses, is expected to increase from 7.09 million tonnes to 25.7 million tonnes, which is a 3.6 times increase. Presently there is no coal-based power plant in the country but a 300 MW coal power plant is expected to be set up by the year 2005. Because of the availability of natural gas, future baseload power plants are expected to be predominantly combined cycle. The large increase in emissions from gas turbines arises from the fact that the peak in the daily power load curve is 33% above the average load and 50% above the minimum load.

Figure 1 Historical Consumption of Different Fuels

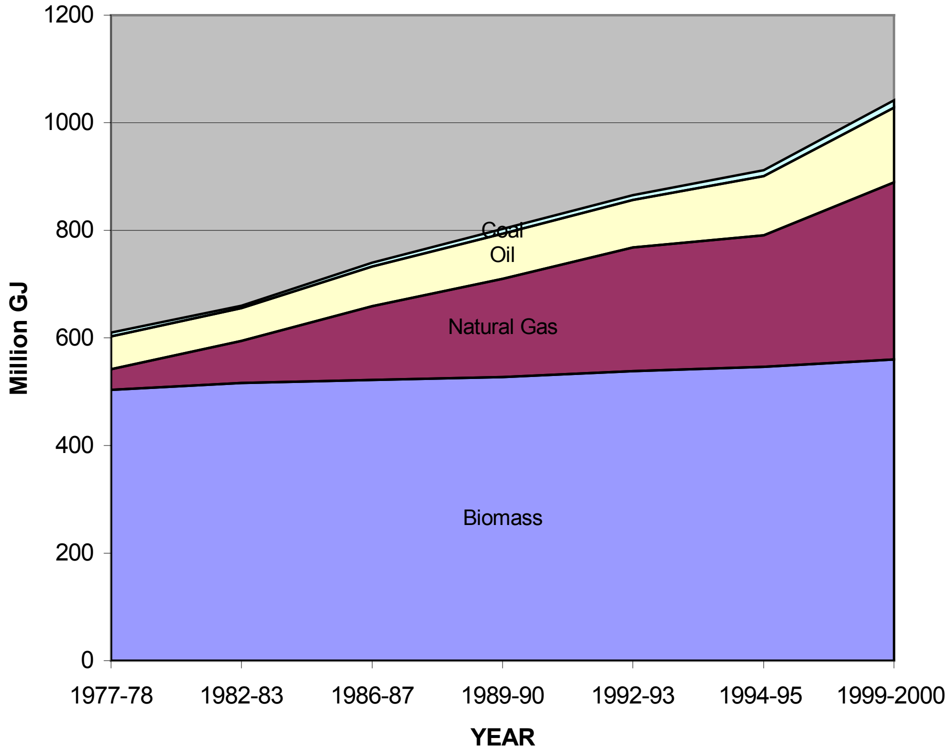


Figure 2 Primary commercial energy requirements

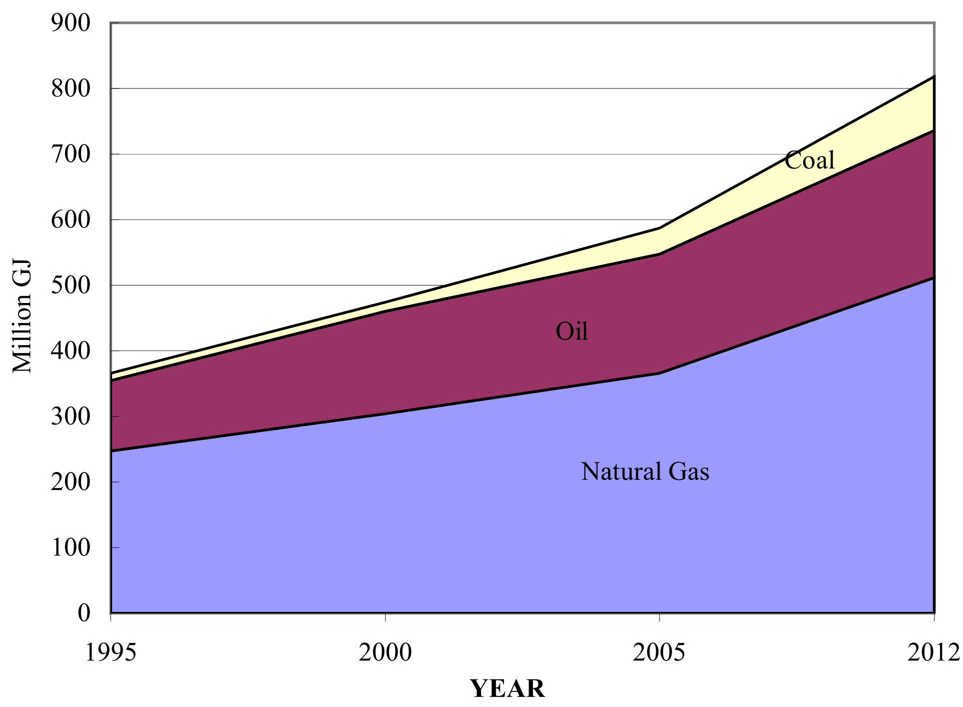


Figure 3 Emissions from commercial fuels in 1995 ($19.3x10^6$ tons)

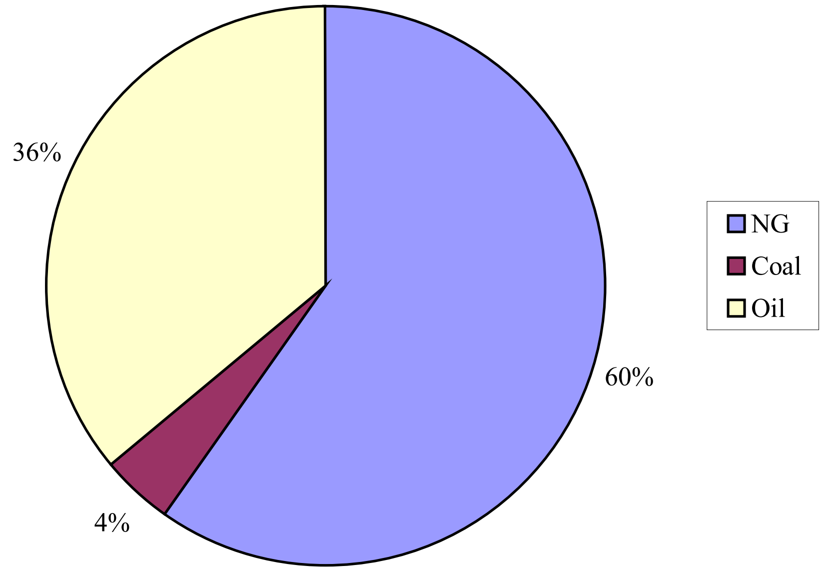


Figure 4 Emissions from commercial fuels in 2012 ($45.7x10^6$ tons)

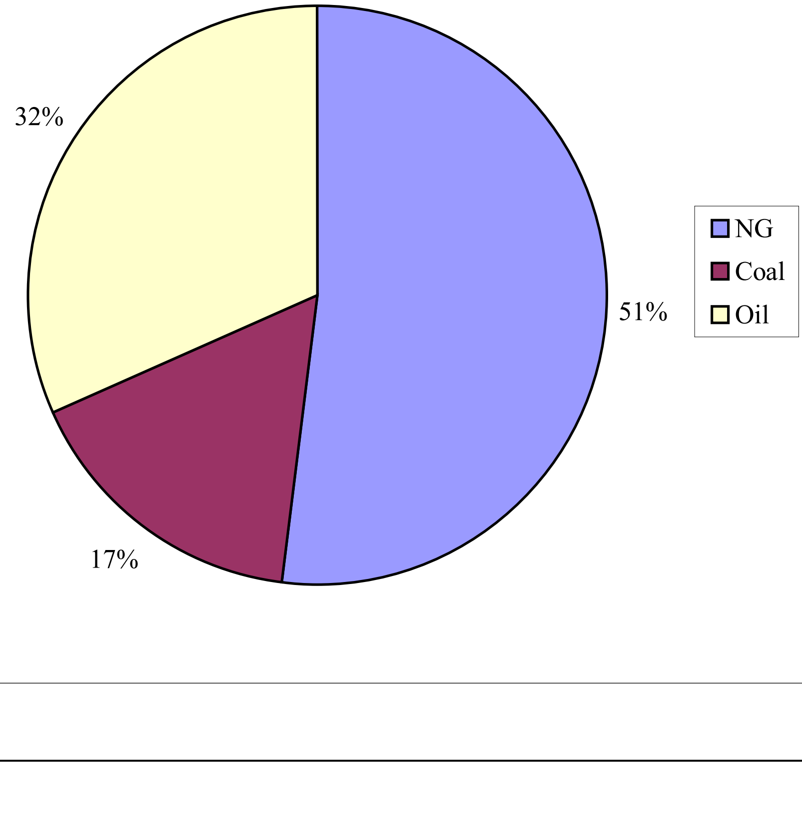


Figure 5 Sectoral CO_2 emissions for 1995 (18.95 x10^6 tons)

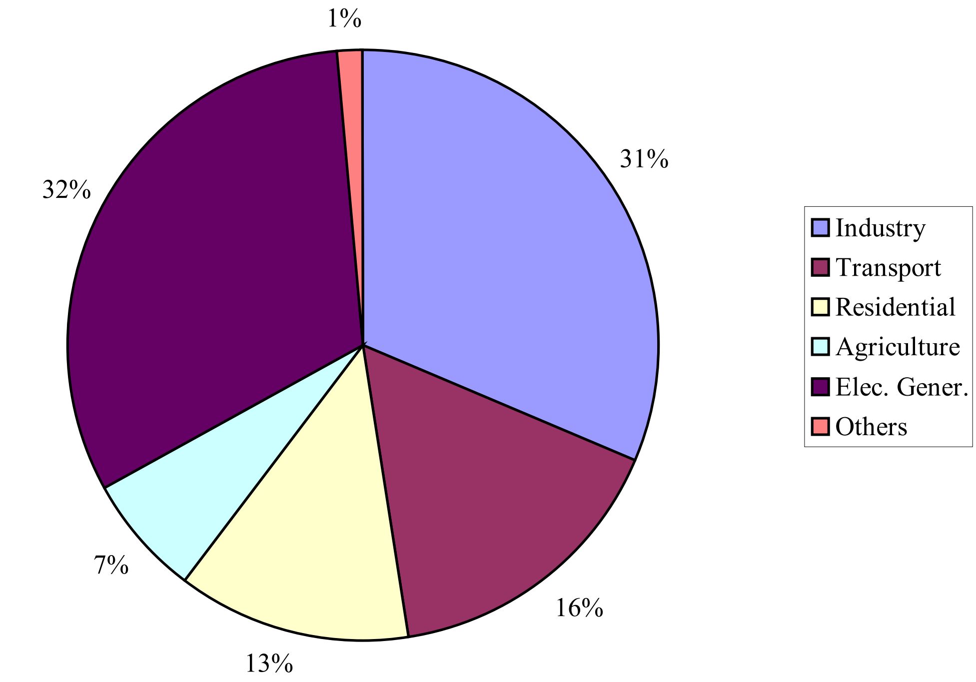


Figure 6 Sectoral CO_2 emissions for 2012 (44.98 x10^6 tons)

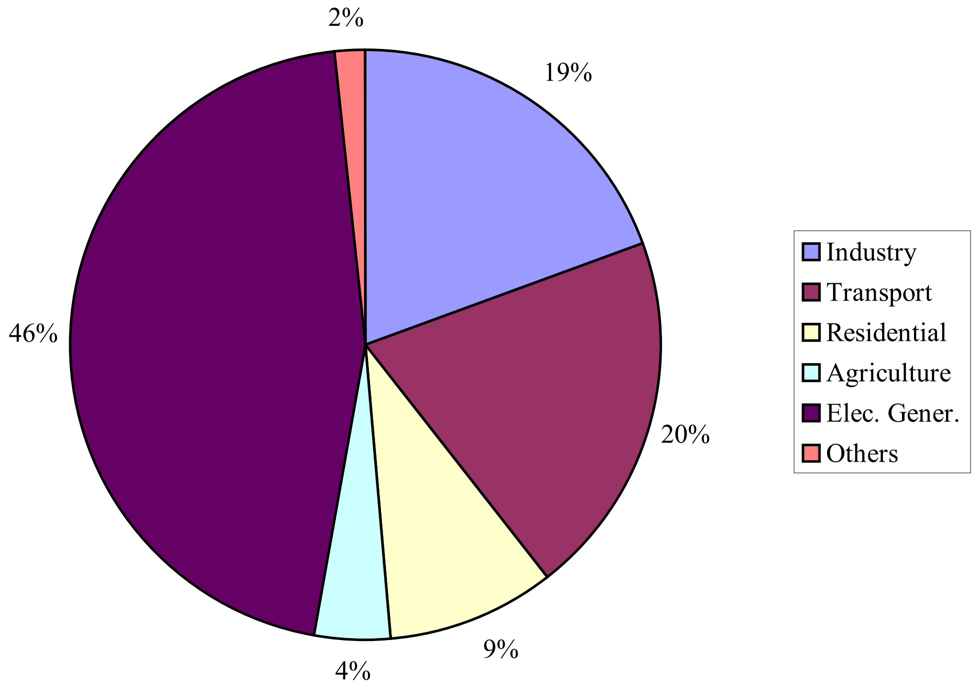


Figure 7 Emissions of some key categories in 1995

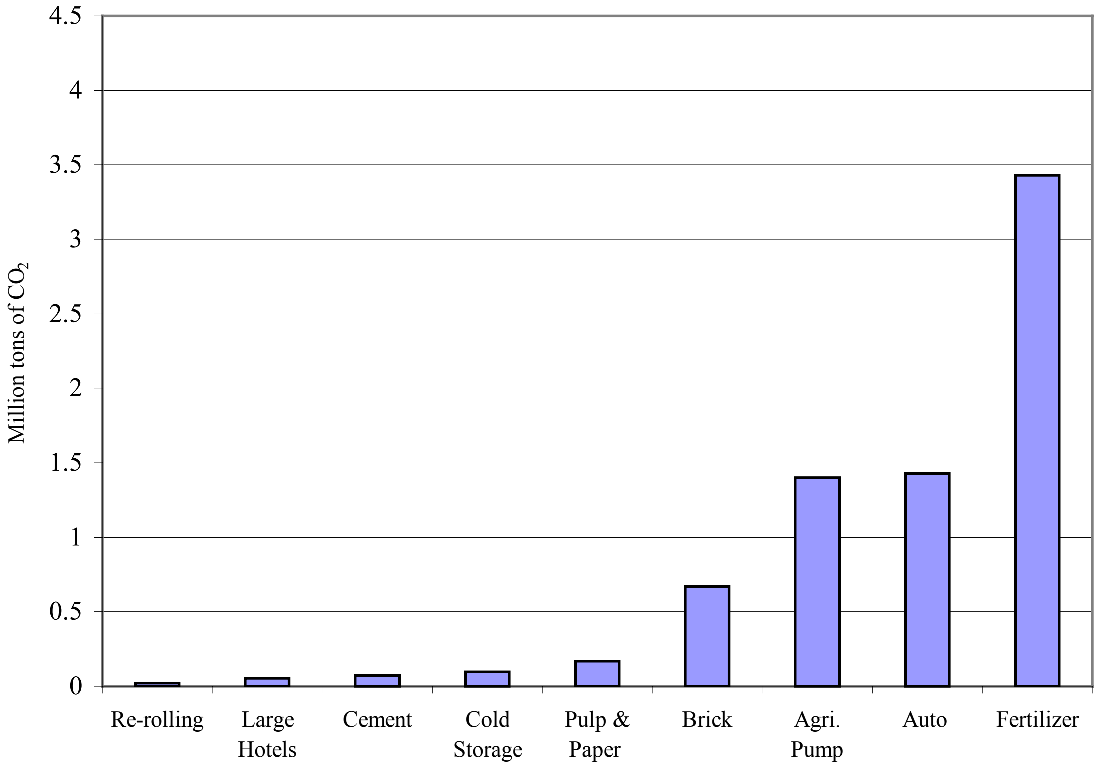


Figure 8 Emissions of some key categories in 2012

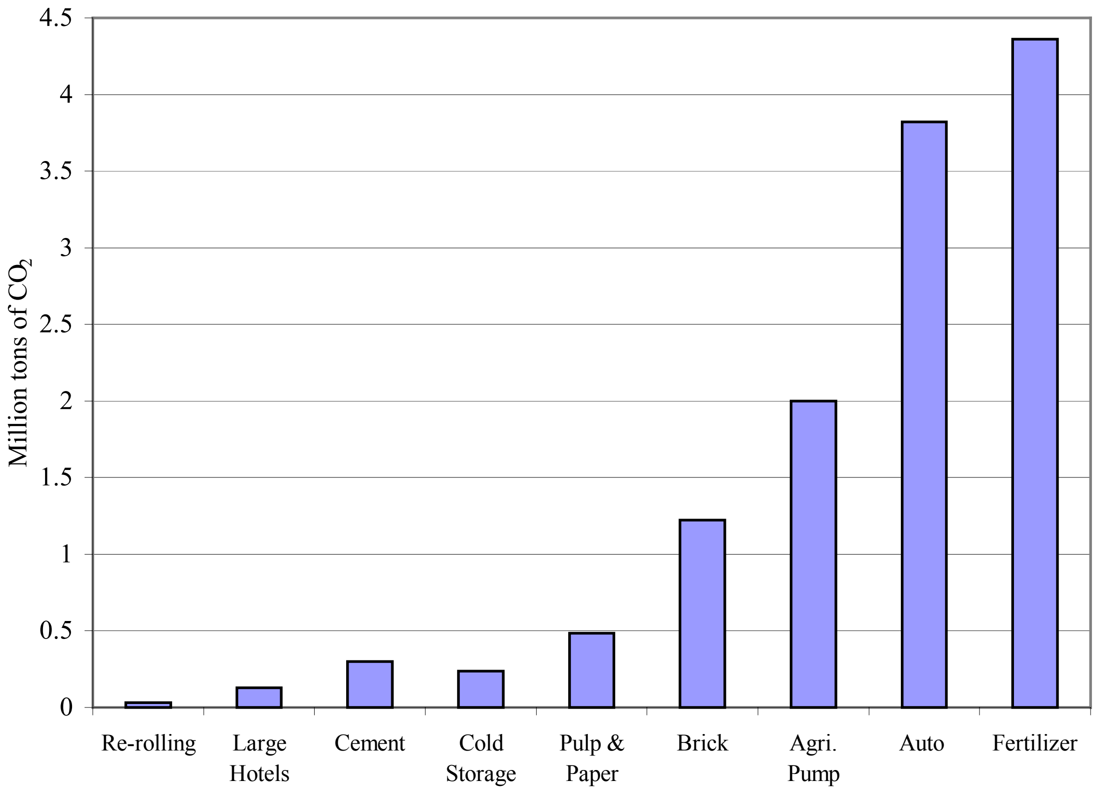


Figure 9 Emissions from different categories in the power sector in 1995

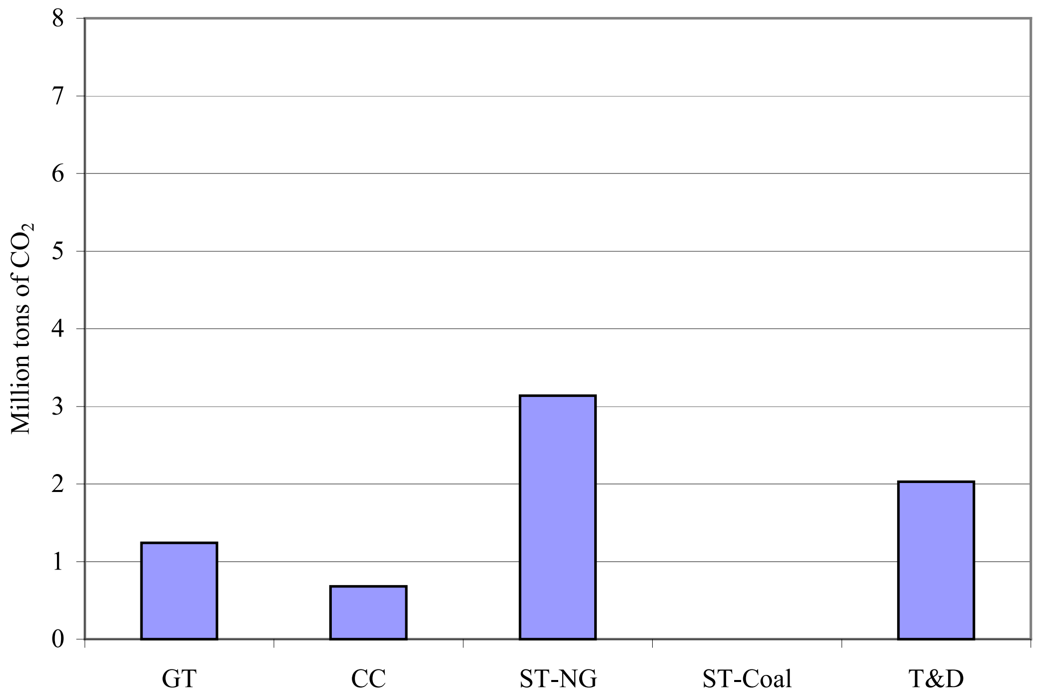
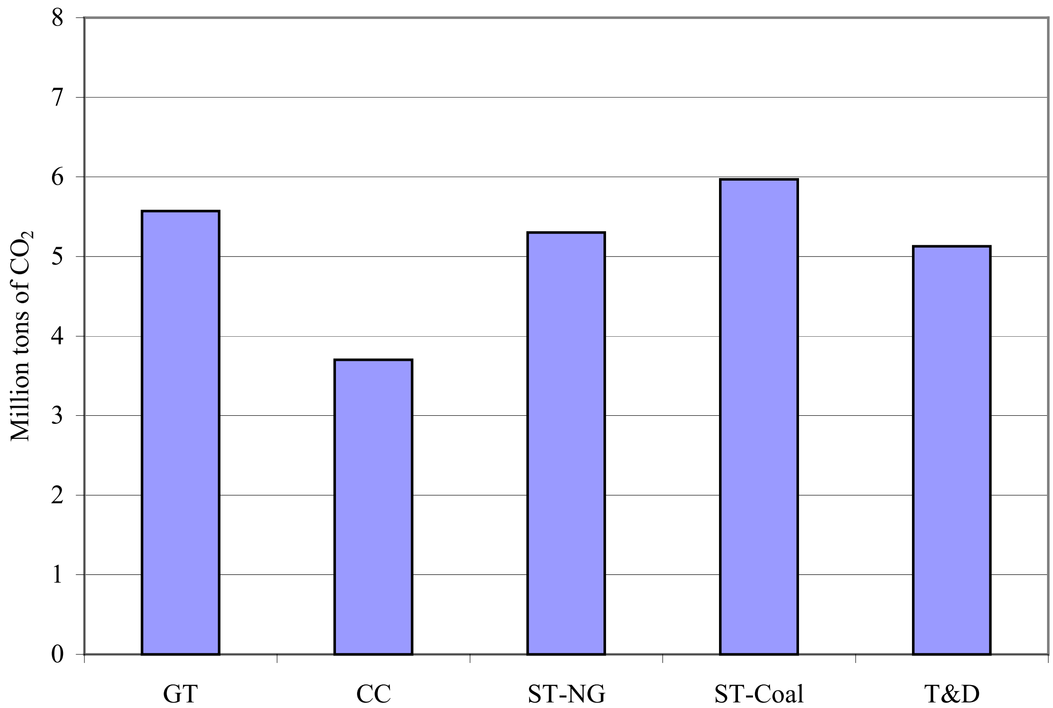


Figure 10 Emissions from different categories in the power sector in 2012



4 Potential Mitigation Options

Table 3.2 shows a snapshot view of the energy consumption in the country for the year 1999-2000. The three largest uses of primary energy are natural gas for electricity generation, natural gas for urea fertilizer production and oil for transport. The other significant energy uses are natural gas for industry, natural gas for residential purposes, oil for residential purposes and oil for agriculture/others purposes.

The most noteworthy feature in Table 3.2 is the large, so-called, "Non-Energy" use. This item represents the energy consumption of the seven ammonia-urea fertilizer complexes. It is instructive to compare the energy use of this sector (which is really a sub-sector of the Industry sector) to that of the total Industry sector. The disproportionately large energy use of these seven industries compared to the total combined energy use of all other industrial activities is obvious. In fact, other than these seven large industrial units, there are only a handful of other large industries. The power sector is plagued by various problems, and at present, there is no reserve margin and the generation capability is about 5% below the peak. The prevailing technical and non-technical system loss is over 35%. The government has taken steps to unbundle the generation, transmission and distribution of electricity. To that effect it has allowed Independent Power Producers' (IPP) participation in generation, created a separate company to transmit electricity, and some distribution networks have been privatized on an experimental basis. The potential mitigation options in each sector are discussed below in broad terms.

4.1 Sector Options

Power

The electricity generation sub-sector is undergoing many changes with the advent of the Independent Power Producers (IPP). Electricity generation efficiency has been typically low. In the year 1999-2000 the average efficiency was 27.7% despite the fact that the predominant fuel is natural gas. The combined-cycle technology has been practically non-existent in Bangladesh until 2002. This scenario is changing fast because the IPPs are using state-of-the-art combined-cycle technology. This will mean that the baseline in Bangladesh for natural gas-based baseload electricity generation will become the combined-cycle technology. Therefore, except in a single coal-based power plant (yet to be built) there will exist no mitigation option to supply baseload electricity. However, when one looks at the load curve, it immediately becomes obvious that 40 to 50% of the generation capacity in Bangladesh must be earmarked for intermediate and peak load. Since IPPs will not cater to intermediate and peak demand, the public sector power company must shoulder that burden. The obvious choice of technology for peak load will be gas-fired combustion turbines. In an arena of acute investment fund crisis, the power company will purchase the cheapest possible gas turbines, the efficiency of which will be well below 30%. High-efficiency combustion turbines can be used to reduce CO_2 emission.

The present generation capacity is old, and while some power plants will be retired, many will continue beyond 2012. Most of these are steam thermal units having efficiencies between 25% and 35%. State-of-the-art natural gas combined-cycle units having efficiencies above 50% can replace the lower efficiency units. In this scheme, the old units have to be discarded, leading to high incremental cost. Given the fact that the old units are functional, the power company will consider these projects only if the full costs of the new projects are provided. It may however be possible to use some of the old equipment and thus lower the investment cost.

Bangladesh will start mining coal in 2003 and most of the output will be used in a 300 MW coal power plant. In all probability the power plant will be a conventional one. Thus, an excellent opportunity exists for the power company to opt for an Integrated Gasification and Combined Cycle (IGCC) power plant. In this case, by providing the incremental investment, i.e., the cost of an IGCC power plant less the cost of a conventional plant, an investor can construct a very good CDM project.

The scope of reducing CO_2 emissions in the Transmission and Distribution of electricity is large because the existing infrastructure is old and inefficient. The present technical transmission loss is about 4.2% and the distribution loss varies between 10 and 14%. In the city of Dhaka, which is the main load center and consumes nearly half of all the electricity generated, the average distribution loss is 11%. Investing in upgrading the present infrastructure can significantly lower these losses. The only down side of this mitigation option is the difficulty of estimating the CO_2 reduction. The other difficulty is dealing with a public sector organization well known for its poor management.

Industrial/Commercial

Apart from the mitigation opportunities in specific industries, there are two options that are common for any country. These are the use of efficient motors and retrofitting boilers. In a previous study (ALGAS) these two options figured prominently in the menu of least-cost opportunities. Not only were the costs of these options low, the potential for reduction was also high. In this study, these options have not been considered because in the opinion of the study team, it would be too difficult to construct a CDM project made up of numerous low cost components in a country like Bangladesh.

There exist very few energy-intensive industries in Bangladesh. CDM opportunities have been considered in most of these. Opportunities exist in the following energy-intensive industries:

- Pulp and paper
- Cement
- Ammonia/Urea

Bangladesh has four very old pulp and paper mills. The only mitigation option for these old mills is the upgrading of technology. In fact, these mills are so old and inefficient that it is probably better to build new ones. An option could exist where advanced technology, as opposed to the state-of-the art technology, is used. However, since these mills are government owned and the government has no investment funds of its own to build new plants, this avenue is effectively blocked.

In the cement sub-sector there exists the opportunity to convert a very old wet-process plant to the dry-process. The government is very keen to make this changeover, but is unable to find financing for it. This 40-year old plant has undergone four BMRE programs to keep it operational.

The special position of the ammonia/urea complexes in the energy scenario of Bangladesh has already been discussed. Mitigation opportunities in these industries only exist because some plants are fairly old. The newer plants have state-of-the-art (when built) technology and no mitigation option exists there, but in some older plants mitigation options can be considered to bring the energy consumption close to the state-of-the-art plants. Such an option has been considered in one of the seven plants. This opportunity can be utilized in two others.

The following is a list of smaller industrial/commercial activities that have significant energy consumption:

- Steel re-rolling mills
- Cold storage for preserving seasonal agricultural products
- Large commercial installations like hotels, hospitals, office blocks and shopping complexes

- Brickfields

The only steel mill of the country is under closure due to recurring losses. The supply of steel in the country is met from two sources, namely, imports of ingots and waste steel from ship breaking. Re-rolling mills process waste steel to produce rods and angled bars used in the construction industry. There are approximately 150 such mills using very crude technology. Technology upgrading of existing mills or constructing new modern industries can be mitigation options.

Cold storages are essentially refrigeration plants. These plants consume significant amounts of electricity because their operation is continuous and the refrigeration process is energy intensive. There are many cold storage plants and many more are expected in the future. The ready availability of natural gas makes the prospect of cogeneration very bright. In the best mitigation scheme, electricity is sold to the grid and the waste heat is used to run vapor absorption refrigeration systems.

Commercial cogeneration in hotels, large commercial blocks, hospitals and supermarkets is a viable option employing the technology described above. The abundance of natural gas and the fact that Bangladesh is a hot country requiring a considerable amount of air-conditioning makes commercial cogeneration an attractive proposition.

The most significant small-scale industry in Bangladesh is the manufacture of bricks. Bricks are produced in cottage-type industries employing a highly polluting crude technology. The infusion of modern technology in this sector can mitigate a significant amount of CO_2 emissions. This sub-sector has been considered as a prime CDM candidate.
Other opportunities in the commercial sector include the introduction of high-efficiency lighting, the use of measures to reduce cooling loads such as window film, and the introduction of high-efficiency air conditioning systems in larger buildings.

There also exist opportunities of lowering emissions in rural industries. A large amount of biomass is consumed in a variety of agricultural and rural-industrial activities, most important of which is paddy parboiling. These operations are very inefficient because of the crude facilities used to perform the operations. Infusion of modern technology and/or upgrading of the existing technology can be mitigation projects but because these are all very small-scale operations some form of aggregation would be required.

Domestic

Opportunities in the domestic sector include the wider use of efficient biomass (wood, crop waste, and dung) cookstoves, the replacement of kerosene lighting with fluorescent lighting from the grid, the replacement of incandescent light bulbs with compact fluorescent lamps (CFLs), metering of the domestic supply of natural gas, batteries or solar photovoltaic (PV) systems, and the increased use of biogas digesters for livestock and human waste.

Biomass cookstoves are used extensively in rural Bangladesh and despite the facts that these have very low efficiencies and there exists a shortage of biomass, efficient biomass cookstoves have not become popular. Popularizing efficient biomass stoves can not only lower greenhouse gases in the form of CH_4 and N_2O, but will also address the worsening deforestation problem.

The kerosene lamps used in rural areas are extremely inefficient. As can be seen from Table 3.1, a large amount of emissions is due to this source. It can be shown that even using grid electricity (which is inefficient from the point of view of primary energy) for lighting will lower CO_2 emissions. The advantages of CFLs are well known. For Bangladesh the benefits are even greater because a substantial portion of electricity demand in Bangladesh is for lighting and the load occurs at the peak time between 6 p.m. and 10 p.m. when inefficient gas turbines have to be brought into the grid.

The unusual option of metering of natural gas arises from the fact that the domestic supply of gas is not metered. Consumers are charged a flat rate for their monthly consumption. This naturally leads to misuse. Not only do people make illegal connections, but also burners are left on continuously to save the bother of lighting it again.

The electricity grid covers less than 25% of the area of Bangladesh. An optimistic coverage by 2012 is 50%. Grid electricity reaching remote areas is not likely before 2020. Solar PV can be a viable alternative for these areas, even as a permanent solution, because extending grid electricity to these areas will be as expensive as present-day PV systems.

Despite several attempts to popularize biogas digesters, the prevalence of these is extremely low. One reason identified is the small number of cattle per household. A good program can tackle this and other barriers in making biogas a viable alternative in rural areas.

Agriculture

Besides crop processing, the only significant commercial energy consuming activity in this sector is water pumping. There exists scope for using solar PV and wind energy to achieve this pumping in off-grid and coastal areas. Even through the mitigation potential is not significant, it has the benefit of using one of the most sustainable forms of energy.

Transport

From the point of view of growth in emissions, the transport sector is an important one. Whereas there is great uncertainly in the growth of the industry, commercial and power sectors, the growth of the transport sector is inevitable. The reason for this is that the transport sector's main driver is population growth, which despite slowing down is still very high. The main driver for the other three sectors is economic growth, which has proved to be unpredictable in Bangladesh. The last decade, which experienced very little economic growth, saw very little growth in the industrial sector but the growth in the transport sector was unabated. Even though many types of mitigation options can be designed for the transport sector, very few can be fitted into the strict requirements of clear baseline and measurable reduction criteria of the CDM. From a national perspective, two transport sector options look attractive. These are the promotion of compressed natural gas (CNG) vehicles and the modal shift of road freight to rail freight.

The plentiful supply of sulfur-free natural gas readily available in major cities makes the CNG vehicles option very promising. Even though there are not many success stories with CNG vehicles (except for in Argentina), this project is worth developing because natural gas is an important energy resource of the country. The government is very keen to see use of this resource expand in the country rather than to export it. There are no technical reasons why a large project to use CNG in all kinds of vehicles cannot be a viable economic proposition.

The other transport sector option worth pursuing is the modal shift of road freight to rail freight. The large railway infrastructure remains heavily underutilized because of lack of funds to purchase locomotives and carriages. The large energy savings for every tonne of freight moved by rail compared to road make this an attractive option.

4.2 Experience to date

Bangladesh has not participated in any JI, AIJ, or for that matter in any actual emission reduction project. Bangladesh has received funding from the GEF in only one project in the biodiversity window. The only project that came close to being implemented was a solid waste management project in the port city of Chittagong. The Netherlands government initiated this project and some preliminary information-gathering work had been performed, but eventually the project did not materialise.

Bangladesh has participated in two climate change studies, namely:

- The US country study
- Asia Least-cost Greenhouse Gas Abatement Strategy (ALGAS)

The ALGAS study, which commenced in 1995 and ended in 1998 was a multi-million dollar 12-country study funded by UNDP/GEF and executed by the Asian Development Bank (ADB). This study focused on four things:

- GHG inventory following the 1995 guidelines
- GHG emission projection up to 2020
- Identification and least-cost analysis of mitigation options
- Development of brief project portfolios for some projects (5 for Bangladesh)

The portion of the ALGAS study that has bearing on the present study was the identification of mitigation options. The least-cost analysis was performed using the MARKAL model. Some projects could not be analyzed by MARKAL. For those, a pair-wise comparison was used to determine the cost effectiveness ($/tonne of carbon dioxide abated). It is worth pointing out that the ALGAS study predates the CDM, and therefore, the ALGAS analysis is not readily usable for constructing CDM projects. The main focus of the ALGAS analysis was the investigation of mitigation options from a national perspective.

5 Priority Projects for CDM

5.1 Criteria for Selection of CDM Opportunities

The CDM projects presented in this report have been selected using expert judgement. No formal selection procedure or criteria was employed. The following factors were however considered when selecting the CDM projects:

- How far removed is the existing technology from the state-of-the-art/advanced technology?
- Is the present inefficiency in the selected option likely to continue up to 2012?
- The total CO_2 reduction potential of the option
- National sustainable development objectives
- How easily the mitigation option can be developed into a CDM project

These five criteria were applied to possible mitigation options in each sector. The discussion of the possible options in each sector is contained in Section 4. It is worth mentioning here that in a previous study (ALGAS – see Section 4.2) nearly 60 projects were analyzed in the preliminary screening. Those 60 options from the ALGAS study and a few new ones formed the pool of options from which the fifteen CDM projects analyzed here have been chosen. The selection procedure used the above five criteria but the process was solely based on expert judgement.

How the criteria listed above have been used is illustrated as follows using specific options. The first criterion (level of technology) allowed the extent of the emissions additionality to be established. Thus, the older the existing technology and how badly it is maintained, put an option higher up in the selection procedure. The batch digesters in the pulp and paper mill and the wet process for cement manufacture are favored by this criterion.

The second criterion (persistent inefficiency) is important in determining the baseline. Several options dropped through the net because of this criterion. Most significant are the combined-cycle power plants and retrofitting gasoline and diesel engines to use CNG.

The third criterion (potential size of emissions reduction) was important in determining the size of the project. If the project were too small, then the transaction cost would be very high for every tonne of CO_2 abated by the project. Thus, unless a significant potential exists, developing a CDM project would not be cost effective. However, some projects that are strong in the other criteria but weak in this one, like wind pumping, have been retained.

The forth criterion (national development objectives) meant that options that address national sustainable development objectives have been targeted. The use of CNG as a vehicle fuel has been advocated as a CDM project because it addresses the severe problem of urban pollution. Sugar cogeneration also has a strong sustainable development angle because the livelihoods of the sugar cane farmers are being threatened due to the poor performance of the sugar mills.

The final criterion (ease of project development) meant that several options, especially projects which are aggregation of many small options, were not included because it was felt that it would be too difficult to develop implementable projects in the time frame available. Two such options in the industrial sector have been discussed in Section 4.1. The dissemination of improved cookstoves, efficiency improvement of kerosene lamps and replacement of incandescent light bulbs by CFLs are some significant potential projects in the domestic sector which did not pass the test. In the commercial sector efficient air-conditioners and the use of solar reflective glass windows to lessen air-conditioning load are two other significant options that it was felt would take too long to develop.

This report contains the preliminary study of 15 CDM projects. Here, criteria such as investor interest, cost effectiveness and the "quality" (risk) could not be given adequate consideration in choosing CDM opportunities because such criteria are strongly dependent upon factors not easily determinable. To determine the influence of these important criteria, an in-depth study is required. A more detailed study of a few selected CDM projects will be performed in the Phase-II of this study.

5.2 List of Priority CDM Projects

The application of the criteria discussed in Section 5.1 produced 15 prospective candidates for development into CDM projects. They are summarized in Table 5.1, and briefly described below. More detailed descriptions of the projects are given in the Appendix. It is worth emphasizing that many more projects could have been identified, especially those that would require aggregation. Some of these have been described in Section 4.1 and again listed in Section 5.3 as probable future options. One reason why a few of these were not in the priority list is that the framework and guidelines of aggregating options have not been fully established.

Table 5.1 Summary of Priority CDM Projects

Emission Reduction Option	CDM Project Description
Industrial Sector Energy Efficiency	
Iron and Steel – Efficiency in Re-rolling mills	Improvement of the burners, the furnace and the insulation. Retrofit of 150 mills
Pulp and Paper – Continuous Digester	Continuous digesters and more complete use of cogenerated power in 1 mill.
Brick Manufacturing – VSBK	Introduction of Vertical Shaft Kiln throughout the industry
Brick Manufacturing – Hoffmann	Reduction in number of kilns using Hoffmann Kilns
Cement Manufacture – Wet to Dry Process	Retrofit of several plants with the Dry Process
Urea Fertilizer Plants	Accelerated upgrading of existing plants
Renewable Energy	
Water pumping (Wind)	Replacement of 100 shallow well diesel pumps with positive displacement wind pumps
Transportation Sector	
CNG vehicles – Gas Engines	Use replacement CNG engines on a subset of vehicles
Power Sector	
Transmission Losses	Upgrading and expansion of electricity network to a larger rural area
Distribution Network Improvement	Replacement of wires, old transformers selected joints, conductors and insulators
Aeroderivative Turbines	Supply peak load using aeroderivative combustion turbines
Cold Storage Cogeneration	Cogeneration in 1 to 4 cold storage

	facilities to run existing vapor compression chillers, and waste heat used to run newly installed absorption refrigeration chillers.
Hotels Cogeneration	Cogeneration using either natural gas engines or turbines with waste heat used to operate absorption refrigeration chillers and to supply other heat loads
Sugar Cogeneration	Bagasse cogeneration in several mills

5.2.1 Industrial Sector Energy Efficiency

Iron and Steel - Efficiency in Re-rolling Mills

The only steel mill in the country has been shut down due to recurring losses. The supply of steel in the country comes from 150 re-rolling mills that process waste steel obtained from ship breaking. These mills produce rods and angled bars using extremely crude technology. Since steel is a basic requirement for infrastructure development, the demand for steel will grow, and hence, the number of re-rolling mills will increase in the future.

The best mitigation strategy is probably to build new modern industries. However, what has been considered here is the improvement of the burners, the furnace and the insulation in the existing mills as a retrofit scheme. The proposed retrofit can bring down the specific natural gas consumption from the present 100 m^3/tonne of steel to 70 m^3/tonne. The CDM project envisaged will retrofit all 150 mills. The proposed retrofit involves standard technology, but it must be appreciated that it is a tremendous improvement over the existing situation. There are of course several barriers to this project. The first barrier is the fact that this is a low-investment, high-transaction-cost project. The second barrier is the requirement of having to deal with 150 small industrial units. The third barrier concerns monitoring. Small industrial units are notorious in concealing their outputs and fuel consumption. Without this information it would not be possible to estimate correctly the CO_2 reduction achieved.

Pulp and Paper – Continuous Digester

There are four very old public-sector pulp and paper mills in the country. Even though these mills have all undergone several overhauls to keep them operational, the main technology for pulping and papermaking has remained the same. In the last two decades the pulp and paper industry worldwide has undergone many technological changes, making it more energy efficient and environment friendly. Incorporating some of these can make the old mills energy efficient.

A CDM project in one mill is considered. The baseline technology is batch digesters and the present low use of cogenerated power. The proposed mitigation technology is continuous digesters and more complete use of cogenerated power. In this project the existing batch digesters would have to be scrapped and continuous digesters installed. The cogeneration plant would also have to be replaced by a new efficient one. The large low-pressure steam requirement for pulping and papermaking makes this an ideal case for using waste heat from the gas turbine exhaust. This will be a low-cost option because of the large savings in energy costs due both to the continuous digester and the use of waste heat. A significant benefit of the project would be the reduction in water use, which will lower the river water pollution in the locality. The only drawback is dealing with a public sector industry that has been losing money due to the inability of locally produced paper to compete with imported paper.

Brick Manufacturing - Vertical Shaft Brick Kilns

Over 90% of the bricks in Bangladesh are manufactured in cottage-type industries using extremely crude technology. The kiln commonly known as the Bull's Trench Kiln (BTK) is essentially a large dugout area where the green bricks are stacked for firing. There are over 5000 such kilns in the country. BTKs are the cause of severe environmental pollution in the city suburbs and some rural areas. As fuel, these kilns use almost anything that will burn, including car tires. The environmental pollution from these kilns has reached such alarming proportions that the government has promulgated regulations to control these emissions. Even though the predominant fuel is coal, these kilns use large quantities of firewood and are the principal cause of deforestation.

A simple kiln technology exists which can replace the polluting BTKs. The mitigation technology being considered is the Vertical Shaft Brick Kiln (VSBK). As the name implies, these kilns are of tower construction and they use pulverized coal. The superior design ensures large energy savings and greatly diminishes the pollution level. VSBKs are more compact and being semi-continuous, have a much higher capacity than BTKs. The cost of this option will be low because the mitigation technology is relatively cheap and there will be large savings in fuel costs. This can be an excellent CDM project but several issues need to be resolved. First is the issue of regulatory additionality. As discussed earlier, the regulatory requirements may cause these kilns to be abandoned in the business-as-usual scenario. However, in the opinion of the study team, the process will require more than 10 years. The second issue that must be addressed concerns the reduction in the number of kilns. Therefore, unless some existing brickfield owners are willing to form some sort of a partnership, they will go out of business. The third issue concerns monitoring. Small industries are notorious for mis-reporting their outputs and fuel consumption in order to avoid paying duties and taxes.

Brick Manufacturing - NG-Fired Hoffman Kilns

This option is an extension of the previous one. Natural gas-fired, improved kilns known as Hoffmann Kilns can replace many of the existing brick kilns. This changeover involves not only the replacement of an inefficient technology, but also fuel switching from coal to natural gas. The major issue in designing a CDM project is that Hoffmann Kilns have nearly five times greater capacity than BTKs. Thus, for every 5 BTKs replaced, only one Hoffmann Kiln would be required. The consequences of this large reduction in the number of units have to be carefully investigated. Fortunately, the labor-intensive part of brickmaking, i.e., the forming of bricks from clay and the loading and unloading of raw material and bricks at various stages of production, will remain the same in the mitigation option.

If the CDM project is properly designed then this is expected to be a very low-cost option because of the large energy savings. The environmental benefits of this option are even greater than the VSBK option discussed above. The technology is not new because there already exists about 25 such kilns in the country. The regulatory issue discussed in the VSBK option applies to this one also.

Cement Manufacture – Wet to Dry Process

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 the wet process.

Annual demand for cement in 2000 is estimated at 4.5 Mt. The installed capacity of one very old integrated cement factory based on the wet-process and sixteen clinker grinding plants is 4.3 Mt/yr. The nominal capacity of the wet-process plant is 0.233Mt/yr, which comprises only 5.4% of the national demand for cement. Clinker is imported from several countries and processed in finishing mills. The conversion of the wet-process in old cement plants to the dry process can be a CDM project. This will be a high-cost option because all old equipment has to be scrapped.

Urea Fertilizer Plants

The fertilizer industry in Bangladesh is so large that it is treated as a separate sector. There are seven urea fertilizer plants producing approximately 3 Mt of urea per year. The government of Bangladesh attaches high priority to the production of urea because it is connected to the attainment of self-sufficiency in food production, in particular, rice production. The typical size of plants is 500,000 tonnes of urea per year. All plants when built had state-of-the-art technology. The older plants have specific energy consumption nearly 50% more than the present state-of-the-art technology. Since it is very expensive to upgrade technology, there is very little possibility of the energy consumption of old plants improving in the next 10 years. A variety of measures including process improvement can be used to lower the specific energy consumption. In the mitigation scheme there also exists the possibility of selling electricity to the grid, making the mitigation project very attractive in terms of cash flow.

The CDM project considered is for one plant but this can be extended to two others. The total potential is large because of the size of these plants. Despite the large energy savings, the cost effectiveness would be medium because substantial investment is involved. The only problem with this option is that the emission reduction that can be achieved by this project is a very rough estimate. This is because the efficiency measures that have been considered are all non-standard. However, once in operation the CO_2 reduction would be accurately known because the project would be easy to monitor. This is because all urea fertilizer plants are highly automated and have a skilled workforce. The fertilizer plants under consideration are public-sector industries, but unlike most other government-owned industries, these plants are well managed and dealing with the developer, i.e., the Bangladesh Chemical Industries Corporation (BCIC) should pose no problems.

5.2.2 Renewable Energy

Water Pumping (Wind)

The potential of wind energy in Bangladesh has not been properly assessed. The most optimistic estimate for wind-based electricity generation is 1,000 MW. The easily harnessable potential is probably close to 100 MW. The average wind speed is 2-4 m/s at the height of 5 to 10 m above ground level. Wind availability is seasonal and diurnal. Such data do not support the development of electricity generating windmills. On a realistic level there exists some potential for developing wind pumping in selected coastal districts. The existing pumps are run on diesel. These pumps essentially lift water from rivers, lakes and ponds into irrigation channels.

The CDM project considered would replace 100 centrifugal diesel shallow-water pumps with positive displacement pumps operated by windmills. The most positive aspect of this project is that it uses a renewable source of energy. The barriers to this project are very similar to the re-rolling mills option. This will be a low-investment, high-transaction-cost project. Difficulties will be encountered in convincing the present diesel pump operators to make the proposed changeover because an unknown technology is being introduced.

5.2.3 Transportation Sector

CNG Vehicles – Gas Engines

Urban air quality of Dhaka city ranks amongst the worst in the world. The government of Bangladesh is therefore very keen to promote measures that will alleviate the problem. Replacement of liquid fuels by compressed natural gas (CNG) is a particularly attractive proposition because of the abundance of sulfur-free natural gas. A large-scale conversion program can achieve significant reduction in urban air pollution, leading to more sustainable transportation. Such a program can bring large benefits to the country because expensive *imported* fuel will be displaced.

The conversion of gasoline cars to use CNG is an on-going program of the Government, started in the mid-eighties. At the present moment the program to convert gasoline cars to CNG suffers from the drawback that there aren't enough re-filling stations. However, the Government has a stated program to build 100 filling stations by the year 2005. For a CNG vehicle project to be successful, an attractive price differential between liquid fuels and CNG must be maintained because using CNG as opposed to liquid fuels is cumbersome and inconvenient. With respect to the CDM, the doubts about methane leakage and the fact that the present program is government owned are serious impediments. In fact for a large-scale program to be successful, private sector participation is essential. Adequate steps in that direction has been taken by the Government.

Using gas engines rather than retrofitted gasoline and diesel engines can enhance the benefits of using CNG. Automobiles with gas engines achieve 10% greater fuel efficiency than converted engines. This option has a particular advantage in that it introduces a new technology in the country and hence addresses the technology additionality issue of the CDM. The two barriers of this option are that gas engine automobiles are not readily available for order and the use of the vehicles will be limited to only CNG-serviced areas (converted engines have a dual fuel option).

5.2.4 Power Sector

Transmission Losses

The lack of upgrading and maintenance funds has caused the electricity transmission network to deteriorate to the extent that the peak transmission loss is 4.2%. One reason for the high loss is the inability of the network to handle the present load. Therefore, what is required is an upgrading and expansion program that will not only lower the system loss, but will also expand the electricity network to a larger rural area. The power company has drawn up a plan for transmission network rehabilitation but is unable to finance it. In the business-as-usual scenario the government, from its own and/or bilateral/multilateral sources, is unlikely to be able to procure more than 50% of the required investment funds. A good CDM project can therefore be constructed which provides the remaining 50%. The project envisaged will lower the system loss from the prevailing 4.2% to 2%.

This project is expected to be a high-cost one. A significant issue for a prospective investor is that the would-be developer is a public-sector organization well known for its poor management. An additional issue in this project is the difficulty in accurately measuring the CO_2 reduction.

Distribution Network Improvement

The average technical system loss of the Dhaka electricity distribution system is 11%. The high technical loss is the result of the lack of investment funds to upgrade the aging infrastructure and to conduct routine maintenance. The electricity distribution company, known as the Dhaka Electricity Supply Authority (DESA), has estimated that US$ 150 million would be required to upgrade the existing facilities, which are capable of distributing about 1,000 MW of power. The renovation of the existing infrastructure will result in the average technical loss being lowered from the existing 11% to 8%. A good CDM project can be constructed in this sub-sector because the Government is unlikely to find the required investment funds for the renovation program. In recent years all efforts by the Government to secure funding for the Dhaka electricity distribution network from bilateral and multilateral loan/grant agencies have failed.

The mitigation project will involve the partial replacement of existing wires by better and higher-quality wires, replacement of old transformers by efficient ones and replacement of faulty joints, conductors and insulators. The mitigation technology proposed involves nothing special, but it must be appreciated that the project will achieve significant improvement over the existing situation. The cost of this option will be high. The major drawback of this otherwise good project is the difficulty in measuring the emission reduction. The reason for this is that as well as technical system loss, very high non-technical system loss exists and it may be difficult to de-couple the two losses. The other drawback from the investor's point of view is the need to deal with a public-sector company well known for poor management.

Aeroderivative Turbines

As explained in Section 4.2, there exists no mitigation opportunity in baseload electricity generation. However, the daily load curve is such that at least 25% of the total generation capacity must cater to the peak load. Because of the abundance of natural gas, the peak generation capacity will be all combustion turbines. Given the poor financial position of the power company, the tendency would be to opt for the cheapest gas turbines with efficiencies below 30%. It is not uncommon for poorly manufactured combustion gas turbines to have efficiencies as low as 25%.

The mitigation technology to supply peak load can be aeroderivative combustion turbines. These turbines cost one-and-one-half times more but can give efficiencies over 40%. Since these turbines will be used for peak load, the operating hours per day will be around five. Such low usage will naturally adversely affect the cost effectiveness but the total potential of mitigating CO_2 by this technology is fairly large. The mitigation project considered here is for a 100 MW electricity generation facility but can be extended to 600 MW at the present time and up to 1,000 MW in the year 2010. Aeroderivative turbines will meet the technology additionality criterion of the CDM. The drawback of this project is that the investor will have to deal with a public-sector organization.

Cold Storage Cogeneration

Cold storages are essentially refrigeration plants used to preserve perishables such as potatoes, fruits, vegetables, spices and eggs for periods ranging from a few weeks to nearly a year. The technology employed is vapor-compression refrigeration running on electricity purchased from the national grid. An average cold storage has a capacity of 100 tonnes of refrigeration (TOR). Since very clean natural gas is available in most parts of the country, an excellent mitigation opportunity exists for employing cogeneration technology. In the cogeneration schemes considered, electricity will be used to operate part of the existing vapor compression chillers and the waste heat from the gas turbine generators will be used to operate absorption refrigeration chillers. Since one cold storage is too small for a CDM project, a cluster comprising 1 to 4 cold storage plants are considered. To derive the maximum benefit from this project, waste heat should be utilized to as great an extent as possible and the electricity sold to the grid. The main problem of designing a CDM project with cold storage that takes full advantage of the waste heat is that all existing chillers have to be scrapped.

Cold storages are private-sector operations and financial and investment additionality issues are not likely to be of any concern. With regard to technology additionality, it can be said that even though cogeneration is not a new or advanced technology, its implementation in cold storages would be a significant technological improvement over the existing situation. This option will be a very low-cost option because of the large savings resulting from the difference between the baseline electricity costs and the mitigation gas costs. To get a CDM project of a reasonable size, at least 20 such cogeneration projects have to be considered under one program. The principal barrier to this option is the difficulty in getting 2 or more owners of cold storage plants to cooperate. The other issue that must be addressed is that industries, especially small ones, are notorious for concealing their outputs and fuel consumption.

Hotel Cogeneration

In a hot country like Bangladesh the air-conditioning load in large luxury hotels is considerable. The vapor compression chillers running on electricity have to be operated nearly 10 months of the year. Refrigeration units consume a large quantity of electricity. Moreover, luxury hotels have all kinds of other energy-consuming equipment and devices. The availability of sulfur-free natural gas makes the prospect of using cogeneration very attractive. In the proposed scheme, electricity will be generated using either gas engines or turbines and the waste heat will be used to operate absorption refrigeration chillers and meet other heat loads. The generated electricity will be used to operate the electrical load of the hotel.

This option will be a low-cost one because of the difference between the baseline electricity costs and mitigation natural gas costs. As such, cogeneration and the absorption refrigeration technologies are not new to the country but their application to hotels is. To make hotel cogeneration into a CDM project, several such projects need to be considered so as to yield a bigger project because a single hotel cogeneration project is expected to be only in the million-dollar range. Such cogeneration projects can also be considered for hospitals, office blocks and shopping complexes. To have a CDM project of, say 10 million dollars, 10 such cogeneration projects have to be implemented under one program. Otherwise, the transaction and monitoring costs would be too high. To make this project successful a good implementation plan would be required. Compared to many other CDM projects for Bangladesh, this should be easier to monitor because the natural gas used can be accurately known in large luxury hotels. One problem associated with this project is the need to generate electricity inside the city.

Sugar Cogeneration

Bangladesh is an agricultural country and its economy is heavily dependent on agriculture. Cash crops are particularly important and, a large farming community is dependent on sugar cane cultivation. In the last decade locally produced sugar has been unable to compete with imported sugar because of high production costs. The reason for this is the highly inefficient sugar mills. The present practice in sugar mills is the burning of bagasse in low-pressure boilers to raise steam. This can be substituted by Bagasse cogeneration, which will improve efficiency and hence, increase profitability. Cogeneration is an ideal choice for a sugar mill because there exists a large demand for steam and process heat, which can be met from the waste heat of the generator turbines. The cogenerated electricity sold to the national grid will displace natural gas-based electricity.

This is expected to be a low-cost option because of the large profit from the sale of electricity. This project should meet the CDM emission additionality criterion very well because it makes efficient use of a renewable resource. In an average mill that operates for 120 days in the year, a 10 MW electricity generation facility can be set up. There are 15 sugar mills in the country and the cogeneration scheme discussed above can be applied to all the mills. The major drawback of this project is the fact that most of these mills are government owned and, depending on how the CDM project is structured, it may encounter difficulties with the investment and financial additionality criteria of the CDM.

5.3 Analysis

Table 5.2 gives the total magnitude of CO_2 reduction and a qualitative indication of the cost effectiveness for all 15 options presented in Section 5.2. This is followed by 16 templates summarizing the analysis (CO_2 emissions reduction) and all other relevant data, including costs. The templates also contain a brief description of the project opportunity and the benefits of the project. Detailed descriptions including the calculations supporting the analysis are presented in the Appendix.

Table 5.2 Summary of Price Range and Magnitude of Carbon Dioxide Reduction

Emission Reduction Option	Price Range[1]	Magnitude (thousand tonnes of CO_2 per year)
Industrial Sector Energy Efficiency		
Iron and Steel – Efficiency in Re-rolling mills	Low	10
Pulp and Paper – Continuous Digester	Low-Medium	250
Brick Manufacturing – VSBK	Low	400
Brick Manufacturing – Hoffmann	Low	250
Cement Manufacture – Wet to Dry Process	High	46
Urea Fertilizer Plants	Medium	500
Renewable Energy		
Water pumping (Wind)	Medium-High	1
Transportation Sector		
CNG vehicles – Gas Engines	High	100
Power Sector		
Transmission Losses	High	400
Distribution Network Improvement	Medium	300
Aeroderivative Turbines	Medium	350
Cold Storage Cogeneration	Low	30
Hotel Cogeneration	Low	30
Sugar Cogeneration	Low	225

[1] Low: up to US$ 10/tonne; Medium: US$10-20/tonne; High: Above US$ 20/tonne

5.3.1 Industrial Sector Energy Efficiency

Iron and Steel – Efficiency in Re-Rolling Mills

Project Opportunity: Improving combustion technology in re-rolling mills

	Baseline	**Project Opportunity**
Description	Re-rolling mills using crude burners and furnace technology	Replacing the crude burners and improving furnace insulation
Cost Components	None	Instigator-type burner; Improving furnace and insulation; Implementation scheme (150 mills)
Benefits		Improvement in the working environment of the mills; More complete combustion will ensure lower emission of CO and CH_4
Additionality		Removes cost effectiveness barrier
Number of Mills	150	150
Average Annual Total Production (tonnes)	160000	160000
Specific NG Consumption (m^3/tonne)	100	70
Energy Consumption (TJ/yr)	560	392
CO_2 Emissions (tonnes/tonne steel)	0.1964	0.1375
CO_2 Savings (tonnes/yr)	None	9492
Initial Investment (million $)		2.25
Other Initial Costs (million $)		0.25 (implementation cost)
Fuel Cost @ $0.09/$m^3$ of NG (million $/yr)	1.4	1.0
Fuel Savings (Baseline – Opportunity) (million $/yr)		0.4
Annual O&M Costs (million $/yr)		0.1
Years of Benefit (Project Life)		15
Other Benefits		Profitability of re-rolling mills will increase

Pulp and Paper – Continuous Digester

Project Opportunity: Replacement of batch digester by continuous digester and efficient use of cogenerated power in a pulp and paper mill

	Baseline	**Project Opportunity**
Description	Batch digester and low use of cogenerated power	Introduction of continuous digester and more efficient use of cogenerated power
Cost Components	None	Continuous digester; Cogeneration plant
Benefits		Reduction in river water pollution; Will improve the working environment of the mill
Additionality		New technology will be introduced
Plant Capacity (tonnes/yr pulp)	30,000	30,000
Power Production (MW)		20 (for 300 days/yr)
Specific Energy Consumption (GJ/tonne)	70 (heat) + 18 (electricity)	25 (heat) + 20MW (electricity)
Energy Consumption (TJ/yr)	3,920	750 + 1,728 = 2,478
CO_2 Emissions (tonnes/yr)	219,912	139,016
CO_2 Savings (tonnes/yr)		80,896
Initial Investment (million $)		20 + 20
Fuel Costs @ $ 0.09/m^3 of NG (million $/yr)	10.1	6.4
Fuel Savings (Baseline – Opportunity) (million $/yr)		3.7
Annual O&M Costs (million $/yr)	0.5	0.5
Years of Benefit (Project Life)	20	20
Other Benefits		Will make the mill profitable and will allow locally produced pulp and paper to compete with imports

Brick Manufacturing - Vertical Shaft Brick Kilns

Project Opportunity: Replacement of traditional brick kilns by vertical shaft brick kilns

	Baseline	**Project Opportunity**
Description	Conventional Bull's Trench Kilns (BTK) fired with low-grade coal, firewood, furnace oil, etc.	Vertical Shaft Brick Kilns (VSBK) using pulverized coal
Cost Components	BTK	VSBK; Coal pulverization; Participation plan among existing manufacturers
Benefits		Will decrease deforestation; Significant improvement in local air quality
Additionality		New technology
Number of Kilns Plant Capacity **(million bricks/yr)**	900 kilns, each producing 1.528 million bricks per year 1,375	240 kilns, each producing 5.729 million bricks per year 1,375
Energy Consumption (TJ/yr)	8,634	4,317
CO_2 Emissions (tonnes/kiln)	907	1,702
CO_2 Emissions (tonnes/yr)	816,776	408,388
Initial Investment ($/kiln) **Total Initial Investment** (million $)	7,280 6.55	31,250 7.5
Other Initial Cost (million $)		0.75 (participation plan)
Fuel Costs @ $ 45/tonne (million $/yr)	18.75	9.37
Fuel Savings (Baseline – Opportunity) (million $/yr)		9.37
Annual O&M Cost (million $/yr)		0.75
Years of Benefit (Project Life)	1	5
Other Benefits		Year round production

Brick Manufacturing - NG Fired Hoffmann Kilns

See Phase II Report

Cement Manufacture – Wet to Dry Process

Project Opportunity: Conversion of wet process to dry process in a cement plant

	Baseline	**Project Opportunity**
Description	Wet process of cement production	Dry process of cement production
Cost Components	None	Clay and limestone dryer; Shortening of existing kilns; Blending silos for dry powder; Suspension preheater; Replacement of planetary coolers with conventional coolers
Benefits		Reduction in water use
Additionality		Introduction of new technology
Plant Capacity (tonnes/yr cement)	233,000	233,000
Specific Natural Gas Consumption for Clinker Production (m^3/tonne)	200	100
Energy Consumption (TJ/yr)	1,631	816
CO_2 Emissions (tonne/tonne of cement)	0.3929	0.1964
CO_2 Emissions (tonnes/yr)	91,546	45,773
CO_2 Savings (tonnes/yr)		45,773
Initial Investment (million $)		40
Fuel Costs @ $0.09/$m^3$ of NG (million $/yr)	4.1	2.05
Fuel Savings (Baseline – Opportunity) (million $/yr)		2.05
Annual O&M Costs (million $/yr)	2	1
Years of Benefit (Project Life)	15	15
Other Benefits		Will make the product competitive with imported cement

Urea Fertilizer Plants

Project Opportunity: Efficiency improvement in a urea fertilizer plant and sale of excess power to the national grid

	Baseline	**Project Opportunity**
Description	Existing process inefficiencies; Old inefficient STG/GT as captive generation; Vapor compression refrigeration system; Pressure reduction in NG	Process modification; More efficient STG/GT, sell power to national grid; Use of excess low pressure steam in absorption refrigeration system; Compression of process NG from the available inlet pressure without pressure reduction
Cost Components	None	Catalyst and other process modification; New STG/GT; Absorption refrigeration system; Modification of compressors
Benefits		2 MW displaced from the national grid; Income from sale of power
Additionality		Removes cost-effectiveness barrier
Plant Capacity	448,000 tonnes/yr	448,000 tonnes/yr + 2 MW cogeneration power sold to the grid
Project Boundary	Fertilizer plant + 2 MW grid power	
Specific Natural Gas Consumption (m^3/tonne of Urea)	991	680
Energy Consumption (TJ/yr)	15,539 + 163 = 15,702	10,662
CO_2 Emissions (tonnes/tonne urea)	1.97	1.335
CO_2 Emissions (tonnes/yr)	871,731 + 9,143 = 880,874	598,160
CO_2 Savings (tonnes/yr)		282,714
Initial Investment (million $)		90
Fuel Costs @ $0.09/$m^3$ of NG (million $/yr)	40	27.5
Fuel Savings (Baseline – Opportunity) (million $/yr)		12.5
Annual O&M Costs (million $/yr)	2.5	2.5
Income from Sale of Power @ $0.05 per kWh (million $/yr)		0.8
Years of Benefit (Project		15

Life)		
Other Benefits		Profitability of the plant will increase

5.3.2 Renewable Energy

Water Pumping (Wind)

Project Opportunity: Replacement of diesel pumps with wind pumps for shallow water lift in selected coastal areas

	Baseline	**Project Opportunity**
Description	Diesel pumps for shallow water pumping for irrigation	Diesel pumps replaced by wind pumps
Cost Components	None	Wind mills; Positive displacement pumps; Implementation scheme
Benefits		No fuel cost ; Reduction in operating cost; SO_X, NO_X and particulate emission reduction at pump site
Additionality		New technology introduction
Project Target	100 diesel pumps	100 wind pumps
CO_2 Emissions (tonnes/yr)	770	
CO_2 Savings (tonnes/yr)		770
Initial Investment (million $)		0.4
Other Initial Cost (million $)		0.1 (implementation scheme)
Diesel consumption/ pump/12 hour day (kg)	12	None
Total fuel consumption (200 days, 100 pumps), kg/year	240,000	None
Energy Consumption (TJ/yr)	10.4	None
Fuel Cost @ $0.42/kg (million $/yr)	0.1	None
Fuel Savings (Baseline – Opportunity) (million $/yr)		0.1
Annual O&M Costs (million $/yr)	0.02	0.02
Years of Benefit (Project Life)		10
Other benefits		Reduction in noise pollution; Use of a renewable energy resource

5.3.3 Transportation Sector

CNG Vehicles – Gas Engines

Project Opportunity: Import/local manufacture of vehicles with gas engines

	Baseline	**Project Opportunity**
Description	Conventional gasoline and diesel vehicles	Small and medium size vehicles having gas engines imported from abroad and/or manufactured locally through technology-transfer mechanism
Cost Components	Standard gasoline and diesel vehicles	Vehicles with gas engines; Marketing strategy; Import plan; Subsidy plan
Benefits		Significant improvement in urban air quality
Additionality		Introduction of new technology;
Specific Energy Consumption per Car (GJ/yr) Gasoline Diesel Natural Gas	90 95.4	70
Energy Consumption (TJ/yr)	1,346 (gasoline) 477 (diesel)	1,260 + electricity used for compression
Project Target		Import 20,000 CNG vehicles in five years
CO_2 Emissions per Car (tonnes)	6.31 (gasoline) 7.04 (diesel)	3.53
CO_2 Emissions (tonnes/yr)	128,595 (93278 gasoline, 35317 diesel)	84,823 (70,686 + 14,137) (20% extra for compression assumed)
Cost per Car, $ Total initial Investment (million $)	12,500 250	14,500 290
Other Initial Costs (million $)		7 (import + subsidy plan)
Fuel Costs (million $/yr) Gasoline @ $0.45/litre Diesel @ $0.27/litre CNG @ $0.18/m^3	20.57	6.54
Fuel Savings (Baseline – Opportunity) (million $/yr)		14.03
Annual O&M Costs (million $/yr)	1.0	2.0
Years of Benefit (Project Life)	20	20

Other Benefits		Displaces imported liquid fuel; Enhances domestic gas utilization

5.3.4 Power Sector

Transmission Losses

Project Opportunity: Improvement of the national electricity transmission system by reducing transmission loss

	Baseline	**Project Opportunity**
Description	Bangladesh electricity transmission network having 4.2% loss	Transmission loss reduced from 4.2% to 2% in 6 years and then continued for another 15 years in the Bangladesh electricity transmission network
Cost Components	None	99 grid sub-stations; 5,198 km transmission line; 540 capacitor banks
Benefits		Infrastructure improvement leading to less power outage; Availability of more electricity leading to less load shedding
Additionality		Removes cost effectiveness barrier
Power Transmitted (MW)	3,500	3,500
Electricity Transmitted (GWh/yr)	30,660	30,660
Average Losses in Power Transmission (MW)	147 (4.2% of Power Transmitted)	70 (2% of Power Transmitted)
Energy Savings (MW)		77
Energy Savings (TJ/yr)		6,940
CO_2 Savings (tonnes/yr)		389,389
Initial Investment (million $)		380
Fuel Costs @ $0.09/m^3 of NG (million $/yr)	811	795
Fuel Savings (Baseline – Opportunity) (million $/yr)		16
Annual O&M Costs (million $/yr)		5
Years of Benefit (Project		18

Life)		
Other Benefits		Expansion of rural electricity network Improvement in the financial position of the power company

Distribution Network Improvement

Project Opportunity: Improvement of Dhaka city electricity distribution network by reducing technical system loss

	Baseline	**Project Opportunity**
Description	Dhaka city electricity distribution system having 11% technical loss	3% reduction of technical system loss in the Dhaka city electricity distribution system
Cost Components	None	Partial replacement with better quality wire; More efficient transformers; Partial replacement with better joints, conductors, insulators
Benefits		Infrastructure improvement leading to less power outage; Availability of more electricity leading to less load shedding
Additionality		Removes cost-effectiveness barrier
Power Distributed (MW)	1,000	1,000
Loss (MW)	110 (11% of Power Distributed)	80 (8% of Power Distributed)
Energy Savings (MW)		30
Energy Savings (TJ/yr)		2,703
CO_2 Savings (tonnes/yr)		151,710
Initial Investment (million $)		150
Fuel Cost @ $0.09/m^3 of NG (million $/yr)	25.5	18.5
Fuel Savings (Baseline – Opportunity) (million $/yr)		7
Annual O&M Costs (million $/yr)		2
Years of Benefit (Project Life)		20
Other Benefits		Increased capability to distribute electricity; Improvement in the financial position of the power company

Aeroderivative turbines

Project Opportunity: Introduction of aeroderivative turbines in place of conventional turbines for peak load power generation

	Baseline	**Project Opportunity**
Description	Conventional combustion turbines	Aeroderivative turbines
Cost Components	Conventional turbines	Aeroderivative turbines
Benefits		Reduction of thermal pollution around the power plant
Additionality		Advanced technology would be introduced
Plant Capacity (MW)	100	100
Power Production, 5 hours/day, 330 days (GWh/yr)	165	165
Efficiency (%)	28	42
Energy Consumption (MJ/kWh)	12.85	8.57
Energy Consumption (TJ/yr)	2,121	1,414
CO_2 Emissions (kg/KWh)	1.4426	0.96
CO_2 Emissions (tonnes/yr)	119,012	79,325
CO_2 Savings (tonnes/yr)		39,690
Initial Investment (million $)	30	45
Fuel Costs @ $0.09/m^3 of NG (million $/yr)	5.46	3.64
Fuel Savings (Baseline – Opportunity) (million $/yr)		1.82
Annual O&M Costs (million $/yr)	1	1.5
Years of Benefit (Project Life)	15	15

Cold Storage Cogeneration

See Phase II Report

Hotel Cogeneration

Project Opportunity: Replacement of grid power with a cogeneration system consisting of a gas-turbine generator and vapor absorption chillers in a 300-room, 5-star hotel

	Baseline	**Project Opportunity**
Description	Purchased electricity from the national grid is utilized to run 600-TOR vapor compression chillers and other appliances	Gas turbine cogeneration will be installed. The produced electricity will be used for non-cooling purposes (additional 0.3 MW will be purchased from the national grid whenever required) and the waste heat will be utilized to run new 600-TOR absorption chillers replacing old compression chillers
Cost Components	None	Gas turbine unit; New absorption chillers; Electrical equipment; Services and installation
Benefits		Reliable power supply; Savings in operating costs
Additionality		Removes cost-effectiveness barrier
Plant Capacity	600-TOR compression chillers (0.53 MW); 1 MW (with a peak of 1.3 MW)	600-TOR absorption chillers run on waste heat; 1 MW (with a peak of 1.3 MW)
Electricity Consumed (GWh/yr)	14.02	9.42
Electricity Produced (GWh/yr)		8.76
Heat Utilized (TJ/yr)		56.76
Energy Consumption (TJ/yr)	170	113
CO_2 Emissions (kg/kWh)	0.68	0.67
CO_2 Emissions (tonnes/yr)	9,520	6,332
Initial Investment (million $)		0.8
Energy Cost @ $0.09/kWh for Electricity and $0.09/m^3 for NG (million $/yr)	1.26 (electricity)	0.33
Energy Savings (Baseline – Opportunity) (million $/yr)		0.932
Annual O&M Cost (million $/yr)		0.04
Years of Benefit (Project Life)		15

Other Benefits		1.5 MW displaced from the national grid; Reduction in T & D losses; Savings in T & D infrastructure

Sugar Cogeneration

Project Opportunity: Replacement of bagasse boilers in single sugar processing plant with cogeneration and sale of electricity to the grid to displace fossil fuels

	Baseline	**Project Opportunity**
Description	Bagasse burned in low-pressure boilers	Cogeneration of bagasse with electricity sold to grid to displace fossil fuels
Cost Components	None	New cogeneration system
Benefits		Income from sale of power; Emission reduction at power plant; Maintains community livelihood; Reliable power supply
Additionality		Removes cost effectiveness barrier
Plant Capacity (120 days per year operation)	1,500 tonnes/day bagasse	1,500 tonnes/day bagasse + 10 MW cogeneration plant
Project Boundary	Sugar mill + 10 MW grid power	
Power Production in 120 Days (GWh/yr)		28.8
CO_2 Emissions (tonnes/yr)	16,619	0
CO_2 Savings (tonnes/yr)		16,619
Initial Investment (million $)		10
Annual O&M Costs (million $/yr)	0.5	0.5
Income from Sale of Electricity @ $0.05/kWh (million $/yr)		1.44
Years of Benefit (Project Life)		20
Other Benefits		10 MW displaced from the national grid; Will make the sugar mill more profitable and allow locally produced sugar to compete with imported sugar; Efficient use of a renewable resource; Displaces fossil fuel

6 Future Options

This report has considered only 15 CDM projects. Many more CDM projects can be considered, especially projects which require aggregation and/or a common baseline. It is worth recalling that such options were excluded from the priority list presented in Section 5.1. To pursue such projects, clear-cut guidelines, which are under development, are required. Once those guidelines are in place the country's situation can be analyzed to develop CDM projects. The following is a partial list of options that would require some form of aggregation and/or common baseline and standardized monitoring:

- Efficiency improvement of motors in the industrial sector
- Efficiency improvement of boilers in the industrial sector
- Efficient air-conditioners in the commercial sector
- Use of solar reflective glass windows/walls to lower air-conditioning load in the commercial sector
- Improved biomass cookstoves in the domestic sector
- Improved kerosene lamps in the domestic sector
- Solar Home Systems (SHS) to replace kerosene lamps
- CLFs to replace incandescent lamps in the domestic and the commercial sectors
- Metering natural gas in the domestic sector
- Electric vehicles to replace small 4-stroke gasoline run vehicles (10 to 14 passenger)

Apart from the opportunities with aggregated small projects, there exists scope for mitigating CO_2 emissions in three prominent industries of Bangladesh. These industries are

- The jute industry
- The tea industry
- The textile industry

These industries have been left out because these do not fall into the energy-intensive category. The potential in a single industry is not large, but if 20 or 30 industries are considered together as one single CDM project then the transaction and monitoring cost can be kept at an acceptable level. Plant modernization, energy management and the use of cogeneration are the opportunities in these three industries. Plant modernization is however an expensive proposition because the investment requirement cannot be justified simply from the energy savings.

Up to this point discussion has focused upon opportunities which exist at the present time but could not be developed due to a variety of reasons. In a developing country like Bangladesh there will be options which will become important in the future. The potential for such options is either non-existent or too little at the present time. Two such options are efficiency improvement in cement clinker grinding plants and the use of the IGCC technology for coal power generation.

The large demand for cement is being met by clinker grinding factories. These factories import clinker from different countries and perform the energy-intensive grinding in the country. The technology used in the grinding factories is not state-of-the-art because the small investors who set up these plants cannot afford the best technology. At present there are 17 such plants, but the projected number for the year 2012 is more than 50. In Fig. 7 and 8 the emissions from cement are predominantly due to the clinker grinding plants.

In Section 4.1 mention was made of the possibility of opting for the IGCC technology for the coal plant to be built in the future. However, because the Government does not have its own funds, it is looking at bilateral sources for the coal power plant. In that case the possibility of having a CDM project is remote because the developer would not be allowed to get the technology from a third country.

7 References

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