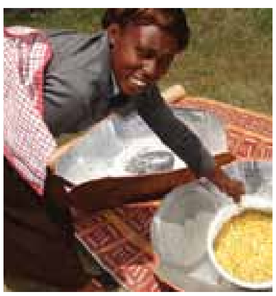
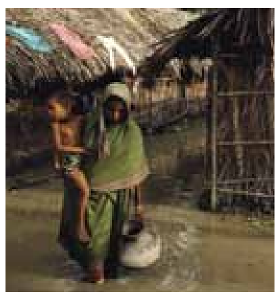
BANGLADESH: ENERGY SECTOR

Assessing the Investments & Financial Flows Required to Mitigate Climate Change





UNDP ENVIRONMENT & ENERGY GROUP | MAY 2011

Capacity development for policy makers: addressing climate change in key sectors

In May 2008, the United Nations Development Program (UNDP) launched the global project, "Capacity Development for Policy Makers to Address Climate Change". The overall goals of the project are twofold:

- Increased national capacity to raise awareness and co-ordinate Ministerial and stakeholder views on climate change, leading to enhanced participation in the UNFCCC process;

- Support for long-term climate change planning and priority setting, using assessments of investment and financial flows to address climate change in key sectors, which can provide a better understanding of the magnitude and intensity of national efforts needed to tackle climate change, as well as provide more accurate estimates of the funds needed to implement mitigation and adaptation actions.

Bangladesh is one of the 15 countries participating in the project that undertook the assessment of investment and financial flows, using a UNDP methodology. National experts in Bangladesh identified three key sectors for the assessment: energy (for mitigation actions), and agriculture and water (for adaptation options).

This project was made possible with funding from the governments of Norway, Switzerland, and Finland, as well as UNDP and the United Nations Foundation.

Disclaimer
The views expressed in this publication are those of the author(s) and do not necessarily represent those of the United Nations, including UNDP, or their Member States.

Acknowledgements
The author(s) gratefully acknowledge the technical comments received from Susanne Olbrisch, UNDP, and The Energy and Resources Institute (TERI), based in India, which operated as a regional centre of excellence under this project.

UNDP GLOBAL PROJECT: CAPACITY DEVELOPMENT FOR POLICY MAKERS TO ADDRESS CLIMATE CHANGE

Assessment of the Investments and Financial Flows to Mitigate Climate Change in the Energy Sector

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MAY 2011

CONTENTS

1	**Introduction**	**4**
1.1	Objectives	4
1.2	Background	4
1.2.1	*Major Documents & Plans*	*4*
1.2.2	*Institutional Arrangements and Collaborations*	*5*
1.2.3	*Basic Methodology and Key Terminology*	*6*
2	**Scope, Data Inputs, and Scenarios**	**9**
2.1	Scope	9
2.2	Data Inputs and Scenarios	9
2.2.1	*Assessment Period and Cost Accounting Parameters*	*9*
2.2.2	*Analytical Approach*	*10*
2.2.3	*Historical IF, FF, and O&M Data, and Subsidies*	*10*
2.2.4	*Baseline Scenario*	*17*
2.2.5	*Mitigation Scenario*	*29*
3	**Results**	**38**
3.1	Incremental Changes in IF, FF, O&M Costs, and Subsidy Costs	38
3.2	Policy Implications	44
3.3	Key Uncertainties and Methodological Limitations	52
4	**References**	**53**

Acronyms and Abbreviations

ADB	Asian Development Bank
BPDB	Bangladesh Power Development Board
BB	Bangladesh Bank
BERC	Bangladesh Energy Regulatory Commission
BPC	Bangladesh Petroleum Corporation
CC	Combined Cycle
DSM	Demand Side Management
EIA	Energy Information Administration
FF	Financial Flow
GSMP	The Gas Sector Master Plan
IF	Investment Flow
O&M	Operation and Maintenance
PSMP	The Power Sector Master Plan
PGCB	Power Grid Company of Bangladesh
REB	Rural Electrification Board
WB	World Bank

1. INTRODUCTION

Although not an MDG goal per se, energy is nevertheless central to the development of sustainable economic, environmental and social progress. For these to be realized, though, the kinds of energy and the manner in which they are produced and used, have to be changed. Otherwise, the effects of 'carbonization' of the atmosphere that is occurring because of the way energy is being used may drastically alter the way we live today. The complex energy systems that the world has built, though, will be difficult to change and it will require a concerted and determined effort by all everywhere – the producers, users and planners.

The purpose of this report is to provide an assessment of the investment and financial flows that will be required to lower the carbon footprint of the energy sector in Bangladesh as it expands its supply. More specifically, the report analyses the changes needed in the investment and physical assets and in the programmatic measures to mitigate GHGs emitted as result of increasing use of fossil fuels in different activities in the energy sector.

1.1 Objectives

The overall objective of the investment and financial flows (I&FF) assessment is to determine the extent and sources of funds that will be required to address climate change concerns at national level in the energy sector. Specifically, the study aims to ensure the following outcomes:

- Developing consolidated information on I&FF currently taking place in the energy sector;
- A projection of the business as usual I&FF scenario without carbon mitigation measures;
- Identification of measures to address climate change and projections of future I&FF associated with their implementation; and
- Finally, to prepare least-cost GHG abatement projections.

1.2 Background

Bangladesh's energy infrastructure is quite small, insufficient and poorly managed. The mainstay of the energy supply continues to be traditional renewables such as wood, animal wastes, and crop residues, estimated to account for over half of the country's consumption.

Electricity is the major source of power for most of the country's economic activities. Bangladesh's installed electric generation capacity was 4.7 GW in 2009; only three-fourth of which is considered to be 'available'. Only 40% of the population has access to electricity with a per capita availability of 136 kWh per annum. Overall, the country's generation plants have been unable to meet system demand over the past decade.

1.2.1 Major Documents & Plans

The Power Sector Master Plan (PSMP), the Gas Sector Master Plan (GSMP), the Perspective Plan and the Strategic Transport Plan are the driving plan documents used to forecast planned investments in the power and energy sectors. The plans and programs enunciated in these documents form the baseline plans for investment in these sectors. These plan documents have been revised from time to time in response to changes in aggregate demand, the fuel supply mix and the assumptions made in the forecasting models. For example, until 2010 Bangladesh was almost entirely a mono-fuel economy but as the supply of natural gas began to tighten, the need to diversify fuel use became imperative. Since then the situation has become acute as the gap between supply and demand for natural gas, the mainstay of the energy sector, has widened greatly. This resulted in changes being wrought in with far greater rapidity and urgency which has/is not reflected in the published data. Hence, discussions with planners, other analytical studies and reasoned judgment have been used to create a realistic baseline projection for the period 2010 to 2030.

Reference of Manuals Used For Analysis/Evaluations and Final Output Calculations

- UNDP: Methodology Guidebook
- GOB: Energy Policy, 1996
- GOB: Vision Statement
- GOB: Towards Revamping Power and Energy Sector
- GOB: Power Sector Master Plan
- GOB: Gas Sector Master Plan
- GOB: Outline Perspective Plan of Bangladesh (2010-2021)
- PC: Bangladesh Power Sector Data Book
- GOB: Strategic Transport Plan.

1.2.2 Institutional Arrangements and Collaborations

The project was implemented by the Ministry of Environment and Forests (MoEF). The Secretary of the Ministry is the National Focal Point (FP) for climate change and in such capacity is also the chairperson of the Country Team (CT) of the project. The Secretary provided policy guidance to it and maintained overall oversight of the activities through the Joint Secretary (Development), MoEF who was designated as the Administrative Focal Point of the project for coordination of the team leaders and the National Project Coordinator (NPC). In addition, there were 2 more Team Focal Points who assisted the FP and the Project Focal Point in coordinating the activities of the project in the 3 key sectors as well as in other areas (policy, advocacy and consolidated I&FF) on behalf of the government.

While the MoEF was the lead ministry for the study, the Ministries of Agriculture, Water Resources and Power & Energy took the lead in their sectors. Other ministries with cross-cutting or cross-thematic or inter-sectoral linkages such as the Ministries of Disaster Management, Health, Food, Land, Fisheries & Livestock, Local Government, Communication, Science & Technology, Industries, Commerce, Finance, and Planning played key roles in the thematic area consultative groups together with relevant civil society, NGOs, academia and think tanks.

The Ministry of Energy & Mineral Resources is the apex government institution responsible for formulating energy policies for the country. The Ministry has two divisions, Power and Energy both headed by a sub-cabinet level Minister and each division by a Secretary. The Power Division which, as the name implies is concerned with power policies and the Energy and Mineral Resources Division with fuels and minerals. The Ministry as a whole is responsible for:

- Overall governance of the energy sector dealing with institutional changes, relationships to other sector policies, international co-operation, local participation, developing plans and programs, initiating demonstration projects;
- Voluntary and legal agreements between Government and key stakeholders, for example, between industry and petroleum sectors;
- Economic issues such as pricing policies, economic incentives, fiscal allocation for specific programs, levies and taxes; and
- Information activities such as labelling of appliances, information and awareness campaigns, demonstration projects.

Role of Government in Energy Service Delivery

In Bangladesh, the role of government in the energy sector can be summarized as follows:

- **Investment and policy planning:** This is the responsibility of the National Economic Council (NEC) dvised by the Ministry of Energy, Power and Mineral Resources and the Planning Commission (PC). The PC recommends proposals initiated by the Ministry to the NEC for approval. In general, policies promoting foreign and local private sector investments are the responsibility of the Board of Investment (BOI) and the sponsoring Ministry;
- **Project processing:** involving project identification, preparation, approval and implementation between sponsoring Ministry, PC and where appropriate, the BOI;
- **Tactical and operational oversight and administration:** On the power side, management, operation and administration of existing generation assets is the responsibility of the Power Development Board (PDB) which provides power to utilities serving urban areas such as DESCO, DPDC as well to REB which serves rural customers. Transmission assets are the responsibility of the Power Grid Company of Bangladesh (PGCB). And on the fuels side, the Oil and Gas Corporation (Petrobangla), manages, operates and administers existing assets through a number of parastatals. The Bangladesh Petroleum Corporation (BPC) carries out similar responsibilities with regard to liquid fuels; rural energy provision is the responsibility of the Rural Electrification Board (REB) which supplies grid electricity along with private companies and NGO's who are promoting decentralized systems in renewable energy; private-public partnership program promotion and administration is the responsibility of the Power Cell (PC); and Regulation: regulation, tariff setting and permitting is the responsibility of the Bangladesh Energy Regulatory Commission (BERC).

1.2.3 Basic Methodology and Key Terminology

The methodological approach of the national assessment of I&FF mitigation followed the eight steps outlined in the methodological guide:

1. Establishing key assessment parameters

Key parameters were identified to:

- Determine in detail the scope of the sector;
- Identify the preliminary measures of mitigation;
- Specify the period of evaluation and the reference year; and
- Select an analytical approach.

2. Compiling historical data

In this exercise, data for the period 2005 to 2010 was compiled to elaborate on the state of the energy sector and to ensure that the projections of plans and programs correspond closely to targets.

3. Defining the baseline

Defining the baseline is a significant exercise and is the basis for determining the cost deltas between the "business-as-usual" scenarios and the more efficient alternatives, the mitigation scenarios. To do this existing plans and programmes had to be identified and projections developed for the outer years of the analysis period.

4. Estimating the I&FF scenario in the baseline

In this section of the framework approach the analysis involved:

- Estimates of I&FF annually disaggregated by investment entity and funding source
- Estimates the O&M annually disaggregated by investment entity and funding source
- Estimate annual subsidy costs for each relevant investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment.

5. Defining potential mitigation scenarios

This involved identifying the mitigating interventions for each sub-sector of the energy sector and listing them for each type of asset.

6. Deriving detailed annual I&FF estimates

This required:

- Estimating annual changes I&FF and EM required to implement mitigation scenarios;
- Estimating the annual IF, FF, and O&M costs, and subsidy costs, if included, explicitly, for mitigation scenario;
- Estimating the annual IF and FF for each investment type, disaggregated by investment entity and funding source;
- Estimating the annual O&M costs for each IF, disaggregated by investment entity and funding source; and
- Estimating annual subsidy costs for each relevant investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment.

7. Calculate the changes in IF, FF, and O&M costs, and in subsidy costs if included explicitly, needed to implement mitigation

- Calculate changes in cumulative IF, FF, and O&M costs for all investment types
- Calculate changes in annual IF, FF, and O&M costs for individual investment types, for individual sources of funds, and for all investment types and funding sources
- If subsidies are included explicitly, consider calculating changes in cumulative and/or in annual subsidies for IF, FF, and O&M for each investment type and all investment types.

8. Assessing policy implications

These highlight the need to:

- Integrate climate change in regional projects, regional and national strategy,
- Strengthen the capacities of all stakeholders,
- Integrating these options in national reference
- Involve local entities proactively; give responsibility/empowerment to the people
- Develop activities that support the generation of income/revenue.

It is expected that this national assessment of I&FF will increase greater awareness and understanding of future investments that address climate change as well as development priorities.

Definitions

Mitigation

In the context of climate change, the UN defines mitigation in terms of human interventions to reduce the sources or enhance the sinks of greenhouse gases. In the energy sector these interventions include using fossil fuels more efficiently for industrial processes or electricity generation, switching to renewable energy (solar energy or wind power), improving insulation of buildings and altering consumption behaviour so that end-use efficiency will all remove greater amounts of GHGs from the atmosphere.

Investment Flows (IF)

Investment flows (IF) are defined as the amount of capital needed for new physical assets with lifespan of more than one year. Examples would be the amount of capital required for the purchase of solar PV kits or a photovoltaic park, a program of reforestation, national parks.

Financial flows (FF)

Financial flows (FF) are the ongoing expenditures on programmatic measures; the FF covers expenditures other than those needed for the expansion or installation of new physical assets.

Operation and Maintenance (O&M) costs

The O&M cost is the expenditure associated with the operation and maintenance of the asset acquired. Examples include ongoing fixed and variable costs such as salaries and raw materials.

Investment Entity

An investment entity is the body or thing making the investment in the asset. This study defines three types of investment entities: families, companies and government.

Sources of I&FF

The sources of I&FF are the origins of the funds invested by investment entities, e.g. domestic equity, foreign debt, domestic subsidies, foreign aid.

Households

Households are individuals or groups of people (e.g. families) acting as one unit financially. Households invest in assets such as houses, farms, crop fields. It is assumed that all their investment funds, including capital (savings), debt (borrowing from friends, family, financial institutions) and government support in form of grants (that is to say-refundable deductions tax, tax credits on purchases) are national funds, to simplify the estimation of I&FF.

Corporations

The companies include both financial firms as non-financial businesses, and organizations may be profit or non-profit. Financial firms are entities such as banks, credit unions and insurance companies that provide financial services to non-financial business, households and governments. The non-financial firms produce goods (such as fossil fuels, electricity, food or wood). The non-governmental organizations are a kind of company of non-profit. Firms invest in physical assets and programs. Their sources of investment funds are from domestic sources and external sources and can be in the form of shares (shares in domestic capital markets and FDI), debt (loans from commercial banks and bonds sold in capital market), national government support (subsidies) or public foreign aid (in the form of grants and loans conditional preference, known as ODA or ODA).

Governments

Governments are the national, provincial, county and local governments of a country. Financial and non-financial corporation's owned wholly or in part by governments, such as public universities, research institutions and publicly held oil companies, utilities and management of waters and forestry authorities belong to this category. Government entities invest in physical assets and long-term programs and services that provide public benefits.

Scenario

A scenario is an internally consistent and plausible characterization of future conditions over a specified period. For each sectoral assessment of I&FF for mitigation, it must include a baseline scenario and a mitigation scenario for that sector. In both cases, the baseline scenario describes the conditions of the status quo, that is to say, this is a description of what will probably happen if no new policy measure to address climate change is put in place.

Mitigation Scenario

The mitigation scenario includes measures to mitigate GHG emissions, that is to say, the mitigation scenario should describe the expected socio-economic developments, technological change (if appropriate), new measures to mitigate GHG emissions and the expected investment in the sector given the implementation of mitigation measures.

Assessment period

The assessment period is the time horizon for assessment i.e. the number of years.

Base Year

The base year is the first year of the assessment period, that is to say the first year of baseline, mitigation and adaptation. The base year should be a recent year for which information on the I&FF and O&M is available so that the IF, FF and O&M costs for the first year of these scenarios are all historical data. In fact, the reference year as the starting waves of cost data for each scenario is based.

2. SCOPE, DATA INPUTS AND SCENARIOS

2.1 Scope

Although the energy sector can be sub-divided in any number of ways, it was decided, for ease of analysis, to disaggregate it into four broad sub-sectors on the basis of whether the activities and assets are supply or demand based. A framework that clearly identifies supply and demand linkages not only lends itself to ease of analysis, it also helps identify the potential mitigation measures more systematically. Based on this approach, the sector was broken down into the following sub-sectors:

SUPPLY SIDE:
1. Production of Primary Energy:
Natural Gas and Coal mining
2. Production of Secondary Energy:
Electricity (Generation, Transmission and Distribution) and Liquid Fuels
DEMAND SIDE
1. Demand for Primary Energy
Natural Gas (Electricity, Fertilizer & Boilers)
Coal (Electricity and Brick Manufacturing)
2. Demand for Secondary Energy
Grid Electricity (Industry, Commercial and Households)
CNG for Transport
Liquid Fuels for Transport

From the above framework, it can be seen that the scope of the present I&FF study covers the energy sector from both the supply and demand sides. On the demand side, the major uses of primary fossil energy are in the production of electricity and in the manufacture of bricks and as a fuel to produce steam for boilers; and of secondary energy in transport and in industry. Except for that used in the fertilizer industry, there is little, if any, energy used as feedstock in other industries. Bangladesh has a large urea ammonia industry but its expansion has, for all practical purposes, been shelved and, therefore, not relevant for the report period except from a retrofitting point of view. Almost all primary energy used in the "industry" category is either for electricity production or steam generation in boilers and for heating and drying in textiles.

2.2 Data Inputs and Scenarios

2.2.1 Assessment Period and Cost Accounting Parameters

Assessment Period

The time horizon chosen for the analysis is 25 years beginning with the "base year" 2005 and ending in the "framework year" 2030. Such a timeline was adopted, in part, to provide historical data and perspective and, in part, to provide depth to the planning horizon. It is noteworthy, however, that the period between 2005 and 2008-2009 was a period of severe inflation in construction costs of power generating plants jumping in some cases by as much as 25% to 30% over the base year and in some technologies (coal) by as much as 85% and wind almost doubling (NY Times, June 2007). Such large changes were unusual and not in line with long run cost trends. And yet these changes must be taken into account in expected future cost trends. One way to do this is to shift the base year and assume steady escalations from the new base year. In this study a new base year, 2010, was chosen which is referred to as the "reference year" to distinguish it from the real base year, 2005. This means that all future costs have been discounted to 2010 and not to 2005. Furthermore, because of the large price escalations during the period, using historical data prior to 2005 does not serve any useful purpose and hence has been ignored. The study, therefore, treats the years between the base year and the reference year as the historical period.

Inflation Rate:

The rate of inflation rate assumed in the study is 6% per year. This rate reflects historical trends which can be seen from Table 2.1. However, this rate is a domestic rate and thus it may not be fully meaningful in projecting future investment costs since most plant and equipment need to be imported. In such cases cost escalations internationally are more important. Nevertheless, all future costs, investment and O&M, have been escalated at this rate on the assumption that this is reasonable and close to international cost escalations.

Table 2.1: Inflation rate (2004-2009)

YEAR	INFLATION RATE %
2004-05	5.32
2005-06	5.73
2006-07	8.34
2007-08	3.54
2008-09	5.94

Source: Bangladesh Bank CPI

Discount Rate / Cost of Capital

The rate used to discount future cash flows to its present value is a key variable of the NPV process. The discount rate is the cost of capital used to calculate the annual costs associated with a capital investment for a generating unit. Higher discount rates make near-term costs more important than costs in later years. The discount factor used also varies according to the type of project. For instance, projects that have 'lumpy' returns that is low returns in the early years and high in the later but are important from a social point of view use a 'social discount rate' which is usually lower than the cost of money. This is one way to price non-priced externalities.

Our analysis, however, uses the classical cost of money approach and return on equity concept. This is because the government is actively pursuing private capital to finance the generation expansion program. Sound privately owned utilities in industrial countries have inflation-adjusted costs of capital (considering the weighted average of debt and equity) of about 8% per year or slightly below. For Bangladesh projects, a 12% discount rate /cost of capital is more appropriate given the riskier environment than a stable industrial economy and because it closely corresponds to the average market rates of interests during the last few decades.

2.2.2 Analytical Approach

UNDP's "Methodology for Assessing Investment and Financial Flows to Address Climate Change" is the master manual that has guided this study. It has been supplemented for detailed approach, calculation, and method by:

- The ALGAS Study
- 1st and 2nd National Communications
- Authors selection of the analytical approach
- Numerous international and domestic studies.

Data Collection Methods

One way to define the method of data collection would be to describe it as a "bottom up" approach. A simple data collection and compilation method was used and where it was not available from a single source, multiple sources were used and approximations made. Much of the data especially those for the initial years of the study period was obtained from data published by the Ministry of Energy and its related agencies.

This report relies on the Bangladesh Bureau of Statistics and the Ministry of Energy and its affiliated agencies such as the Power Development Board, Petrobangla and to a lesser extent the Rural Electrification Board as its major sources for the data. The O&M calculations relied on data gathered from secondary information sources available nationally and internationally and from research papers and published reports. These were supplemented by direct surveys of institutions and planners. Separate data collection questionnaires (data-formats) were prepared and personal visits made to various institutions relevant to each energy sub-sector to clarify and expand on the published data and sometimes to verify findings as required by the approach adopted in the study. This enabled the compilers to generate additional supplementary information. In some instances the available data was converted using standard conversion factors to recast them in the relevant formats.

2.2.3 Historical If, Ff, And O&M Data, And Subsidies: Historical Context

Primary Energy Production

In Bangladesh, there are two principal primary energy resources, natural gas and coal. These are mined and used mostly in the production of secondary energy, some for use directly by industry bulk feedstock and as fuel in the transport sector.

Natural Gas: Since the discovery of the first well at Sylhet in 1955, a total number of 23 gas fields have been explored successfully. From Table 2.2 we can see that about 2000 MMCFD of gas is produced from these fields.

Table 2.2: Gas Scenario Snapshot

TOTAL NUMBER OF GAS FIELDS	23
Number of producing gas fields	17 (79 wells)
Extractable gas reserves (proven and probable)	20.5 TCF
Total consumption of gas up to April 2010	8.5 TCF
Total reserve remaining	12 TCF
Daily Gas Production	2000 MMCFD (APROX)

Source: Energy and Mineral Resources Division, 2010

Coal: Even as recently as a decade ago all of Bangladesh's coal needs were met from imports. Since 2005 though, some coal, about 1.8 million is being mined at Barapukuria. About 2,355 million tons of coal deposits (Table2.3) have been discovered in five locations in northern Bangladesh. Total peat reserves in Bangladesh are estimated at about 600 million tons. In some rural areas, locally extracted peat is used for domestic cooking and in small industries.

Table 2.3: Coal Reserve Estimates

LOCATION & YEAR OF DISCOVERY	DEPTH (METER)	MINE AREA (SQ. KM.)	ESTIMATED RESERVES (MILLION TON)
Boropukuria, Dinajpur (1985)	119-506	6.88	390
Khalashpur , Rangpur (1995)	257-483	12	143 (GSB)
Fhulbaria, Dinajpur (1997)	150-240	30	572
Jamalganj, Bogura (1965)	900-1000	16	1050
Dighipara, Dinajpur(1995)	327	Not Available	200 (Partial Evaluation)

Source: Energy and Mineral Resources Division, 2010

Secondary Energy Production

In the Secondary Energy Production sub-sector major activities relate to the production of electricity, its transmission and distribution and to a lesser on the production of liquid fuels. Liquid fuel production is mostly carried out at the lone refinery in Chittagong although some condensate is recovered from natural gas liquids.

Electricity Generation: At the time of partition of India in the year 1947, power generation and its distribution was in the hands of few private companies who generated a total of 21 MW. No transmission system existed. By 2008 the installed capacity was 5,202 MW but the available capacity was 3,717 (Table 2.4).

Table 2.4: Installed and Available Power Generation Capacity 2004-2008

YEAR	INSTALLED CAPACITY (MW)		AVAILABLE CAPACITY (MW)	ELECTRICITY GENERATION (GWH)		LOAD SHEDDING (MW)
	BPDB	IPP	BPDB+IPP	BPDB	IPP	
2004	3,420	1,260	3,592	13,342	7,478	694
2005	3,735	1,260	3,720	14,067	7,939	770
2006	3,895	1,260	3,782	15,416	8,286	1,312
2007	3,872	1,330	3,717	15,494	8,244	1,345
2008	3,814	1,388	4,130	16,155	9,138	2,087

BPDB = Bangladesh Power Development Board, GWh = gigawatt-hour, IPP = independent power producer,
Source: ADB Report

Electricity Transmission and Distribution: The high voltage transmission system consists of a 230 KV loop around Dhaka with radial extensions to the other regions. The 132 KV systems initially extended radially from Dhaka to the other regions, but now include loops ringing Dhaka and Chittagong, and larger loops in the Southern, Western, and Northern regions (Table 2.5).

Table 2.5: Existing Transmission Lines (2005)

REGION	VOLTAGE , NOMINAL KV	LENGTH, CIRCUIT-KM
Southern	230	623
	132	1326
Dhaka	230	673
	132	597
Central	132	804
Western	230	140
	132	990
Northern	132	1151
Total	230	1436
	132	4868

Table 2.6: Existing 230/132 KV Transformers (2005)

REGION	CAPACITY (MVA)
Southern	675
Dhaka	2800
Northern	450
Total	3925

Source: Power Grid Company

Petroleum Fuel: In 2005, total import of crude oil and refined petroleum products was about 1.0425 million tons and 0.847 million tons, respectively. This has now risen to over 3.7 million metric tons. Imported crude oil is refined at the lone refinery in Chittagong to produce secondary fuels such as liquid propane gas, naphtha, gasoline, furnace oil, bitumen and other oil products. There is also a small amount of distillates produced from natural gas liquids, about 6856 tons, at north-eastern gas fields.

Table 2.7: Production of Petroleum Products (2003-2008) (Quantity in Metric Tonnes)

PETROLEUM PRODUCTS	LIQUEFIED PETRO-LEUM GAS (LPG)	NAPHTHA	MOTOR SPIRIT (MS)	HIGH OCTANE BLENDING COMPOUND (HOBC)	SUPERIOR KEROSENE OIL (SKO)	DIFFERENT TYPES OF DIESEL	DIFFERENT TYPES OF FURNACE OIL	PETROL (MS)	REDUCED CRUDE OIL (RCO)
2003-2004	23,985	71,342	79,082	43,287	338,126	29,728	29,895	9,382.19	411,369
2004-2005	22,755	79,948	59,902	39,327	204,863	348,359	88,430	8,843.24	343,822
2005-2006	23,914	121,631	52,852	40,865	311,379	316,603	0	8,219.94	316,699
2006-2007	17,507	120,235	37,299	38,202	315,178	256,762	34,092	11,686.11	402,172
2007-2008	15,033	134,561	42,868	34,655	262,758	269,909	14,101	18,918.10	395,737

Source: Bangladesh Petroleum Corporation

Demand for Primary Energy

Natural Gas: Natural gas is the most significant source of commercial energy accounting for almost 75% of all commercial energy consumption in Bangladesh. Out of 483 PJ energy supplied from natural gas, the major share was accounted for by grid and captive generation (55%) while non-energy sectors such as fertilizer production, manufacturing and tea paroduction, residential use, commercial and transports accounted for about 21%, 11.5%, 11.5% 1% and 1%, respectively. The share of natural gas in different uses in the National Energy Balance is presented in Table 2.12.

Table 2.8: Demand for Natural Gas by Sector 2004-2009

FISCAL YEAR	CONSUMPTION (BCF)									
	POWER	FERTI-LIZER	INDUS-TRY	CAPTIVE POWER	TEA ES-TATES	BRICK FIELDS	COMMER-CIAL	DOMESTIC	CNG	TOTAL
2004-05	211.02	93.97	51.68	37.87	0.80	0.00	4.85	52.49	3.62	456.30
2005-06	222.72	88.58	63.44	49.02	0.76	0.00	5.24	57.13	6.71	493.60
2006-07	221.10	93.47	77.48	62.51	0.75	0.00	5.66	63.25	11.90	536.12
2007-08	234.28	80.23	78.67	92.19	0.71	0.00	6.60	69.02	22.80	584.50
2008-09	256.30	94.70	74.85	104.30	0.65	0.00	7.46	73.78	31.00	643.04

Source: Energy and Mineral Resources Division

Coal: Up to 2005, the main demand for coal was for manufacturing bricks. Total coal consumed by brick entities was 2.2 million tons in 2005. However, from 2006 coal began to be used for the first time to produce electricity at a 250 MW mine-mouth power plant in the Barapukuria coal mine. The changing use pattern is reflected in the data compiled in (Table 2.9) below.

Table 2.9: Demand for Coal 2005-2010

YEAR	POWER PLANT (TONNES)	BRICK KILN (TONNES)
2005	0	2,195,841
2006	631,596	2,318,245
2007	631,596	2,447,471
2008	631,596	2,583,901
2009	631,596	2,727,936
2010	631,596	2,880,000

Source: Authors Compilations

Demand for Secondary Energy

Electricity: In 2005, the total installed generating capacity was 5025 MW including the 250 MW coal-fired plants at Barapukuria. However, only 80% of this installed capacity could be used to supply 21,408 MkWh to the grid. This is mainly due to the operational performance capacity (that is plant efficiencies and availability) of the major generating entity, the PDB. Erratic power supply caused by inadequate maintenance, corruption and bureaucratic delays continues to disrupt industrial production, household supply, water and sewage services and irrigation.

Table 2.10: Sector wise consumption of Electricity In Million Kilowatt Hour

YEAR	DOMESTIC	INDUSTRIAL	COMMERCIAL	OTHERS	TOTAL
2005	6946	7153	1243	994	16336
2006	8910	9175	1595	1274	20954
2007	9006	9275	1612	1288	21181
2008	9619	9906	1722	1375	22622
2009	10020	3734	2049	6098	21901

Source: BBS Statistical Pocket Book

Petroleum Products: The sector-wise consumption of the petroleum products for the year 2004-2005, converted into common energy units is shown in Table 2.11. The transport sector is by far the largest consumer of petroleum products at about 52%, followed by the domestic sector at about 15%, *agriculture* about 20%, power generation about 9% and industry about 4%. Non-energy uses account for another 2.0 peta joules of consumption which is equivalent to about 1.25% of the total consumption. Non energy uses are asphalt bitumen, lubricants, solvents.

Table 2.11: Consumption of Petroleum Products by Sector 2004-2005 (in Metric Tonnes)

YEAR	AGRICULTURE	INDUSTRIAL	POWER	TRANSPORT	DOMESTIC & OTHERS	TOTAL
2004-05	744,260	139,161	336,834	1,968,138	579,337	3,767,730
2005-06	792,606	99,399	325,101	2,031,101	533,575	3,781,782
2006-07	722,829	145,334	253,724	1,938,644	513,394	3,573,925
2007-08	702,767	153,304	264,455	2,040,026	465,722	3,626,274

Source: Statistical Pocket Book Bangladesh 2009

Energy Balance

The national energy balance of Bangladesh for the year 2004-05 and summarized in Table 2.12 clearly shows that natural gas is Bangladesh's only significant indigenous source of commercial energy.

Table 2.12: The Energy Balance 2004-2005 (in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis)

SUPPLY AND CONSUMPTION	COAL AND PEAT	CRUDE OIL	PETROLEUM PRODUCTS	GAS	NUCLEAR	HYDRO	GEOTHERMAL, SOLAR, ETC.	COMBUSTIBLE RENEWABLE AND WASTE	ELECTRICITY	HEAT	TOTAL*
Production	0	0	1174.08	10910.23	0	0	0	16,958.65	0	0	
Imports	535.81	0	2731.74	0	0	0	0	0	0	0	
Exports	0	0	-82.20	0	0	0	0	0	0	0	
International Marine Bunkers**	0	0	0	0	0	0	0	0	0	0	
International Aviation Bunkers**	0	0	0	0	0	0	0	0	0	0	
Stock Changes	0	0	0	0	0	0	0	0	0	0	
TPES	535.81	0	3823.62	10910.23	0	0	0	16,958.65	0	0	
Transfers	0	0	0	0	0	0	0	0	0	0	0
Statistical Differences	0	0	0	0	0	0	0	0	0	0	0
Electricity Plants	0	0	0	0	0	0	0	0	0	0	0
CHP Plants	0	0	0	0	0	0	0	0	0	0	0
Heat Plants	0	0	0	0	0	0	0	0	0	0	0
Gas Works	0	0	0	0	0	0	0	0	0	0	0
Petroleum Refineries	0	0	0	0	0	0	0	0	0	0	0
Coal Transformation	0	0	0	0	0	0	0	0	0	0	0
Liquefaction Plants	0	0	0	0	0	0	0	0	0	0	0
Other Transformation	0	0	0	0	0	0	0	0	0	0	0
Own Use	0	0	0	0	0	0	0	0	0	0	0
Distribution Losses	0	0	0	-682.52	0	0	0	0	0	0	-0
TFC	535.81	0	3823.62	10227.71	0	0	0	16,958.65	0	0	0

Industry sector	**535.81**	**0**	**141.22**	**1176.31**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Transport sector	**0**	**0**	**1997.19**	**81.14**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Power sec-tors	**0**	**0**	**342.08**	**5578.73**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Residential	**0**	**0**	**587.89**	**1176.53**	**0**	**0**	**0**	**16,958.65**	**0**	**0**	**0**
Commercial and Public Services	**0**	**0**	**0**	**108.71**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Agriculture / Forestry	**0**	**0**	**755.25**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Fishing	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Fertilizer	**0**	**0**	**0**	**2106.28**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Non-Energy Use	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
- of which Petrochemi-cal Feed stocks	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***

** Totals may not add up due to rounding.*
*** International marine and aviation bunkers are not included min the transport sector.*

2.2.4 Baseline Scenario

Production of Primary Energy

Natural Gas: Natural gas has been the mainstay of the energy economy of Bangladesh since the 1960s. The foreign currency burden associated with importing energy led Bangladesh to concentrate on natural gas since it was/is a domestic resource. Its exploitation and use was the first and invariably the only choice which resulted in the mono fuel economy of today. Its price too was set low ignoring its true economic value. This is the reason why cost of energy in Bangladesh is amongst the lowest in the region: the price of natural gas, for example, is $1.1/GJ and $2/GJ for the power and industry sectors respectively. Consequently, the price of electricity is also low, about US¢ 5/kWh for both industry and households.

Another striking feature of the sector is the little upstream activities conducted in the last decade even though there is a looming shortage. The remaining recoverable (2P) gas reserve was estimated to be only 12 Tcf in 2009. Even without exploration activities, most experts agree that there is significant field growth potential in wells that are presently producing, most state-owned fields have yet to be fully appraised. The transmission infrastructure is lagging too: the average growth rate over the last 17 years has been about 10 percent annually but its supply has grown at about 8.7% leading to the demand and supply gap that we see today about 500 mmcfd, currently supply being limited to 2000 mmcfd.

Demand Forecast

Demand for gas for the period 2010 to 2030 is provided in Table 2.13. The projections in the Table have been developed on the assumption that availability of gas will be limited in the coming years and, therefore, its use should be limited to areas where it could be more useful and necessary. Hence, the plan assumes limited or no growth in the fertilizer and household sectors and in the transport sector, growth will be limited slowing down to zero from 2015 onwards. Hence, the demand drivers will be the power and industrial sectors. Based on these factors and assumptions, the sector-wide demand schedule for natural gas has been developed in the Table.

Table 2.13: Projection of sector-wise demand for Natural Gas, 2010-2030 Billion Cubic Feet (Bcf)

YEAR	POWER	CAPTIVE POWER	FERTILIZER	INDUSTRY	HOUSEHOLD	CNG	TOTAL
2010	283.69	120.90	62.05	63.15	88.90	37.20	655.88
2011	221.81	120.90	62.05	68.20	88.90	40.81	602.67
2012	232.19	120.90	62.05	73.65	88.90	44.77	622.46
2013	283.34	120.90	62.05	79.54	88.90	49.11	683.84
2014	322.03	120.90	62.05	85.91	88.90	53.87	733.66
2015	309.71	120.90	62.05	92.78	88.90	59.10	733.44
2016	334.38	120.90	62.05	100.20	0.00	59.10	676.63
2017	362.94	120.90	62.05	108.22	0.00	59.10	713.21
2018	379.84	120.90	62.05	116.88	0.00	59.10	738.76
2019	408.40	120.90	49.00	126.23	0.00	59.10	763.63
2020	417.51	120.90	49.00	136.33	0.00	59.10	782.83
2021	441.60	120.90	49.00	147.23	0.00	59.10	817.83
2022	463.68	120.90	46.65	159.01	0.00	59.10	849.34
2023	492.24	120.90	32.79	171.73	0.00	59.10	876.76
2024	519.45	120.90	32.79	185.47	0.00	59.10	917.70
2025	532.06	120.90	32.79	200.31	0.00	59.10	945.15
2026	550.50	120.90	32.79	216.33	0.00	59.10	979.62
2027	545.50	120.90	32.79	233.64	0.00	59.10	991.93
2028	554.80	120.90	18.93	252.33	0.00	59.10	1006.06
2029	580.52	120.90	18.93	272.51	0.00	59.10	1051.96
2030	593.13	120.90	18.93	294.32	0.00	59.10	1086.37
Total	8829.32	2538.90	972.82	3183.96	533.40	1171.33	17229.73
Percentage	*51.24%*	*14.74%*	*5.65%*	*18.48%*	*3.10%*	*6.80%*	*100.00%*

Source: Towards Revamping Power and Energy Sector Plan, Finance Division, GoB

Projected Production Schedule for Natural Gas:

Based on the demand projections, a Production Schedule for natural gas for the period 2010 to 2030 was developed as shown in Table 2.14. Part of the projection that is up to 2015, has already been translated into investment plans by the government; and part, beyond 2015 has been constructed on the expected demand growth in the power and industry sectors.

On the supply side, the projections assume that the supply in the production schedule is expected to come either from existing wells or partly from new fields. A number of studies conducted in recent years on natural gas reserves and undiscovered resource potential have all concluded that Bangladesh has a mean undiscovered gas resource of at least 32 Tcf. The two most widely recognized studies are the United States Geological Survey (USGS)/ Petrobangla Study (2001), which concluded that the mean undiscovered resource potential was about 32.1 Tcf and the Hydrocarbon Unit/Norwegian Petroleum Directorate (NPD) Study also in 2001, which concluded that the mean undiscovered resource potential was even higher at 41.6 Tcf. These studies, however, only took into account offshore acreage to a water depth of 200m and so the potential for greater resources exist.

Table 2.14: Planned & Projected Natural Gas Production 2010-2030

YEAR	TOTAL DAILY PRODUCTION (BCF)	TOTAL YEARLY PRODUCTION (BCF)	CUMULATIVE PRODUCTION (BCF)
2010	2.23	814.41	814.41
2011	2.54	925.37	1,739.77
2012	2.84	1,036.33	2,776.10
2013	3.14	1,147.29	3,923.39
2014	3.45	1,258.25	5,181.63
2015	3.75	1,369.21	6,550.84
2016	4.17	1,520.83	8,071.67
2017	4.63	1,689.78	9,761.45
2018	5.15	1,878.09	11,639.54
2019	5.72	2,088.05	13,727.58
2020	6.36	2,322.20	16,049.78

Gas Transmission Program:

Based on projected expansion plan for natural gas and spatial needs, a program to extend the transmission assets was designed. The planned line extensions for the period 2010-2023 as shown in Table 2.17 is based on the Gas Sector Master Plan. During this period the line will be extended by 808 km. The projected expansion during 2024 -2030 is a 30" pipeline of 404 Km.

Table 2.15: Gas Transmission Line Expansion Program

PROPOSED PROJECT	SEGMENT	PLANNED & PROJECTED EXPANSION PROGRAM
2009-10	Muchai to Ashuganj	82 km of 30"
	Ashuganj to Elanga	125 km of 30"
2011-12	Bakhrabad to Chittagong	178 km of 30"
2012-13	BAKHRABAD TO S/SW	224 km of 24"
2013-14	Muchai	2 x 15,000 hp compressors
2014-15	Ashaganj to Elanga	125 km of 30"
2016-17	Elanga west	91 km of 30"
2018-19	BKB to S/SW	2 x 15,000 hp compressors
2019-20	Muchai to Ashuganj	82 km of 30"
2020-21	Ashuganj to Elanga	125 km of 30"
2022-23	Bakhrabad to Chittagong	2 x 15,000 hp compressors
2024-2030	Expansion of 404 Km	404 km pf 30"

Coal: At present, 2010, the demand for coal comes from two primary sources: production of bricks and electricity production. In 2010, most of the coal went ot eh brick sector and a small amount to the mine-mouth power plant at Barapukuria. This situation will change drastically from 2015 as the country moves away from its dependence on natural gas to other fuels, principally coal for its power production. This is reflected in Table 2.16 which is a reflection of the expected growth in demand for coal.

Table 2.16: Baseline Projection for Coal demand 2010-2030

YEAR	POWER PLANT (000' MT)	BRICK KILN (000' MT)	TOTAL (000' MT)
2010	632	2,880	3,512
2011	632	3,032	3,664
2012	632	3,192	3,824
2013	947	3,361	4,308
2014	947	3,538	4,486
2015	7,516	3,725	11,241
2016	8,710	3,922	12,632
2017	9,905	4,129	14,033
2018	11,099	4,347	15,446
2019	12,293	4,576	16,869
2020	13,488	4,818	18,305
2021	14,682	5,072	19,754
2022	15,876	5,340	21,216
2023	17,070	5,622	22,692
2024	18,265	5,919	24,184
2025	19,459	6,231	25,690
2026	20,653	6,560	27,214
2027	21,848	6,907	28,754
2028	23,042	7,271	30,313
2029	24,236	7,655	31,892
2030	25,431	8,060	33,490
Total	267,362	106,157	373,519

Source: Authors Compilation

At the present moment, the government has no plans to mine coal at any location other than at Barapukuria. In the short term until extraction technology issues have been sorted out, the country is expected to rely on imported coal and that mined at Barapukuria. On the assumption though that mining activities to extract coal from other fields will be started upon sorting out the technology issues, the production program shown in Table 2.17 has been developed. The assumption in the investment design is that domestic production will replace imports as it comes on stream. Accordingly, investment in the Phulbari field will begin in 2014 and production will begin in 2016. Annual production from Phulabari is expected to be 15Mt. Similarly, investment in the Khalashpur field is assumed to begin in 2017 and supply will begin in 2019. Annual production expected from this field will be about 18Mt. The reason why these particular fields have been chosen for mining is because the coal streams are at relatively shallow depths.

Table 2.17: Projection of Coal Production 2010-3020

YEAR	ACTUAL PRODUCTION ('000 MT)	PROJECTED PRODUCTION ('000 MT)	TOTAL PRODUCTION ('000 MT)
2010	714	0.00	714
2011	714	0.00	714
2012	714	0.00	714
2013	714	0.00	714
2014	714	0.00	714
2015	714	0.00	714
2016	714	15000.00	15,714
2017	714	15000.00	15,714
2018	714	15000.00	15,714
2019	714	33000.00	33,714
2020	714	33000.00	33,714
2021	714	33000.00	33,714
2022	714	33000.00	33,714
2023	714	33000.00	33,714
2024	714	33000.00	33,714
2025	714	33000.00	33,714
2026	714	33000.00	33,714
2027	714	33000.00	33,714
2028	714	33000.00	33,714
2029	714	33000.00	33,714
2030	714	33000.00	33,714
Total	14,984	441,000	455,984

Source: Authors Compilation

Baseline Costs for Primary energy:

Table 2.18 summarizes the primary energy production baseline costs. The Table shows that over a 21 year period a total of USD 44 billion will be spent for the development of new gas fields and work-over of older fields. The investment requirement for development and extension of the natural gas transmission system will be US 1.4 billion and that for the development of coal mines will be US$ 1.3 billion. All figures are in 2010 US dollars. The year-wise breakdown of the above summary is provided in Table 2.19 below.

Table 2.18: Baseline cost for Primary Energy by Investment type and entity

CATEGORY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	NATURAL GAS PRODUCTION			NATURAL GAS TRANSMISSION			COAL PRODUCTION			BRICK KILN (FCK)			GAS BOILER			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Government	15410.32		0.00	1468.50		31.25	0.00		1510.34	0.00		0.00	0.00		0.00	16878.82		1541.59
Corporations	28626.11		0.00	0.00		0.00	1136.42		5256.26	317.39		15333.50	2432.34		0.00	32512.27		20589.75
Total	44036.43		0.00	1468.50		31.25	1136.42		6766.59	317.39		15333.50	2432.34		0.00	46958.75		22131.34

Table 2.19: Baseline cost for Primary Energy by Investment type

YEAR	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	NATURAL GAS PRODUCTION			NATURAL GAS TRANSMISSION			COAL PRODUCTION			BRICK KILN (FCK)			GAS BOILER			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	1204.45		0.00	199.00		4.00	0.00		17.68	15.62		756.80	42.71			1419.07		778.48
2011	1295.23		0.00	0.00		0.00	0.00		19.87	15.61		754.08	47.56			1310.84		773.94
2012	1372.83		0.00	160.00		3.20	0.00		22.32	15.55		751.36	51.76		0.00	1548.39		776.88
2013	1438.41		0.00	162.00		3.20	0.00		25.08	15.50		748.66	56.34		0.00	1615.90		776.94
2014	1493.01		0.00	59.00		1.80	52.78		28.18	15.44		745.96	61.32		0.00	1620.24		775.94
2015	1537.64		0.00	113.00		2.30	49.96		31.67	15.39		743.28	66.74		0.00	1715.98		777.24
2016	1616.42		0.00	0.00		0.00	47.28		302.73	15.33		740.60	72.64		0.00	1679.03		1043.33
2017	1699.77		0.00	82.00		1.60	98.34		292.82	15.28		737.93	79.06		0.00	1895.38		1032.35
2018	1787.99		0.00	0.00		0.00	93.07		284.21	15.22		735.28	86.04		0.00	1896.28		1019.49
2019	1881.38		0.00	59.00		1.80	88.08		548.71	15.17		732.63	93.65		0.00	2043.63		1283.14
2020	1980.27		0.00	86.00		1.70	83.36		528.26	15.11		729.99	101.93		0.00	2164.74		1259.95
2021	2084.99		0.00	113.00		2.30	78.90		510.01	15.06		727.36	110.94		0.00	2291.95		1239.67
2022	2195.92		0.00	0.00		0.00	74.67		493.98	15.00		724.75	120.74		0.00	2285.60		1218.72
2023	2313.46		0.00	59.00		1.80	70.67		480.20	14.95		722.14	131.42		0.00	2458.08		1204.14
2024	2438.01		0.00	53.79		1.08	66.88		468.73	14.90		719.54	143.03		0.00	2573.58		1189.34
2025	2570.03		0.00	53.79		1.08	63.30		459.63	14.84		716.95	155.68		0.00	2701.96		1177.66
2026	2709.98		0.00	53.79		1.08	59.91		453.00	14.79		714.37	169.44		0.00	2838.47		1168.45
2027	2858.38		0.00	53.79		1.08	56.70		448.95	14.74		711.79	184.41		0.00	2983.60		1161.82
2028	3015.76		0.00	53.79		1.08	53.66		447.62	14.68		709.23	200.72		0.00	3137.89		1157.93
2029	3182.70		0.00	53.79		1.08	50.79		449.16	14.63		706.68	218.46		0.00	3301.90		1156.92
2030	3359.80		0.00	53.79		1.08	48.07		453.78	14.58		704.13	237.77		0.00	3476.23		1158.99
Total	44036.43		0.00	1468.50		31.25	1136.42		6766.59	317.39		15333.50	2432.34		0.00	46958.75		22131.34

Production of Secondary Energy

Electricity: Generation Expansion Program

All through the last decade, electricity supply has lagged behind demand; the country's generation plants have been unable to meet system demand. Recent surveys and studies show that failure to adequately manage the load has resulted in the loss of industrial output worth about $1 billion a year which is equivalent to a reduction in GDP growth by about half a percentage point. There are numerous reasons for this, among them administrative inaction, plant mismanagement and corruption.

Outline Perspective Plan

The 1994 paper "Power Sector Reforms in Bangladesh" which outlined a reform process focusing on institutional issues and the 2000 Vision and Policy Statement which set a time bound target for supplying power to all citizens were the seminal declarations to reform and expand the power sector. The latter objective coupled to the need to make electricity available in sufficient quantity and quality to achieve a high GDP growth rate became the basis for the development of a power systems plan. Accordingly, a net load and net energy generation program for three potential growth scenarios: Low (4.5%), Base (5.2%), and High (8%) was developed by Nexant (…). The Power Sector Master Plan covered the period 2010-2025. The generation plan embodied in the model was entirely natural gas based and it assumed that sufficient gas equivalent to 9.5 TCF would be available for the pants during the plan period.

In addition to macro management targets, the plan also aimed at certain sub-objectives:

- Ensure reliable and quality supply of electricity;
- Increase sector efficiency;
- Develop demand management and energy efficiency measures;
- Develop alternative/renewable energy sources;
- Base new generation on a least cost expansion plan; and
- Expand transmission in balance with the generation capacity.

The earlier plan has now been revised partly because of its dependency on a single fuel and partly because planned investments were not implemented up to 2010. According to projections by Petrobangla, present gas reserves and production are inadequate to serve the existing power system alone let alone additional plants. It is highly probable though that additional gas reserves could be found but the risks associated with assured supply do not justify the high dependency on it in the PSMP. A similar situation prevails in the coal sub-sector. Although Bangladesh has substantial high grade coal deposits, its exploitation in the near term appears 'politically' unlikely. A planned 100 MW expansion of the existing hydro plant is the only substantial additional hydro feasible in the country. Imported coal or petroleum products are the other main options for fuel supply in the near to middle term.

The revised plan, Electricity Outline Perspective Plan, introduces a different fuel mix with a higher degree of dependency on liquid fuels and coal while retaining flexibility in fuel use through its planned dependency on dual fuel equipment. The revised plan also assumes a higher and more ambitious GDP growth rate. Based on these changes, the revised plan established generation targets for the period 2010 to 2020. We have projected the government's plan to 2030 based on the assumptions implicit in the Perspective Plan.

- Generation capacity by 2010 7,327 MW
- Generation capacity by 2015 15,000 MW
- Generation capacity by 2021 20,000 MW
- Generation Target by 2030 32,790 MW

Planned investments in the Reference Year, 2010, are expected to increase generation capacity by 1,927 MW so that the sum of existing and planned expansion will amount to 7,327 MW in that year. Between 2010 and 2015, the planned increase in generation capacity will add another 5,500 MW to the grid. By 2021 the government plans to expand the total generation capacity to 20,000 MW but it does not specify the mix of fuels and plant sizes by location. Annual capacity expansion for the period 2021-2030 is based on the assumption that the mix and type of plants and the growth rates will follow trends. Table 12 details the generation expansion program for the period 2010 to 2030.

Table 2.20: Planned & Projected Electricity Generation 2010-2030

YEAR	CUMULATIVE GENERATION (MW)
2010	1927
2011	2847
2012	5166
2013	6709
2014	7879
2015	9464
2016	11106
2017	12748
2018	14390
2019	16032
2020	17673
2021	19315
2022	20957
2023	22599
2024	24241
2025	25883
2026	27525
2027	29167
2028	30809
2029	32450
2030	34092

Based on the above generation program the Cumulative Discounted IF, FF and O&M by Investment type and entity is provided in Table 2.21 and Annual Discounted IF, FF and O&M by Investment type in Table 2.22.

Transmission & Distribution:

The transmission system consists of 230 KV and 132 KV lines. At present most of the 230 KV transmission assets have been upgraded and almost doubled from the 2005 base to a total of 2644.5 circuit kilo meters and the 132 KV to 5715 circuit kilo-meters an increase of about 20 percent over the 2005 levels. This existing system must, however, be further extended so that the additional power that will result from implementing the Outline Perspective Plan can be evacuated from plant sites and distributed to consumers. The expansion plan calls for the PGCB to build an additional 3,000 kilo meters by 2015.

The total urban distribution grid of 266,460 kilo meters served about 11.7 million customers up to 2010. New projects have been planned to develop an additional 60,000 kilo meter distribution lines by 2015. In addition to the urban system, the Bangladesh Rural Electrification Board (REB) maintains its own distribution system which it administers through 70 cooperatives called Palli Biddyut Samities (PBSs). Till 2010, 53,281 or about 62% of Bangladesh's 86,038 villages (Census 1991) have been connected to the REB 33/11 KV grid system. The REB expansion program includes a short term (up to 2015) and a medium term (up to 2021). These plans along with those of the urban utilities are detailed in Table 2.23 below.

Table 2.21: Transmission & Distribution Expansion Plan 2010-2030

YEAR	400KV LINE (KM)	230KV LINE (KM)	132KV LINE (KM)	DISTRIBUTION LINE (KM)	DATA TYPE
2010	0	0	0	15217	Planned
2011	0	0	0	26900	
2012	168	217	110	26900	
2013	30	203	312	26900	
2014	0	0	0	26900	
2015	452	40	0	26900	
2016	113	80	73.2	29900	Projected
2017	113	80	73.2	29900	
2018	113	80	73.2	29900	
2019	113	80	73.2	29900	
2020	113	80	73.2	29900	
2021	113	80	73.2	29900	
2022	113	80	73.2	29900	
2023	113	80	73.2	29900	
2024	113	80	73.2	29900	
2025	113	80	73.2	29900	
2026	113	80	73.2	29900	
2027	113	80	73.2	29900	
2028	113	80	73.2	29900	
2029	113	80	73.2	29900	
2030	113	80	73.2	29900	
Total	2345	1660	1520	598217	

Source: Authors Compilation

Table 2.22: Baseline Cost of Generation by Investment type and entity

CATEGPRY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	GAS-FIRED POWER PLANTS-SIMPLE CYCLE			GAS-FIRED POWER PLANTS-COMBINED CYCLE			COAL-FIRED POWER PLANTS-CONVEN-TIONAL			DIESEL POWER PLANTS			HFO-BASED POWER PLANTS			WIND TURBINE POWER PLANTS		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	161.77		57.45	1690.24		400.02	16308.71		1842.83	270.99		145.85	1479.23		693.67	238.92		43.51
Household	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
Government	531.91		216.18	3217.10		751.20	813.08		94.65	134.85		64.75	946.72		483.60	0.00		0.00
TOTAL	693.68		273.63	4907.34		1151.22	17121.79		1937.48	405.84		210.60	2425.95		1177.27	238.92		43.51

Table 2.23: Baseline Cost of Generation by Investment type

YEAR	ANNUAL IF, FF & O&M ESTIMATE FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	GAS-FIRED POWER PLANTS-SIMPLE CYCLE			GAS-FIRED POWER PLANTS-COMBINED CYCLE			COAL-FIRED POWER PLANTS-CONVEN-TIONAL			DIESEL POWER PLANTS			HFO-BASED POWER PLANTS			WIND TURBINE POWER PLANTS		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	186.68		7.33	80.70		2.08	0.00		0.00	270.99		17.08	611.23		34.82	0.00		0.00
2011	0.00		6.93	254.57		8.55	0.00		0.00	0.00		16.16	353.36		46.97	0.00		0.00
2012	0.00		6.56	401.56		18.46	0.00		0.00	134.85		20.64	784.84		85.72	121.90		1.40
2013	170.17		12.40	570.07		32.19	175.63		2.55	0.00		19.54	204.20		91.61	0.00		1.40
2014	0.00		11.74	841.67		52.21	0.00		2.42	0.00		18.49	0.00		86.70	0.00		1.40
2015	0.00		11.11	0.00		49.41	3272.19		49.84	0.00		10.86	0.00		61.45	0.00		1.40
2016	32.10		11.98	262.90		53.55	1303.08		66.10	0.00		10.28	45.01		60.34	19.50		1.63
2017	30.38		12.72	248.82		57.11	1233.27		80.48	0.00		9.73	42.60		59.17	19.50		1.85
2018	28.75		13.35	235.49		60.13	1167.20		93.13	0.00		9.20	40.32		57.95	19.50		2.08
2019	27.21		13.87	222.87		62.67	1104.67		104.20	0.00		8.71	38.16		56.69	19.50		2.30
2020	25.75		14.31	210.93		64.76	1045.49		113.81	0.00		8.25	36.11		55.40	19.50		2.53
2021	24.37		14.65	199.63		66.44	989.48		122.09	0.00		7.80	34.18		54.09	19.50		2.75
2022	23.07		14.92	188.94		67.76	936.48		129.16	0.00		7.39	32.35		52.76	0.00		2.75
2023	21.83		15.11	178.82		68.75	886.31		135.12	0.00		6.99	30.61		51.41	0.00		2.75
2024	20.66		15.24	169.24		69.44	838.83		140.07	0.00		6.62	28.97		50.06	0.00		2.75
2025	19.56		15.32	160.17		69.86	793.89		144.10	0.00		6.26	27.42		48.71	0.00		2.75
2026	18.51		15.34	151.59		70.03	751.36		147.30	0.00		5.93	25.95		47.35	0.00		2.75
2027	17.52		15.32	143.47		69.98	711.11		149.74	0.00		5.61	24.56		46.01	0.00		2.75
2028	16.58		15.25	135.78		69.74	673.01		151.50	0.00		5.31	23.25		44.67	0.00		2.75
2029	15.69		15.15	128.51		69.32	636.96		152.64	0.00		5.02	22.00		43.34	0.00		2.75
2030	14.85		15.02	121.62		68.75	602.84		153.22	0.00		4.75	20.82		42.03	0.00		2.75
Total	693.68		273.63	4907.34		1151.22	17121.79		1937.48	405.84		210.60	2425.95		1177.27	238.92		43.51

Table 2.22: Baseline Cost of Generation by Investment type and entity (continued)

CATEGPRY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR BASELINE SCENARIO (IN MILLION 2010USD)											
	SOLAR POWER			RICE HUSK			NUCLEAR POWER			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	2491.45		177.98	594.66		83.79	0.00		0.00	23235.98		3445.10
Household	480.00		764.25	0.00		0.00	0.00		0.00	480.00		764.25
Government	3584.69		375.68	0.00		0.00	3434.29		604.52	12662.64		2590.58
TOTAL	6556.14		1317.91	594.66		83.79	3434.29		604.52	36378.62		6799.93

Table 2.23: Baseline Cost of Generation by Investment type (continued)

YEAR	ANNUAL IF, FF & O&M ESTIMATE FOR BASELINE SCENARIO (IN MILLION 2010USD)											
	SOLAR POWER			RICE HUSK			NUCLEAR POWER			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	0.00		15.75	0.00		0.00	0.00		0.00	1149.60		77.06
2011	15.00		17.25	0.00		0.00	0.00		0.00	622.94		95.86
2012	80.69		19.65	0.00		0.00	0.00		0.00	1523.84		152.43
2013	15.00		21.15	0.00		0.00	0.00		0.00	1135.08		180.85
2014	22.50		23.40	0.00		0.00	0.00		0.00	864.17		196.35
2015	15.00		24.90	0.00		0.00	0.00		0.00	3287.19		208.97
2016	228.95		29.96	29.15		0.58	0.00		0.00	1920.69		234.43
2017	228.95		35.03	29.15		1.17	0.00		0.00	1832.66		257.26
2018	221.45		39.34	29.15		1.75	3434.29		65.18	5176.15		342.13
2019	228.95		44.41	29.15		2.33	0.00		59.76	1670.51		354.94
2020	228.95		49.48	29.15		1.00	0.00		56.55	1595.89		366.08
2021	228.95		54.54	29.15		3.50	0.00		53.53	1525.27		379.39
2022	560.20		64.77	46.64		4.43	0.00		50.66	1787.66		394.60
2023	552.70		74.26	46.64		5.36	0.00		47.94	1716.91		407.70
2024	560.20		84.49	46.64		6.30	0.00		45.38	1664.54		420.34
2025	552.70		93.97	46.64		7.23	0.00		42.94	1600.37		431.14
2026	560.20		104.20	46.64		8.16	0.00		40.64	1554.25		441.71
2027	560.20		114.43	46.64		9.09	0.00		38.47	1503.49		451.41
2028	560.20		124.67	46.64		10.03	0.00		36.41	1455.46		460.32
2029	567.70		135.65	46.64		10.96	0.00		34.46	1417.50		469.29
2030	567.70		146.63	46.64		11.89	0.00		32.61	1374.47		477.66
Total	6556.14		1317.91	594.66		83.79	3434.29		604.52	36378.62		6799.93

Table 2.24: Baseline cost of T&D by Investment type and Entity

CATEGORY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR BASELINE SCENARIO (IN MILLION 2010USD)														
	TRANSMISSION LINE 400KV			TRANSMISSION LINE 230KV			TRANSMISSION LINE 132KV			DISTRIBUTION LINE			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Government	627.70			324.02			373.48			5574.63			6899.83		
Corporations	1105.31			544.26			560.63						2210.20		
Total	1733.01			868.28			934.11		0.00	5574.63		0.00	9110.04	0.00	0.00

Table 2.25: Baseline cost of T&D by Investment type

YEAR	ANNUAL IF, FF & O&M ESTIMATE FOR BASELINE SCENARIO (IN MILLION 2010USD)														
	TRANSMISSION LINE 400KV			TRANSMISSION LINE 230KV			TRANSMISSION LINE 132KV			DISTRIBUTION LINE			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	0.00			0.00			0.00			238.91			238.91		
2011	0.00			0.00			0.00			399.71			399.71		
2012	187.43			113.07			27.14			378.29			705.93		
2013	121.10			135.29			341.37			358.03			955.79		
2014	0.00			60.78			0.00			338.85			399.62		
2015	353.15			67.45			0.00			320.69			741.29		
2016	102.09			46.86			53.90			337.36			540.21		
2017	96.62			44.35			51.01			319.29			511.27		
2018	91.45			41.97			48.28			302.19			483.88		
2019	86.55			39.72			45.69			286.00			457.96		
2020	81.91			37.59			43.25			270.68			433.43		
2021	77.52			35.58			40.93			256.18			410.21		
2022	73.37			33.67			38.74			242.45			388.23		
2023	69.44			31.87			36.66			229.46			367.44		
2024	65.72			30.16			34.70			217.17			347.75		
2025	62.20			28.55			32.84			205.54			329.12		
2026	58.87			27.02			31.08			194.53			311.49		
2027	55.71			25.57			29.41			184.10			294.80		
2028	52.73			24.20			27.84			174.24			279.01		
2029	49.90			22.90			26.35			164.91			264.06		
2030	47.23			21.68			24.94			156.07			249.92		
Total	1733.01			868.28			934.11			5574.63			9110.04		

Demand for Secondary Energy

Transport:

In the last three decades, transportation has been one of the priority sectors of the government. During this period around USD 40 billion has been invested in the transport sector alone. The road sector has received by far the major share of this expenditure, exceeding investments in the other modes. Currently, about 90 percent of transport sector's budget goes for maintenance and development of roads and highways. As a result, roadway inventory and the motorized vehicle population have experienced very high growth. This can be seen from the historical data group in Table 2.26. Assuming similar growth patterns which is a reasonable assumption since GDP growth is expected to be even more than the past years, projections have been extrapolated up to 2030.

Table 2.26: Growth of motor vehicles up to 2030

YEAR	NO. OF VEHICLES (CUM.)	DATA TYPE
2003	737400	Historical Data
2004	786602	
2005	852480	
2006	932785	
2007	1054057	
2008	1198476	
2009	1343719	
2010	1504897	
2011	1614539	Projection
2012	1724182	
2013	1833824	
2014	1943467	
2015	2053109	
2016	2162752	
2017	2272394	
2018	2382036	
2019	2491679	
2020	2601321	
2021	2710964	
2022	2820606	
2023	2930249	
2024	3039891	
2025	3149533	
2026	3259176	
2027	3368818	
2028	3478461	
2029	3588103	
2030	3697746	

The estimated forecast for the 2030 is shown in the following figure. Passenger growth has been reported from 11.75 billion to 131.75 billion during 1973-2007 periods with an average growth rate of 7.45% per year. Freight transport has grown at a faster rate with 8.46% per year from 1.44 billion to 21.87 billion in the same period. Transportation forecasting has been done based on recent trends (data from 90s onwards) shows that by 2030 PKM and TKM will go to around 220 billion and 39 billion respectively; while energy use reaches almost 85000 TJ at 2030.

Table 2.27: Projected growth of passenger, freight and energy use in transport sector

YEAR	PKM (BILLION)	TKM (BILLION)	ENERGY (TJ)
2011	139.81	23.65	52630.90
2012	144.07	24.45	54323.00
2013	148.33	25.25	56015.11
2014	152.59	26.05	57707.22
2015	156.85	26.85	59399.32
2016	161.11	27.65	61091.43
2017	165.37	28.45	62783.53
2018	169.63	29.25	64475.64
2019	173.89	30.05	66167.75
2020	178.15	30.85	67859.85
2021	182.41	31.65	69551.96
2022	186.67	32.45	71244.06
2023	190.93	33.25	72936.17
2024	195.19	34.05	74628.28
2025	199.45	34.85	76320.38
2026	203.71	35.65	78012.49
2027	207.97	36.45	79704.59
2028	212.23	37.25	81396.70
2029	216.49	38.05	83088.81
2030	220.75	38.85	84780.91

Table 2.28: Baseline Cost of Transport by Investment type and Entity

CATEGORY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	HIGHWAY			MASS TRANSIT (BRT, METRO)			TRAFFIC MAN-AGEMENT			RAILWAY			WATERWAY			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Government	1019.01			2308.61			26.95			639.65			31.98			4026.20		
Corporations	0.00			0.00			0.00									0.00		
Total	1019.01			2308.61			26.95		0.00	639.65		0.00	31.98		0.00	4026.20	0.00	0.00

Table 2.29: Baseline Cost of Transport by Investment type

YEAR	ANNUAL IF, FF & O&M ESTIMATE FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	HIGHWAY			MASS TRANSIT (BRT, METRO)			TRAFFIC MANAGE-MENT			RAILWAY			WATERWAY			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	39.20			37.60			6.00			50.00			2.50			135.30		
2011	37.10			35.59			5.68			47.32			2.37			128.05		
2012	35.11			33.68			5.37			44.79			2.24			121.19		
2013	33.23			31.88			5.09			42.39			2.12			114.70		
2014	31.45			30.17			4.81			40.12			2.01			108.55		
2015	136.68			182.24			0.00			37.97			1.90			358.79		
2016	129.36			172.48			0.00			35.93			1.80			339.57		
2017	122.43			163.24			0.00			34.01			1.70			321.38		
2018	115.87			154.49			0.00			32.19			1.61			304.16		
2019	109.66			146.22			0.00			30.46			1.52			287.87		
2020	38.98			294.07			0.00			28.83			1.44			363.32		
2021	36.89			278.31			0.00			27.29			1.36			343.86		
2022	34.91			263.41			0.00			25.82			1.29			325.43		
2023	33.04			249.29			0.00			24.44			1.22			308.00		
2024	31.27			235.94			0.00			23.13			1.16			291.50		
2025	10.25			0.00			0.00			21.89			1.09			33.23		
2026	9.70			0.00			0.00			20.72			1.04			31.45		
2027	9.18			0.00			0.00			19.61			0.98			29.77		
2028	8.69			0.00			0.00			18.56			0.93			28.17		
2029	8.22			0.00			0.00			17.56			0.88			26.66		
2030	7.78			0.00			0.00			16.62			0.83			25.23		
Total	1019.01			2308.61			26.95			639.65			31.98			4026.20		

2.2.5 Mitigation Scenario

In the energy sector emissions from fossil fuels can be reduced in several ways: by switching to low-carbon and renewable technologies, by increasing energy efficiency and by reducing demand for carbon-intensive products. Reducing non-fossil fuel emissions are also an important source of emission savings. This study, however, focuses only on one of the ways, switching to low carbon intensive technologies as a way to mitigating emissions from the use of fossil fuels.

A range of low-carbon technologies are already available, although most are currently more expensive than fossil-fuel equivalents, at least, in initial investments are concerned and GHG externalities are not considered. Cleaner and more efficient power, heat and transport technologies are needed to make radical emission cuts in the medium to long term. Their future costs are uncertain, but experience with other technologies has helped to develop an understanding of the key risks. The evidence indicates that efficiency is likely to increase and average costs to fall with scale and experience. It is also uncertain which technologies will turn out to be the least expensive in terms of unit savings so a portfolio of choices will be required for low-cost abatement. Moreover, with time new technologies may emerge that may make today's technologies less efficient. The intervention choices and the associated costs will, therefore, depend largely on the selected approach. Below some of these are highlighted:

2.2.5.1 Mitigating Sectors

For the purposes of this study, Second National Communication (SNC) the following GHG mitigation sectors/areas have been taken into consideration. DSM techniques have not been considered even though this may be a significant source of GHG abatement.

- Primary Energy: Gas and Coal Mining
- Secondary Energy Production (only power)
- Transport – road, rail and water
- Energy Intensive Industries – Bricks (direct users of primary energy)
- Cross Sectoral Options: Boilers and Motors.

Gas

Natural gas is a blend of gaseous hydrocarbons consisting mainly of methane (CH4). The natural gas in Bangladesh consists of about 94-96% methane with the remainder consisting of other hydrocarbons. Natural gas is of interest for climate change mitigation both for its potential role as a low-carbon substitute for other fossil fuels and for the direct warming effect of un-combusted methane. Compared to the average air emissions from coal, natural gas produces half as much carbon dioxide and less than a third as much nitrogen oxides.

Natural gas is extracted at wells and transported by pipelines to processing facilities and ultimately to end users in the electricity sector, in industry and to households for cooking. Unlike other fossil fuels, its use requires infrastructure that is used only for the transport of natural gas. However, once it is delivered and combusted fully, natural gas has the lowest carbon dioxide intensity of any of the fossil fuels (~55kg CO2 per GJ, about half of that of coal). When good practices are followed, there are very little fugitive emissions in its extraction but potentially larger in its use since it may escape un-combusted into the air. Therefore, GHG abatement from natural gas use is in the main a DSM issue.

Coal Mining

From the perspective of climate change, GHG emissions can result from coal mining in two fundamental ways: fugitive emissions, mainly methane (coal-bed methane), during mining and carbon dioxide, (CO_2) from combustion during use. In Bangladesh, the contribution to GHG emissions from mining is at present insignificant although that from its use in the production of bricks is fairly large about 6million tons annually. However, since coal extraction may become a substantial source of primary energy in the coming years, the method of extraction and the way it is used will be most significant. Specific energy efficiency and conservation measures that can be adopted in its extraction will involve:

- use of high efficiency motors and generators
- use of variable drives to improve the energy efficiency of operations
- design of piping systems with insulation to reduce heat losses
- design of piping systems with appropriate pipe sizes

to reduce pressure drops and therefore reduce pumping energy requirements

- use of graded road surfaces on site and maintenance of optimum tyre pressure to maximize fuel economy
- Development of a comprehensive equipment database that includes documentation on all major equipment highlighting their energy use and maintenance requirements
- Consideration of the total 'life-cycle' costs when making decisions about capital expenditure; and
- Management of on-site building lighting, heating and cooling requirements and loads.

Electricity Production

The mitigation measures proposed here are:

- Conversion of simple cycle gas turbine plants to combined cycle,
- Addition of 'carbon capture and storage' (CCS) to combined cycle plants and
- Addition of CCS measures to conventional coal-fired plants.

Improved corporate governance, managerial autonomy, and performance-based incentives can significantly change institutional performance even if there is no change in ownership and personnel. The improved operational and managerial performance due to the commercialization and corporatisation of the Power Grid Company of Bangladesh (PGCB) and DESA AND DESCO have demonstrated that full privatization alone is not an essential requirement for improved performance; appropriate incentives and a corporate culture can sometimes be a good substitute.

Electricity Transmission & Distribution

In general, the distribution infrastructure in Bangladesh is old and overloaded: demand growth is being catered to from existing infrastructure without optimising the distribution lines and sub-stations as is required by good practice. This is especially true in the rural network system. A study conducted in three REB units, revealed that the distribution loss can be reduced by 4-5% simply by:

- Correcting the power factor using capacitor banks and
- Using bigger sized conductors.

The situation in many urban areas is no better and due mostly to the haphazard supply expansion because of demand increases from rapid urbanization. Many feeders are overloaded to the point that the resulting technical system losses are nearly double that of what would have been normally. Studies show, that upgrading the distribution infrastructure in the country alone can reduce technical losses by nearly 8%.

Transport sector

Mitigation measures in the transport sector are very difficult to implement. Even more difficult is to quantify the GHG reduction. Nevertheless it is an important option for any country because a sizable portion of the GHG emission comes from this sector. Moreover, with GDP growth and increasing prosperity, the transport sector has, in the past, and continues to experience, into the foreseeable future, faster growth than other sectors.

The following steps can be considered as potential mitigation measures for the transport sector of Bangladesh:

- Road – vehicle efficiency improvement, mass rapid transit and traffic management
- Railway – diesel to electricity; shift passenger and freight from road to railway
- Water – efficient engines; shift passenger and freight from road to water.

Vehicle efficiency: more efficient use of fuel: Fuel efficient vehicles represent a significant option for mitigation. For Bangladesh, the development of fuel-efficient technology remains an external factor because all motorized vehicles are either imported or assembled using imported technology and parts.

However, some enforcement measures can be effective in this regard including removal of old and outdated vehicles. These vehicles lose their efficiency with time and burn more fuel as they age. Government has already taken some steps to remove them from the roads.

Reducing congestion: There are a number of ways in which congestion can be reduced. One set of interventions, low cost and relatively simple, would include traffic management, driver training, good urban planning and zoning; and the other, involving large investment costs, improving and expanding infrastructure.

Traffic management is an important low cost way to reduce fuel use since it will lead to an easing of congestion on roads and highways. At the very basic, traffic management is the maximum use of existing infrastructure, using traffic operations enforcement, materials and equipments to achieve safe and efficient movement of people and goods. The opportunities and potential benefits from better, more efficient use of the existing transport services and infrastructure are very high in Bangladesh. It is also the most cost effective means to address and resolve operational and system capacity problems. The role and use of advanced technology may represent a future possibility, but only if and when basic levels of traffic management are first achieved.

Infrastructure expansion, the other way to reduce traffic congestion, particularly in the capital Dhaka, is also part of the package of interventions and is now being implemented. These include introducing viable mass transit systems, underground railways, elevated light rail, rapid transit (BRT) and expansion of the road grid and elevated highways are being planned.

Modal shift to more fuel efficient modes

Railway: Studies have found that rail traffic to move both passengers and freight is more efficient than road traffic. A passenger-kilometer of rail traffic is 2-3 times more efficient than buses and freight-kilometer 5-6 times than trucks. Modal shift through expansion and upgrading the railway system can be a a good mitigation option. Since the government has a commitment to enhance rail services in the country, the expansion of the rail transport system can be considered as one of the mitigation options.

Waterway: The following are the characteristics of water transport of Bangladesh established through a survey of road, rail and water transport for passenger and freight:

- Water transport is the most efficient mode in terms of energy use, more than even railway.
- In the waterway mode, a passenger-kilometer 3-4 times more efficient than buses and freight-kilometer is 8-10 times more efficient than trucks.

Brick manufacturing

From a climate change perspective, brick making is one of the largest sources of anthropogenic emissions in Bangladesh accounting for almost 15% of the total industrial emissions. The predominant brick making technology is the highly inefficient Fixed Chimney Kiln (FCK) which constitutes almost 90% of the total kilns in the country. This has led to the introduction of cleaner technologies that require less energy and also create less pollution. In this study, Hybrid Hoffman Kiln (HHK) has been considered as the major mitigating technology to replace the existing FCKs in the brick making industry.

The following issues were considered during the mitigation stage:

- No of existing kilns (new & old) in 2010 was estimated as 4400;
- New kiln growth rate was assumed to be 5.28% (GEF study);
- An HHK is considered to be equivalent to 7.5 FCK units with respect to production;
- Annual Production of FCK kilns was estimated as 12 Billion in 2010;
- Coal consumption per million brick was taken as 240 Tonnes; and
- Annual CO_2 emission per brick was taken 0.0007024 tCO_2 (CDM Analysis).

Cross Sectoral: Boilers and Motors

Boilers: The Second National Communication notes that there are more than 5000 registered boilers in Bangladesh, most of which are operating in the 70% efficiency region. It also notes that boilers in the Textile Dyeing are in dilapidated condition and even those in the more modern RMG sector are also not being properly maintained and operated. The most prospective size range for intervention in boiler efficiency improvement is the 1-5 Ton/h because more than 50% of the boilers are in this size range.

In order to improve the boiler efficiency by at least 8% on an average, the following mitigating measures should be taken:

1. Installation of Economizers,
2. Installation of Pre heaters
3. Installation of auto blow down systems.

The number of registered boiler, according to the 2nd National Communication is about 5000. With this baseline, the analysis assumes a 15% growth rate in boiler use. There are no data available to estimate growth in boilers, so this study has used the growth projected for the knitwear industry which is a good barometer of the expected growth rate of boilers. These figures are from the BKMEA website.

Motors: Since more than 80% of the electricity in industries is consumed by motors, they are a it is always worthwhile to consider mitigation options for motors. Consumption of electricity due to motors can be reduced by:

- Intelligent Motor Controllers (IMC)
- Variable speed drives or Cyclo-converters
- Efficient motors.

These are all standard measures, but because these increase the investment cost, entrepreneurs do not opt for these options. Efficiency improvement of motors is considered to be a difficult option in Bangladesh because all large motors are imported, and retrofitting motors have been found to be difficult. Moreover, at this time the government has no intervention planned.

2.2.5.2 Costs of Mitigation

Reducing emissions of greenhouse gasses that cause climate change will entail additional costs. Costs include the expense of developing and deploying low-emission and high-efficiency technologies and the cost to consumers of switching spending from emission-intensive to low-emission goods and services.

Globally, an estimate of resource costs suggests that the annual cost of cutting total GHG to about three quarters of current levels by 2050, consistent with a 550ppm CO_2e stabilization level, will be in the range – 1.0 to + 3.5% of GDP, with an average estimate of approximately 1%. This depends on steady reductions in the cost of low-carbon technologies, relative to the cost of the technologies currently deployed, and improvements in energy efficiency. The range is wide because of the uncertainties as to future rates of innovation and fossil-fuel extraction costs. The better the policy, the lower is the cost.

Mitigation costs will vary according to how and when emissions are cut. Without early, well-planned action, costs of mitigating emissions may become greater. In Tables 2.31 through 2.38 the present values of mitigating interventions have been detailed. In Tables 2.31 and 2.32, the present value of all costs of using cleaner technologies than the "business-as-usual" ones are provided. The associated costs have been obtained from different sources for the different options. For instance, costs associated with using efficient extraction equipment were obtained from a study conducted by Asia Energy in respect of their proposal for the Phulbari project. Tables 2.33 and 2.34 provide detailed incremental costs of the mitigating technologies associated with each fuel type. Similarly, Tables 2.35 and 2.36 are the mitigating costs of transmission and distribution investments. In Tables 2.37 and 2.38 the incremental costs associated with the use of clean options in the transport sector have been detailed.

Production of Primary Energy:

Table 2.31: Mitigation Cost for Primary Energy by Investment type and entity

CATEGPRY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIUMATES SCENARIO (IN MILLION 2010USD)																				
	NATURAL GAS PRO-DUCTION			NATURAL GAS TRANSMISSION			COAL PRODUCTION			MITIGATION IN COAL MINES			BRICK KILN (HHK)			GAS BOILER WITH RETROFIT			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	15410.32		0.00	1468.50		31.25	0.00		1510.34	0.00		0.00	0.00		0.00	0.00		0.00	16878.82		1541.59
Government	28626.11		0.00	0.00		0.00	1136.42		5256.26	209.73		159.15	681.28		8415.59	3521.45		0.00	34175.00		13831.00
TOTAL	44036.43		0.00	1468.50		31.25	1136.42		6766.59	209.73		159.15	681.28		8415.59	3521.45		0.00	51053.82		15372.58

Table 2.32: Mitigation Cost for Primary Energy by Investment type

YEAR	INCREMENTAL ANNUAL IF, FF & O&M ESTIMATES (IN MILLION 2010USD)																				
	NATURAL GAS PRO-DUCTION			NATURAL GAS TRANSMISSION			COAL PRODUCTION			MITIGATION IN COAL MINES			BRICK KILN (HHK)			GAS BOILER			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	1204.45		0.00	199.00		4.00	0.00		17.68	0.00		0.00	33.54		415.36	61.84		0.00	1498.82		437.04
2011	1295.23		0.00	0.00		0.00	0.00		19.87	0.00		0.00	33.51		413.86	68.85		0.00	1397.59		433.73
2012	1372.83		0.00	160.00		3.20	0.00		22.32	0.00		0.00	33.39		412.37	74.94		0.00	1641.16		437.90
2013	1438.41		0.00	162.00		3.20	0.00		25.08	0.00		0.00	33.27		410.89	81.56		0.00	1715.24		439.17
2014	1493.01		0.00	59.00		1.80	52.78		28.18	95.56		0.00	33.15		409.41	88.77		0.00	1822.28		439.39
2015	1537.64		0.00	113.00		2.30	49.96		31.67	0.00		7.11	33.03		407.94	96.62		0.00	1830.24		449.02
2016	1616.42		0.00	0.00		0.00	47.28		302.73	0.00		6.73	32.91		406.47	105.16		0.00	1801.77		715.93
2017	1699.77		0.00	82.00		1.60	98.34		292.82	97.01		6.37	32.79		405.01	114.46		0.00	2124.37		705.79
2018	1787.99		0.00	0.00		0.00	93.07		284.21	0.00		12.06	32.67		403.55	124.57		0.00	2038.30		699.82
2019	1881.38		0.00	59.00		1.80	88.08		548.71	0.00		11.41	32.56		402.09	135.58		0.00	2196.60		964.02
2020	1980.27		0.00	86.00		1.70	83.36		528.26	0.00		10.80	32.44		400.65	147.57		0.00	2329.64		941.41
2021	2084.99		0.00	113.00		2.30	78.90		510.01	0.00		10.22	32.32		399.20	160.61		0.00	2469.82		921.74
2022	2195.92		0.00	0.00		0.00	74.67		493.98	0.00		9.68	32.21		397.77	174.81		0.00	2477.61		901.42
2023	2313.46		0.00	59.00		1.80	70.67		480.20	0.00		9.16	32.09		396.34	190.26		0.00	2665.48		887.49
2024	2438.01		0.00	53.79		1.08	66.88		468.73	0.00		8.67	31.97		394.91	207.08		0.00	2797.74		873.38
2025	2570.03		0.00	53.79		1.08	63.30		459.63	0.00		8.20	31.86		393.49	225.38		0.00	2944.36		862.40
2026	2709.98		0.00	53.79		1.08	59.91		453.00	0.00		7.76	31.74		392.07	245.30		0.00	3100.73		853.91
2027	2858.38		0.00	53.79		1.08	56.70		448.95	0.00		7.35	31.63		390.66	266.99		0.00	3267.49		848.04
2028	3015.76		0.00	53.79		1.08	53.66		447.62	0.00		6.95	31.52		389.25	290.59		0.00	3445.32		844.90
2029	3182.70		0.00	53.79		1.08	50.79		449.16	0.00		6.58	31.40		387.85	316.27		0.00	3634.95		844.67
2030	3359.80		0.00	53.79		1.08	48.07		453.78	0.00		6.23	31.29		386.46	344.23		0.00	3837.17		847.54
Total	44036.43		0.00	1468.50		31.25	1136.42		6766.59	192.57		135.30	681.28		8415.59	3521.45		0.00	51036.66		15348.73

Production of Secondary Energy:

Table 2.33: Mitigation Cost of Power Generation by Investment type and entity

CATEGORY OF INVEST-MENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR MITIGATION SCENARIO (IN MILLION 2010USD)																	
	GAS-FIRED POWER PLANTS-SIMPLE CYCLE			GAS-FIRED POWER PLANTS-COMBINED CYCLE			COAL-FIRED POWER PLANTS-CONVEN-TIONAL			DIESEL POWER PLANTS			HFO-BASED POWER PLANTS			WIND TURBINE POWER PLANTS		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	174.66		62.34	1858.31		430.34	8909.98		1091.96	388.81		221.73	2399.47		1016.50	538.39		56.18
Government	602.28		237.77	3586.65		817.85	446.54		57.45	331.72		119.27	1740.58		740.59	0.00		0.00
TOTAL	776.93		300.11	5444.97		1248.19	9356.52		1149.41	720.53		341.00	4140.05		1757.08	538.39		56.18

Table 2.34: Mitigation Cost of Power Generation by Investment type

YEAR	ANNUAL IF, FF & O&M ESTIMATES FOR MITIGATION SCENARIO (IN MILLION 2010USD)																	
	GAS-FIRED POWER PLANTS-SIMPLE CYCLE			GAS-FIRED POWER PLANTS-COMBINED CYCLE			COAL-FIRED POWER PLANTS-CONVEN-TIONAL			DIESEL POWER PLANTS			HFO-BASED POWER PLANTS			WIND TURBINE POWER PLANTS		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	186.68		7.33	80.70		2.08	0.00		0.00	270.99		17.08	611.23		34.82	0.00		0.00
2011	0.00		6.93	254.57		8.55	0.00		0.00	0.00		16.16	353.36		46.97	0.00		0.00
2012	0.00		6.56	401.56		18.46	0.00		0.00	134.85		20.64	784.84		85.72	218.38		2.51
2013	170.17		12.40	570.07		32.19	175.63		2.55	0.00		19.54	204.20		91.61	0.00		2.38
2014	0.00		11.74	841.67		52.21	0.00		2.42	0.00		18.49	0.00		86.70	0.00		2.25
2015	0.00		11.11	0.00		49.41	3272.19		49.84	0.00		10.86	0.00		61.45	0.00		2.13
2016	40.03		12.34	314.13		54.88	563.08		55.35	29.99		12.06	208.36		68.25	30.50		2.37
2017	37.89		13.41	297.31		59.62	532.91		60.13	28.38		13.09	197.19		74.15	28.86		2.57
2018	35.86		14.32	281.38		63.69	504.36		64.24	26.86		13.99	186.63		79.21	27.32		2.75
2019	33.94		15.10	266.30		67.15	477.34		67.73	25.42		14.75	176.63		83.52	25.85		2.90
2020	32.12		15.75	252.04		70.07	451.77		70.67	24.06		15.38	167.17		87.14	24.47		3.03
2021	30.40		16.30	238.54		72.47	427.57		73.10	22.77		15.91	158.21		90.14	23.16		3.13
2022	28.77		16.73	225.76		74.42	404.66		75.06	21.55		16.34	149.74		92.56	21.92		3.22
2023	27.23		17.08	213.66		75.95	382.99		76.60	20.40		16.67	141.72		94.47	20.74		3.28
2024	25.77		17.34	202.22		77.11	362.47		77.77	19.30		16.92	134.12		95.90	19.63		3.33
2025	24.39		17.52	191.38		77.92	343.05		78.59	18.27		17.10	126.94		96.91	18.58		3.37
2026	23.08		17.63	181.13		78.42	324.67		79.10	17.29		17.21	120.14		97.54	17.58		3.39
2027	21.85		17.68	171.43		78.65	307.28		79.32	16.37		17.26	113.70		97.82	16.64		3.40
2028	20.68		17.68	162.24		78.63	290.82		79.30	15.49		17.25	107.61		97.79	15.75		3.40
2029	19.57		17.62	153.55		78.38	275.24		79.05	14.66		17.20	101.85		97.48	14.91		3.39
2030	18.52		17.52	145.33		77.93	260.49		78.60	13.87		17.10	96.39		96.93	14.11		3.37
Total	776.93		300.11	5444.97		1248.19	9356.52		1149.41	720.53		341.00	4140.05		1757.08	538.39		56.18

Table 2.33: Mitigation Cost of Power Generation by Investment type and entity (continued)

CATEGORY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR MITIGATION SCENARIO (IN MILLION 2010USD)														
	SOLAR PV POWER PLANTS			CONVERSION FROM GAS-SC TO COMBINED CYCLE			ADDITION OF CCS TO GAS-COMBINED CYCLE			ADDITION OF DESULF/ DENOX UNIT & CO2 SCRUBBER TO CONVENTIONAL COAL PLANT			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	123.69		4.79	137.40		-9.38	2640.87		379.99	1841.83		4050.25	19013.40		7304.68
Government	66.91		2.61	473.79		-32.74	5097.03		722.16	92.31		213.10	12437.80		2878.06
TOTAL	190.60		7.40	611.19		-42.12	7737.90		1102.15	1934.13		4263.34	31451.20		10182.74

Table 2.34: Mitigation Cost of Power Generation by Investment type (continued)

YEAR	ANNUAL IF, FF & O&M ESTIMATES FOR MITIGATION SCENARIO (IN MILLION 2010USD)														
	SOLAR PV POWER PLANTS			CONVERSION FROM GAS-SC TO COMBINED CYCLE			ADDITION OF CCS TO GAS-COMBINED CYCLE			ADDITION OF DESULF/ DENOX UNIT & CO2 SCRUBBER TO CONVENTIONAL COAL PLANT			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	0.00		0.00	146.86		-0.96	114.68		1.84	0.00		0.00	1149.60		61.31
2011	0.00		0.00	0.00		-0.91	361.78		7.55	0.00		0.00	607.94		78.61
2012	75.87		0.33	0.00		-0.86	570.66		16.30	0.00		0.00	1615.50		134.23
2013	0.00		0.31	133.87		-1.75	810.13		28.43	36.31		9.47	2100.38		197.13
2014	0.00		0.29	0.00		-1.66	1196.11		46.10	0.00		8.96	2037.77		227.50
2015	0.00		0.28	0.00		-1.57	0.00		43.63	676.41		184.85	3948.59		411.99
2016	10.71		0.31	31.49		-1.74	446.42		48.46	116.40		205.30	1791.10		457.57
2017	10.37		0.34	29.80		-1.89	422.50		52.64	110.16		223.03	1695.38		497.07
2018	9.81		0.36	28.21		-2.02	399.87		56.24	104.26		238.26	1604.56		531.04
2019	9.29		0.38	26.70		-2.13	378.45		59.30	98.67		251.23	1518.60		559.93
2020	8.79		0.40	25.27		-2.22	358.17		61.87	93.39		262.12	1437.25		584.21
2021	8.32		0.41	23.91		-2.30	338.99		63.99	88.38		271.12	1360.25		604.28
2022	7.87		0.42	22.63		-2.36	320.83		65.71	83.65		278.41	1287.38		620.52
2023	7.45		0.43	21.42		-2.41	303.64		67.07	79.17		284.14	1218.41		633.29
2024	7.05		0.44	20.27		-2.44	287.37		68.08	74.93		288.46	1153.14		642.91
2025	6.68		0.45	19.19		-2.47	271.98		68.80	70.91		291.49	1091.37		649.68
2026	6.32		0.45	18.16		-2.49	257.41		69.25	67.11		293.38	1032.90		653.88
2027	5.98		0.45	17.19		-2.49	243.62		69.45	63.52		294.22	977.57		655.76
2028	5.66		0.45	16.26		-2.49	230.57		69.43	60.12		294.14	925.20		655.57
2029	5.36		0.45	15.39		-2.48	218.21		69.21	56.90		293.22	875.63		653.51
2030	5.07		0.45	14.57		-2.47	206.52		68.82	53.85		291.55	828.72		649.80
Total	190.60		7.40	611.19		-42.12	7737.90		1102.15	1934.13		4263.34	31451.20		10182.74

Table 2.35: Mitigation Cost for T&D by Investment type and Entity

CATEGORY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR MITIGATION SCENARIO (IN MILLION 2010USD)																	
	TRANSMISSION LINE 400KV			TRANSMISSION LINE 230KV			TRANSMISSION LINE 132KV			DISTRIBUTION LINE			T&D REHABILITATION			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Government	627.70			324.02			373.48			5574.63			217.86			7117.70		
Corporations	1105.31			544.26			560.63			0.00						2210.20		
Total	1733.01			868.28			934.11			5574.63			217.86		0.00	9327.90		0.00

Table 2.36: Mitigation Cost for T&D by Investment type

YEAR	ANNUAL IF, FF & O&M ESTIMATE FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	TRANSMISSION LINE 400KV			TRANSMISSION LINE 230KV			TRANSMISSION LINE 132KV			DISTRIBUTION LINE			T&D REHABILITATION			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	0.00			0.00			0.00			238.91			17.03			255.94		
2011	0.00			0.00			0.00			399.71			16.12			415.82		
2012	187.43			113.07			27.14			378.29			15.25			721.19		
2013	121.10			135.29			341.37			358.03			14.44			970.22		
2014	0.00			60.78			0.00			338.85			13.66			413.29		
2015	353.15			67.45			0.00			320.69			12.93			754.22		
2016	102.09			46.86			53.90			337.36			12.24			552.45		
2017	96.62			44.35			51.01			319.29			11.58			522.86		
2018	91.45			41.97			48.28			302.19			10.96			494.85		
2019	86.55			39.72			45.69			286.00			10.38			468.34		
2020	81.91			37.59			43.25			270.68			9.82			443.25		
2021	77.52			35.58			40.93			256.18			9.29			419.50		
2022	73.37			33.67			38.74			242.45			8.80			397.03		
2023	69.44			31.87			36.66			229.46			8.32			375.76		
2024	65.72			30.16			34.70			217.17			7.88			355.63		
2025	62.20			28.55			32.84			205.54			7.46			336.58		
2026	58.87			27.02			31.08			194.53			7.06			318.55		
2027	55.71			25.57			29.41			184.10			6.68			301.48		
2028	52.73			24.20			27.84			174.24			6.32			285.33		
2029	49.90			22.90			26.35			164.91			5.98			270.05		
2030	47.23			21.68			24.94			156.07			5.66			255.58		
Total	1733.01			868.28			934.11			5574.63			217.86			9327.90		

Table 2.37: Mitigation Cost for Transport by Investment type and Entity

CATEGPRY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIUMATES SCENARIO (IN MILLION 2010USD)																				
	HIGHWAY			MASS TRANSIT (BRT, METRO)			TRAFFIC MANAGE-MENT			RAILWAY			WATERWAY			SHIFT FROM ROAD TO RAILWAY & WA-TERWAY			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	1019.01		0.00	2308.61		0.00	26.95		0.00	639.65		0.00	31.98		0.00	230.27		0.00	4256.47		0.00
Government	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
TOTAL	1019.01		0.00	2308.61		0.00	26.95		0.00	639.65		0.00	31.98		0.00	230.27		0.00	4256.47		0.00

Table 2.38: Mitigation Cost for Transport by Investment type

YEAR	ANNUAL IF, FF & O&M ESTIMATE FOR BASELINE SCENARIO (IN MILLION 2010USD)																				
	GAS-FIRED POWER PLANTS - SIMPLE CYCLE			GAS-FIRED POWER PLANTS - COMBINED CYCLE			COAL-FIRED POWER PLANTS-CONVEN-TIONAL			DIESEL POWER PLANTS			HFO-BASED POWER PLANTS			WIND TURBINE POWER PLANTS			SOLAR PV POWER PLANTS		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	39.20		0.00	37.60		0.00	6.00		0.00	50.00		0.00	2.50		0.00	18.00		0.00	153.30		0.00
2011	37.10		0.00	35.59		0.00	5.68		0.00	47.32		0.00	2.37		0.00	17.04		0.00	145.09		0.00
2012	35.11		0.00	33.68		0.00	5.37		0.00	44.79		0.00	2.24		0.00	16.12		0.00	137.31		0.00
2013	33.23		0.00	31.88		0.00	5.09		0.00	42.39		0.00	2.12		0.00	15.26		0.00	129.96		0.00
2014	31.45		0.00	30.17		0.00	4.81		0.00	40.12		0.00	2.01		0.00	14.44		0.00	123.00		0.00
2015	136.68		0.00	182.24		0.00	0.00		0.00	37.97		0.00	1.90		0.00	13.67		0.00	372.46		0.00
2016	129.36		0.00	172.48		0.00	0.00		0.00	35.93		0.00	1.80		0.00	12.94		0.00	352.51		0.00
2017	122.43		0.00	163.24		0.00	0.00		0.00	34.01		0.00	1.70		0.00	12.24		0.00	333.62		0.00
2018	115.87		0.00	154.49		0.00	0.00		0.00	32.19		0.00	1.61		0.00	11.59		0.00	315.75		0.00
2019	109.66		0.00	146.22		0.00	0.00		0.00	30.46		0.00	1.52		0.00	10.97		0.00	298.83		0.00
2020	38.98		0.00	294.07		0.00	0.00		0.00	28.83		0.00	1.44		0.00	10.38		0.00	373.70		0.00
2021	36.89		0.00	278.31		0.00	0.00		0.00	27.29		0.00	1.36		0.00	9.82		0.00	353.68		0.00
2022	34.91		0.00	263.41		0.00	0.00		0.00	25.82		0.00	1.29		0.00	9.30		0.00	334.73		0.00
2023	33.04		0.00	249.29		0.00	0.00		0.00	24.44		0.00	1.22		0.00	8.80		0.00	316.80		0.00
2024	31.27		0.00	235.94		0.00	0.00		0.00	23.13		0.00	1.16		0.00	8.33		0.00	299.83		0.00
2025	10.25		0.00	0.00		0.00	0.00		0.00	21.89		0.00	1.09		0.00	7.88		0.00	41.11		0.00
2026	9.70		0.00	0.00		0.00	0.00		0.00	20.72		0.00	1.04		0.00	7.46		0.00	38.91		0.00
2027	9.18		0.00	0.00		0.00	0.00		0.00	19.61		0.00	0.98		0.00	7.06		0.00	36.83		0.00
2028	8.69		0.00	0.00		0.00	0.00		0.00	18.56		0.00	0.93		0.00	6.68		0.00	34.85		0.00
2029	8.22		0.00	0.00		0.00	0.00		0.00	17.56		0.00	0.88		0.00	6.32		0.00	32.99		0.00
2030	7.78		0.00	0.00		0.00	0.00		0.00	16.62		0.00	0.83		0.00	5.98		0.00	31.22		0.00
Total	1019.01		0.00	2308.61		0.00	26.95		0.00	639.65		0.00	31.98		0.00	230.27		0.00	4256.47		0.00

3. RESULTS

3.1 Incremental Changes in IF, FF, O&M Costs, and Subsidy Costs

Incremental changes represent the difference in all types of investments in the mitigation scenario compared to the baseline scenario. These are provided in Tables 3.2 through Tables 3.9 and summarized in Table 3.1. We can see from Table 3.1 that a total of 26.6 billion in 2010 US Dollars will be required to lower the carbon footprint in selected interventions in the energy sector. These estimates do not account for costs associated with substitutions of fossil fuels by supplies from renewable options, DSM type activities and energy efficiency projects and programs. For a complete analysis of the mitigating costs these too must be undertaken.

Table 3.1: Costs of Mitigation Measures

SECTOR	INDUSTRY	INVESTMENT COST (MILLION USD)	O&M COST (MILLION USD)	TOTAL COST FOR THE SECTOR
Primary Energy	Mitigation in Coal Mines	192.57	135.30	327.87
	Brick Kiln (FCK)	-317.39	-15333.50	-15650.89
	Brick Kiln (HHK)	681.28	8415.59	9096.87
	Gas Boiler	1089.11	1645.57	2734.68
	All Investment Types (A)	1645.57	-6782.60	-5137.03
Power Generation	Conversion from Gas-Simple cycle to Combined Cycle	545.69	-38.39	507.3
	Addition of CCS to Gas-Combined Cycle	6973.88	1016.52	7990.4
	Addition of De-Sulphurization/ De-Noxing Unit & CO2 Scrubber to Conventional Coal Plant	3539.33	7186.42	10725.75
	All Investment Types (B)	11058.90	8164.56	19223.46
Transmission and Distribution	T&D Rehabilitation	217.86	0.00	217.86
	All Investment Types (C)	217.86	0.00	217.86
Transport	Shift from Road to Railway & Waterway	230.27	0.00	230.27
	All Investment Types (D)	230.27	0.00	230.27
	TOTAL (A+B+C+D)	13152.60	1381.96	14534.56

Table 3.2: Primary Energy: Incremental Cost by Investment type and entity

CATEGPRY OF INVEST-MENT ENTITY	INCREMENTAL CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES (IN MILLION 2010USD)																							
	NATURAL GAS PRODUCTION			NATURAL GAS TRANSMISSION			COAL PRODUCTION			MITIGATION IN COAL MINES			BRICK KILN (FCK)			BRICK KILN (HHK)			GAS BOILER			ALL INVESTMENT TYPES		
	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M
Corporations	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
Government	0.00		0.00	0.00		0.00	0.00		0.00	192.57		135.30	-317.39		-15333.50	681.28		8415.59	1089.11		0.00	1645.57		-6782.60
TOTAL	0.00		0.00	0.00		0.00	0.00		0.00	192.57		135.30	-317.39		-15333.50	681.28		8415.59	1089.11		0.00	1645.57		-6782.60

Table 3.3: Primary Energy: Incremental Annual Cost by Investment type

YEAR	INCREMENTAL ANNUAL IF, FF & O&M ESTIMATES (IN MILLION 2010USD)																							
	NATURAL GAS PRODUCTION			NATURAL GAS TRANSMISSION			COAL PRODUCTION			MITIGATION IN COAL MINES			BRICK KILN (FCK)			BRICK KILN (HHK)			GAS BOILER			ALL INVESTMENT TYPES		
	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M	ΔIF	FF	ΔO&M
2010	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	-15.62		-756.80	33.54		415.36	19.13		0.00	37.04		-341.44
2011	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	-15.61		-754.08	33.51		413.86	21.29		0.00	39.19		-340.21
2012	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	-15.55		-751.36	33.39		412.37	23.18		0.00	41.01		-338.99
2013	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	-15.50		-748.66	33.27		410.89	25.23		0.00	42.99		-337.77
2014	0.00		0.00	0.00		0.00	0.00		0.00	95.56		0.00	-15.44		-745.96	33.15		409.41	27.46		0.00	140.72		-336.55
2015	0.00		0.00	0.00		0.00	0.00		0.00	0.00		7.11	-15.39		-743.28	33.03		407.94	29.88		0.00	47.52		-328.22
2016	0.00		0.00	0.00		0.00	0.00		0.00	0.00		6.73	-15.33		-740.60	32.91		406.47	32.52		0.00	50.10		-327.40
2017	0.00		0.00	0.00		0.00	0.00		0.00	97.01		6.37	-15.28		-737.93	32.79		405.01	35.40		0.00	149.93		-326.56
2018	0.00		0.00	0.00		0.00	0.00		0.00	0.00		12.06	-15.22		-735.28	32.67		403.55	38.53		0.00	55.98		-319.67
2019	0.00		0.00	0.00		0.00	0.00		0.00	0.00		11.41	-15.17		-732.63	32.56		402.09	41.93		0.00	59.32		-319.12
2020	0.00		0.00	0.00		0.00	0.00		0.00	0.00		10.80	-15.11		-729.99	32.44		400.65	45.64		0.00	62.97		-318.54
2021	0.00		0.00	0.00		0.00	0.00		0.00	0.00		10.22	-15.06		-727.36	32.32		399.20	49.67		0.00	66.94		-317.94
2022	0.00		0.00	0.00		0.00	0.00		0.00	0.00		9.68	-15.00		-724.75	32.21		397.77	54.06		0.00	71.27		-317.30
2023	0.00		0.00	0.00		0.00	0.00		0.00	0.00		9.16	-14.95		-722.14	32.09		396.34	58.84		0.00	75.98		-316.64
2024	0.00		0.00	0.00		0.00	0.00		0.00	0.00		8.67	-14.90		-719.54	31.97		394.91	64.04		0.00	81.12		-315.96
2025	0.00		0.00	0.00		0.00	0.00		0.00	0.00		8.20	-14.84		-716.95	31.86		393.49	69.71		0.00	86.72		-315.26
2026	0.00		0.00	0.00		0.00	0.00		0.00	0.00		7.76	-14.79		-714.37	31.74		392.07	75.87		0.00	92.82		-314.53
2027	0.00		0.00	0.00		0.00	0.00		0.00	0.00		7.35	-14.74		-711.79	31.63		390.66	82.57		0.00	99.47		-313.79
2028	0.00		0.00	0.00		0.00	0.00		0.00	0.00		6.95	-14.68		-709.23	31.52		389.25	89.87		0.00	106.71		-313.02
2029	0.00		0.00	0.00		0.00	0.00		0.00	0.00		6.58	-14.63		-706.68	31.40		387.85	97.82		0.00	114.59		-312.25
2030	0.00		0.00	0.00		0.00	0.00		0.00	0.00		6.23	-14.58		-704.13	31.29		386.46	106.46		0.00	123.18		-311.45
Total	0.00		0.00	0.00		0.00	0.00		0.00	192.57		135.30	-317.39		-15333.50	681.28		8415.59	1089.11		0.00	1645.57		-6782.60

Table 3.4: Power Generation: Incremental Cost by Investment type and entity

CATEGPRY OF INVESTMENT ENTITY	INCREMENTAL CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES, BY INVESTMENT TYPE, AND INVESTMENT ENTITY (IN MILLION 2010USD)																	
	GAS-FIRED POWER PLANTS-SIMPLE CYCLE			GAS-FIRED POWER PLANTS-COMBINED CYCLE			COAL-FIRED POWER PLANTS-CONVEN-TIONAL			DIESEL POWER PLANTS			HFO-BASED POWER PLANTS			WIND TURBINE POWER PLANTS		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
Government	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
TOTAL	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00

Table 3.5: Power Generation: Incremental Annual Cost by Investment type

YEAR	INCREMENTAL ANNUAL IF, FF & O&M ESTIMATES BY INVESTMENT TYPE (IN MILLION 2010USD)																	
	GAS-FIRED POWER PLANTS-SIMPLE CYCLE			GAS-FIRED POWER PLANTS-COMBINED CYCLE			COAL-FIRED POWER PLANTS-CONVEN-TIONAL			DIESEL POWER PLANTS			HFO-BASED POWER PLANTS			WIND TURBINE POWER PLANTS		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2011	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2012	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2013	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2014	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2015	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2016	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2017	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2018	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2019	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2020	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2021	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2022	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2023	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2024	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2025	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2026	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2027	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2028	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2029	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
2030	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
Total	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00

Table 3.4: Power Generation: Incremental Cost by Investment type and entity (continued)

CATEGPRY OF INVESTMENT ENTITY	INCREMENTAL CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES, BY INVESTMENT TYPE, AND INVESTMENT ENTITY (IN MILLION 2010USD)														
	SOLAR PV POWER PLANTS			CONVERSION FROM GAS-SC TO COM-BINED CYCLE			ADDITION OF CCS TO GAS-COMBINED CYCLE			ADDITION OF DESULF/ DENOX UNIT & CO2 SCRUBBER TO CON-VENTIONAL COAL PLANT			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	0.00		0.00	137.40		-9.38	2640.87		379.99	1841.83		4050.25	4620.09		4420.85
Government	0.00		0.00	473.79		-32.74	5097.03		722.16	92.31		213.10	5663.13		902.52
TOTAL	0.00		0.00	611.19		-42.12	7737.90		1102.15	1934.13		4263.34	10283.22	0.00	5323.37

Table 3.5: Power Generation: Incremental Annual Cost by Investment type (continued)

YEAR	INCREMENTAL ANNUAL IF, FF & O&M ESTIMATES BY INVESTMENT TYPE (IN MILLION 2010USD)														
	SOLAR PV POWER PLANTS			CONVERSION FROM GAS-SC TO COM-BINED CYCLE			ADDITION OF CCS TO GAS-COMBINED CYCLE			ADDITION OF DESULF/ DENOX UNIT & CO2 SCRUBBER TO CON-VENTIONAL COAL PLANT			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	0.00		0.00	146.86		-0.96	114.68		1.84	0.00		0.00	261.53	0.00	0.00
2011	0.00		0.00	0.00		-0.91	361.78		7.55	0.00		0.00	361.78	0.00	6.64
2012	0.00		0.33	0.00		-0.86	570.66		16.30	0.00		0.00	570.66	0.00	15.76
2013	0.00		0.31	133.87		-1.75	810.13		28.43	36.31		9.47	980.31	0.00	36.45
2014	0.00		0.29	0.00		-1.66	1196.11		46.10	0.00		8.96	1196.11	0.00	53.70
2015	0.00		0.28	0.00		-1.57	0.00		43.63	676.41		184.85	676.41	0.00	227.19
2016	0.00		0.31	31.49		-1.74	446.42		48.46	116.40		205.30	594.31	0.00	252.32
2017	0.00		0.34	29.80		-1.89	422.50		52.64	110.16		223.03	562.47	0.00	274.11
2018	0.00		0.36	28.21		-2.02	399.87		56.24	104.26		238.26	532.34	0.00	292.84
2019	0.00		0.38	26.70		-2.13	378.45		59.30	98.67		251.23	503.82	0.00	308.78
2020	0.00		0.40	25.27		-2.22	358.17		61.87	93.39		262.12	476.83	0.00	322.17
2021	0.00		0.41	23.91		-2.30	338.99		63.99	88.38		271.12	451.28	0.00	333.23
2022	0.00		0.42	22.63		-2.36	320.83		65.71	83.65		278.41	427.11	0.00	342.19
2023	0.00		0.43	21.42		-2.41	303.64		67.07	79.17		284.14	404.23	0.00	349.23
2024	0.00		0.44	20.27		-2.44	287.37		68.08	74.93		288.46	382.57	0.00	354.54
2025	0.00		0.45	19.19		-2.47	271.98		68.80	70.91		291.49	362.08	0.00	358.27
2026	0.00		0.45	18.16		-2.49	257.41		69.25	67.11		293.38	342.68	0.00	360.59
2027	0.00		0.45	17.19		-2.49	243.62		69.45	63.52		294.22	324.32	0.00	361.63
2028	0.00		0.45	16.26		-2.49	230.57		69.43	60.12		294.14	306.95	0.00	361.52
2029	0.00		0.45	15.39		-2.48	218.21		69.21	56.90		293.22	290.50	0.00	360.39
2030	0.00		0.45	14.57		-2.47	206.52		68.82	53.85		291.55	274.94	0.00	358.34
Total	0.00		7.40	611.19		-42.12	7737.90		1102.15	1934.13		4263.34	10283.22	0.00	5323.37

Table 3.6: T&D: Incremental Cost by Investment type and Entity

CATEGORY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIMATES FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	TRANSMISSION LINE 400KV			TRANSMISSION LINE 230KV			TRANSMISSION LINE 132KV			DISTRIBUTION LINE			T&D REHABILITATION			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Government	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	217.86		0.00	217.86		0.00
Corporations	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
Total	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	217.86		0.00	217.86		0.00

Table 3.7: T&D: Incremental Annual Cost by Investment type

YEAR	ANNUAL IF, FF & O&M ESTIMATE FOR BASELINE SCENARIO (IN MILLION 2010USD)																	
	TRANSMISSION LINE 400KV			TRANSMISSION LINE 230KV			TRANSMISSION LINE 132KV			DISTRIBUTION LINE			T&D REHABILITATION			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	17.03	0.00	0.00	17.03		0.00
2011	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	16.12	0.00	0.00	16.12		0.00
2012	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	15.25	0.00	0.00	15.25		0.00
2013	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	14.44	0.00	0.00	14.44		0.00
2014	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	13.66	0.00	0.00	13.66		0.00
2015	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	12.93	0.00	0.00	12.93		0.00
2016	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	12.24	0.00	0.00	12.24		0.00
2017	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	11.58	0.00	0.00	11.58		0.00
2018	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	10.96	0.00	0.00	10.96		0.00
2019	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	10.38	0.00	0.00	10.38		0.00
2020	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	9.82	0.00	0.00	9.82		0.00
2021	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	9.29	0.00	0.00	9.29		0.00
2022	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	8.80	0.00	0.00	8.80		0.00
2023	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	8.32	0.00	0.00	8.32		0.00
2024	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	7.88	0.00	0.00	7.88		0.00
2025	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	7.46	0.00	0.00	7.46		0.00
2026	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	7.06	0.00	0.00	7.06		0.00
2027	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	6.68	0.00	0.00	6.68		0.00
2028	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	6.32	0.00	0.00	6.32		0.00
2029	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	5.98	0.00	0.00	5.98		0.00
2030	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	5.66	0.00	0.00	5.66		0.00
Total	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	217.86		0.00	217.86		0.00

Table 3.8: Transport: Incremental Cost by Investment type and Entity

CATEGPRY OF INVESTMENT ENTITY	CUMULATIVE DISCOUNTED IF, FF & O&M ESTIUMATES SCENARIO (IN MILLION 2010USD)																				
	HIGHWAY			MASS TRANSIT (BRT, METRO)			TRAFFIC MANAGE-MENT			RAILWAY			WATERWAY			SHIFT FROM ROAD TO RAILWAY & WA-TERWAY			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
Corporations	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	230.27		0.00	230.27		0.00
Government	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00
TOTAL	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	230.27		0.00	230.27		0.00

Table 3.9: Transport: Incremental Annual Cost by Investment type

YEAR	ANNUAL IF, FF & O&M ESTIMATE FOR BASELINE SCENARIO (IN MILLION 2010USD)																				
	HIGHWAY			MASS TRANSIT (BRT, METRO)			TRAFFIC MANAGE-MENT			RAILWAY			WATERWAY			SHIFT FROM ROAD TO RAILWAY & WA-TERWAY			ALL INVESTMENT TYPES		
	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M	IF	FF	O&M
2010	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	18.00		0.00	18.00		0.00
2011	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	17.04		0.00	17.04		0.00
2012	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	16.12		0.00	16.12		0.00
2013	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	15.26		0.00	15.26		0.00
2014	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	14.44		0.00	14.44		0.00
2015	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	13.67		0.00	13.67		0.00
2016	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	12.94		0.00	12.94		0.00
2017	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	12.24		0.00	12.24		0.00
2018	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	11.59		0.00	11.59		0.00
2019	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	10.97		0.00	10.97		0.00
2020	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	10.38		0.00	10.38		0.00
2021	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	9.82		0.00	9.82		0.00
2022	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	9.30		0.00	9.30		0.00
2023	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	8.80		0.00	8.80		0.00
2024	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	8.33		0.00	8.33		0.00
2025	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	7.88		0.00	7.88		0.00
2026	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	7.46		0.00	7.46		0.00
2027	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	7.06		0.00	7.06		0.00
2028	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	6.68		0.00	6.68		0.00
2029	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	6.32		0.00	6.32		0.00
2030	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	5.98		0.00	5.98		0.00
Total	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	230.27		0.00	230.27		0.00

3.2 Policy Implications

ISSUES AND GOALS

The effect of climate change on Bangladesh can almost be described as unfair. It barely contributes to it: the country's energy consumption of about one liter of oil equivalent per week accounts for only a small fraction of 1% of the total global greenhouse gas emissions. Yet international climate change risk assessments identify Bangladesh as the worlds most "at risk" country. There is, in fact, an almost unanimous consensus that the relationship between land and people in Bangladesh is subject to increasing vulnerability and destabilization. In the southern coastal region where the population is projected to reach 44 million by 2015, rising sea levels threaten inundation and saline intrusion menace livelihoods.

With 40% of coastal land already affected by salinity, the Bangladesh Climate Change Strategy and Action Plan published in 2009 anticipates permanent displacement of 6-8 million people by 2050 there. It is little wonder, therefore, that the concentration of almost all stakeholders in Bangladesh is on adaptation, mitigation being a distant vague matter, a concern for industrialized countries. Coupled to this is the fact that Bangladesh, being a developing country, does not have any obligations to reduce its GHG emissions. In such an environment there is very little urge for carbon reduction as a policy goal. A stand-alone policy of reducing GhG emissions from the energy sector does not have much appeal with policy makers. And yet there are enormous benefits to be derived from just such a goal. The flip side of carbon reduction is the reduced use of primary energy resources and this has the makings of a good policy goal. Hence, initiatives to lower C02 emissions have to be aligned closely to overall strategies in reforming the sector in Bangladesh with carbon reduction being set as a co-benefit rather than as a primary goal. Therefore, promoting energy efficiency and conservation and increasing the use of renewable alternatives are the ways by which lower carbon trajectories can be charted for Bangladesh.

The overarching issue in this effort though is the lack of and the need to improve awareness among policy-makers, planners and decision-makers about eco-efficiency concepts. This is the major cause of the weak response to date of the government to energy efficiency, conservation and renewable energy issues and it underscores the fact that a lot more needs to be done to mainstream energy efficiency and environmental issues in infrastructure projects which this study shows has the largest scope for emission reductions.

The present study indicates that in Bangladesh the largest cut in emissions will come from the power sector as the country embarks upon a very ambitious energy expansion program. Innovation, enterprise, policy support and institutional backing will be essential if a significant dent is to be made in creating efficiencies in this plan. However, it is apparent that there is a lack of capacity to program and to build lifecycle assessments into the planning process. The emphasis is on expansion alone without any constraining technology specifications which could create low-tech technology lock-ins for years to come, at the very least, for the life of the equipment. On the other hand, the government policy of selecting investors on the basis of competitive tariffs, the so-called "capacity charge", could result in the selection of the most efficient technology since capacity charges are generally efficiency driven. There is no guarantee, however, that, in fact, such will be the result.

The opportunity presented by a growing economy for expansion of energy supplies has been the central point of the estimations and projections of the present study. The Bangladesh economy has been growing at above 6.5% even with a low energy supply base. This rate is expected to rise rapidly as energy availability improves, creating a twin energy challenge for the country: improving environmental sustainability and enhancing energy security. In the case of Bangladesh, an LDC facing liquidity constraints, an additional factor, the availability of investible funds (especially for more expensive clean technologies), must also be factored into the planning equation. Least cost options that assess initial capital costs and not life time flows generally result in decisions to invest in less efficient technologies because their first costs are low. By comparison capital costs of clean technologies are much higher for they embody research and development costs, deploying and disseminating costs and other costs such as those borne by consumers for switching to goods and services produced by the new technologies. Employing lower technologies though are often rationalized on the 'justice argument' referred to previously. Yet cleaner technology solutions can and often do give larger long run benefits because they use input resources efficiently. Here lies another challenge in the planning process: reconciling low first cost investments of the older inefficient technologies with the larger downstream benefits of newer ones and how to bridge the cost divide.

The cost hurdle should not be minimized, it is substantial and it is a significant barrier in large infrastructure projects such as those associated with power plants, transmission and distribution systems. The present study estimates, that the total incremental requirement in the power sector alone will exceed a staggering 25 billion over a 20 year period. There is no clear understanding how this will be met. There are many barriers to financing such projects. Among them are the negative externalities associated with large projects which need to be taken into account otherwise the large divergences between social and private costs will lower the incentives for investments. Credit market failures such as lack of familiarity by lenders, high transactions costs and the tendency of bankers to look for "deep pocket" investors are other examples of barriers that constrain financing availability.

In smaller projects, the lack of knowledge and familiarity with new technologies, lack of available technical personnel and a business as usual attitude fostered and sustained by a supply constrained economy along with widespread market failures are serious stumbling blocks to the development of efficient economies in different sectors. Markets and especially energy markets do not always function in ways which achieve an appropriate balance between competing ends as many of the conflicts cannot be addressed by the power of competitive markets. In such cases government must intervene directly to set and meet targets. This is especially so in the case of energy efficiency and renewable energy projects.

The bullets below summarize the issues that impede the development of carbon reduction efforts:

Overarching Issues

(i) Awareness of key players is a significant barrier as is the individual and institutional capacity to ensure the desired outcomes;
(ii) Willingness to modify behavior whether by individuals, corporations or government;
(iii) Reforms especially price reforms are often slow and intractable because of political considerations;
(iv) The commitment to follow through on policy statements and the enforcement of and compliance with regulatory reforms are not always done; and
(v) Sometimes, systemic responses to the introduction of new technologies or other measures taken to reduce resource use may offset the beneficial effects of the new technology or the other measures taken; and

Infrastructure Development

(i) Lack of inclusiveness of climate issues in infrastructure planning;
(ii) Energy security and diversity may not always be the most cost effective solution in the short term;
(iii) Measures to stabilize the effects of greenhouse gas are expensive, estimated to cost 1% of GDP;
(iv) Thermal power, while inexpensive, externalizes environmental costs and contributes to the emission of pollutants and greenhouse gas;

Renewable Energy Development

(i) Renewable energy projects are often not commercially viable;
(ii) There is a lack of effort to level the playing field for renewable technologies vis-à-vis fossil fuels; and
(iii) Renewable energy cannot provide significant amounts of power in the short to medium term to offset fossil fuels and therefore are neglected.

DSM Projects

(i) Efficiency projects are rarely well understood by users and are not glamorous enough for politicians unlike, say, a large wind turbine which can attract greater attention;
(ii) Lack of technical assistance that provide bankable energy audit services to identify how/where demand reduction or conservation measures can be taken;
(iii) Lack of financial assistance such as hire-purchase schemes, low interest loans, rebates/discounts to pay for DSM activities.

INVESTMENT PRIORITIES

Notwithstanding the challenges inherent in moving to a sustainable energy path, the strategic direction for the sector is clear and manifest. The energy sector offers the highest mitigation potential not only in Bangladesh but in most countries. The Second National Communication Study shows that the energy sector is by far the largest emitter of GHGs. In 2005, CO_2 emissions from the sector were 42 million tons along with very small amounts of CH_4 (O.2mtons) and N20. Within the sector, a number of sources can be identified from where emissions occur, however, usually they are from the combustion of fuel in the generation of electricity, in petroleum refining, in transport use, residential and commercial activities, agriculture and fisheries. GhG emissions also occur from burning coal in brick kilns, about 6 million tons. The largest chunk of emissions, though, was from electricity generation amounting to 23 million tons of CO_2-eq which represented 48.94 percent of the total CO_2 equivalent energy sector emissions. The transport sector emitted 12 percent of the emissions (6 million tons of CO_2-eq). 13 percent of the emissions were from residential and commercial sectors (149.51 million tons of CO_2-eq). Fossil fuel combustion in Petroleum refining and in the Agriculture and Fisheries sector and fugitive emissions from gas and coal mining and handling of oil and natural gas are very small and not significant.

From the above discussion we can see that the introduction of clean technologies in the power sector will provide, in addition to production efficiency, the greatest benefits in terms of CO_2 reductions. These interventions can best be categorized and studied from the matrix below. The matrix categorizes interventions from both the supply and demand sides of the power production, distribution and end use cycles. The implementation measures outlined in items 4 through 8 in the matrix can result in reducing emissions from generation or at least slowing down the rate of growth of emissions whereas items 2 and 3 can reduce dependency on fossil fuels. Initiatives under Item 1 can result in improving the efficiency of converting fossil fuels into secondary carriers.

SUPPLY SIDE			DEMAND SIDE
1. Improving fossil fuel conversion efficiency	5. Reducing transmission losses	6. Reducing technical losses	7. Improving end use efficiency
2. Increasing share of renewable energy in the supply mix			8. Energy conservation: Adopting measures to reduce the use of electricity by consumers
3. Introducing other supply options such as nuclear generation or importing clean power			
4. Reducing auxiliary consumption in power plants			

Each of the interventions shown in the matrix is discussed below:

- **Improving Supply-side Generation Efficiency:** Much of the load shedding occurring in Bangladesh is a result of the low plant availability of existing units. This is because of the lack of spares, low maintenance, the age of plants and shortages in the supply of the fuel, natural gas. Plant efficiency and availability could be improved through simple interventions such as timely repairs, maintenance and improving operating parameters. Other interventions such as improving heat rates and load factors could also contribute to better plant efficiency through retrofitting and replacing low efficiency equipments and those that have outlived their utility. The economic returns of improvements are likely to be high especially in Bangladesh.

- **Use of state-of the arts technology in new generation:** Interventions to improve efficiency of existing assets, in the aggregate, will reduce but not eliminate the need to construct additional power plants to increase the total supply of electricity. Given the electricity production targets for the next 20 years up to 2030 of about 30,000 MW and the country's energy-resource endowment, it is evident that most of the future energy generation capacity will be from a mix of fuels, natural gas, coal and liquid fuels. This move towards coal and liquid fuel fired power plants and away from natural gas which has very low carbon emissions will have large effects on future emissions. It is, therefore, necessary that the technologies chosen for the new capacity stream should be the most efficient and clean. The present study estimates the additional cost for using clean technologies is about USD 10 billion over the next 20 years. This amount includes cost associated with retooling existing assets.

Improving Supply Side Efficiency in Transmission and Distribution Assets: Transmission losses in Bangladesh are higher than in most countries. This is partly due to low power factors and partly from congestion caused by overly large concentrations of generation in small areas and overloaded distribution lines. Recommended actions include further installation of power factor correction equipment, and coordinated system planning with regulatory support. Cost associated with T&D improvements is a more manageable amount of USD 217 million.

Distribution efficiency gains have been noteworthy, over the past five years, mainly prompted by system overhauls and regulatory pressures. For the momentum to be sustained, the distribution sector needs to increase its revenues to sustainable levels.

Improving end use supply efficiency: In Bangladesh there exists high potential to rationalize the present patterns and levels of end-use through straightforward improvements, such as metering all forms of end-use consumption, eliminating or better targeting energy price subsidies, reducing avoidable leakage and unnecessary losses, use of energy efficient lighting and other appliances, and pricing consumption at its economic cost, including time-of-day and area variations. Beyond these basic reforms there is additional scope for technical improvements in the efficiency of end-use consumption.

Promoting Renewable Technology as an alternate energy source: Bangladesh is well endowed with solar coverage. This endowment is presently being used to benefit stand alone household solar systems. Given the present stage of development of renewable technologies, use of other renewable resources appears to have limited short run potential in Bangladesh. Hence, power generated from wind, rice-husk biomass gasification and municipal waste should be the focus of investment priorities. Off-grid, though, the stand-alone solar PV systems should be central to the effort to provide modern energy to rural households. Other priorities for renewable technology applications are in: use of biomass and anaerobic digestion to manage waste and/or to release energy for cooking in new, well-designed improved stoves, refrigeration and lighting in rural households; solar hot water and heating in domestic and commercial buildings; and solar pumps for irrigation.

Mitigation in Energy Transport: road, rail and water:

Transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and also carbon dioxide emissions. Around the world and in urban Bangladesh, GhG emissions from transport are increasing at a faster rate than any other energy using sector. It is also a major contributor to local air pollution and smog.

Transport is considered to be a major vehicle for pro-poor growth especially in countries like Bangladesh. Like energy there is a relationship between economic growth and the demand for transport services. The demand for transport is, therefore, expected to grow in the future along with it CO_2 emissions as incomes continue to grow. The present study estimates that the total cost of mitigation in the transport sector will be about 4.2 billion US dollars.

EXPECTED CO BENEFITS AND DEVELOPMENT OBJECTIVES

There are enormous possibilities to make the power sector less carbon-intensive from all sides of the electricity cycle: generation, transmission, distribution and consumption. Improving generation efficiency, reducing auxiliary consumption and transmission and distribution losses also has another equally powerful beneficial effect, reduction in the cost of producing and reaching electricity to end users. This in turn could reduce tariffs or, at the least, reduce the inflationary pressure on electricity tariffs. RE-based electricity and energy conservation measures, on the other hand, directly reduce CO_2 emissions. These also help to reduce the need for fossil fuels whose costs are continually trending upwards.

Improvements in the effectiveness of energy use have a three-fold impact: (i) improving energy security; (ii) reducing costs and (iii) mitigating environmental externalities. Improving energy efficiency — using either the technical or the economic definition — can lead to two different outcomes. First, it can lead to more output or wellbeing being created for each unit of energy used. Secondly, it can lead to less energy being used to create the same amount of output or wellbeing. Either or both of these outcomes will increase the quantum of energy supply and thereby contribute to energy security. Cost reductions will make projects more attractive and improve the potential for further investments in low carbon technologies and projects.

POLICY MEASURES TO PROMOTE THE INVESTMENT PRIORITIES

To move the energy economy of Bangladesh to a sustainable path will require policy and institutional support to overcome market failures and barriers. Over the next decade, new power plants, roads, and railroads that are planned to be built in Bangladesh will lock in technology and largely determine emissions through 2050 and beyond. Energy capital stock has a long life. A World Bank Study estimates that the lock-in for a coal plant, for instance, is over 50 years. Therefore, reforming the sector and providing policy support to deploy technology and innovation, develop human and institutional capacity, creation of a favorable regulatory framework and importantly, access to finance all measures that will promote a low carbon intensity sector have taken on an urgency. The present study shows that approximately $12.5 billion will be required by Bangladesh over the next two decades as concessional financing to cover the incremental costs and risks of energy efficiency and renewable energy. In addition, substantial grants will be needed to build the capacity of local stakeholders and provide technical assistance.

Policy tools and financing mechanisms exist for such transformations. These are shown in the Table below; they are generic in nature and, therefore, need to be tailored to the national context. Implementing these will require strong political will and unprecedented international cooperation. Bangladesh has already begun to move in this direction. As a first step towards promoting energy efficiency, conservation and alternative sources of energy a government agency, the Sustainable Energy Development Agency (SEDA), dedicated to such ends is being finalized.

Policy Tools and Financing Sources

ABATEMENT MEASURES	ENERGY EFFICIENCY	RENEWABLE ENERGY	NEW TECHNOLOGIES
Policy tools	Regulations & Financial incentives	Feed-in tariff or renewable portfolio standards	Support for R&D
	Financing Mechanisms	Tax on fossil fuel	Financing incremental cost
	Institutional Reforms	Promoting house-hold PVs	Transfer technologies
Financing sources	TA Grants	TA Grants	TA Grants
	Concessional Financing	Concessional Financing	Concessional Financing
	Commercial public & private investment	Commercial public & private invest-ment	Commercial public & private investment

The policy tools tabulated above concentrate on those abatement measures that can be carried out more readily and those that will result in the highest reductions.

New technologies: In the short term, new technologies such as Integrated Gasification Combined Cycle, or IGCC; CCS; advanced technologies coal-fired power plants; electric vehicles; energy storage; and smart grids may provide the largest source of emission abatement. The projections in this study show that the government intends to build up generating capacity by more than six hundred times from 5,000 MW in 2010 to about 34,000 MW by 2030. Of this about 40% will be coal fired. Emission savings can be extremely large depending on the type of technology used. Supercritical and ultra-supercritical plants, for instance, use higher steam temperatures and pressures to achieve higher efficiency of 38%–40% and 40%–42% respectively, compared to large-scale sub-critical power plants with an average efficiency of 35%–38%.

Energy efficiency: As s previously noted, in the short term, the second largest and cheapest source of emission reductions in Bangladesh is in improving the energy efficiencies in power, industry, buildings, and transport. Many of these interventions are financially viable but they have not been realized because of other factors such as market failures. In Bangladesh market failure is primarily caused by the low cost of energy which acts as a disincentive to reform. If the right policy and regulatory frameworks are in place cost of energy efficiency measures can be met from domestic investments although costs associated with incremental risks, with building capacity of financiers and energy service providers will need external concessional or TA type financings.

Renewable energy: Although the use of renewable energy presents immense opportunities in Bangladesh especially since prices of RETs have been declining dramatically, they are still not viable when compared to conventional energy in a financial sense although they are economically. This means that ways must be found to internalize externalities either through direct subsidies or through price increases of conventional energy. Under the right policy and regulatory regime, these technologies can become commercially viable. PV solar for household electricity shows great promise, by end 2011 more than a million systems will have been sold in Bangladesh; and other renewable based power from fluidized bed rice husk technology also hold out good potential. As in other cases, baseline costs can come from domestic investors while international concessional financing and grants will be needed to cover incremental (costs above fossil fuels) and soft costs.

Historically, innovation and technology breakthroughs have reduced the costs of overcoming formidable technical barriers, given effective and timely policy action—a key challenge facing the world today. The largest barrier is the high incremental costs between these technologies and conventional options, particularly in developing countries. Effective, innovative, fair, and affordable ways are needed to accelerate the transfer of low-carbon technologies and the financing of incremental costs of these technologies to the developing world.

In terms of energy resources Bangladesh is not well endowed. Therefore, there is a great need to be as efficient as possible. New policies especially targeted to achieve higher efficiencies of resource utilisation need to formulated and strictly followed. However, many policies exist which if implemented will lead to GHG emission reduction. But, most of these policies have not been implemented because of lack of funds, lack of political will, shortage of trained manpower, management deficiencies, and rules/regulations of public procurement policy which does not allow the purchase of the best technology. Until and unless these factors are tackled, it would be very difficult to achieve growth in the power and energy sector in line with GHG mitigation.

Clearly the most urgent policy implementation that is required in the power sector is to improve the efficiencies of the power plants and rehabilitate the Transmission and Distribution infrastructure. While some plants can undergo balancing and modernisation, others have to be shut down and new CCGT as baseload and state-of-the-art gas turbines for peaking will need to be constructed. The T&D infrastructure need to be vastly improved to carry the projected generation growth. If urgent rehabilitation is not done along with the construction of new infrastructure, the system losses will go up significantly.

Since Bangladesh will need to go for coal based power plants, there is an urgent need to build capacity in clean coal technology. If the best technologies are not employed, the GHG emission per kWh will go up significantly. It will also lead to below optimum use of the coal resources.

The potential of renewables for power generation need to clearly mapped. While the potential of SHSs is being harnessed, more can be done in this regards because less than 45% of the country is covered by the grid. The Government should give a clear endorsement for SHSs by designating areas where NGOs can operate without the fear of the grid being extended to those areas.

The potential of biomass need to be harnessed because Bangladesh produces huge quantities of it every year. However, existing supplies are very tight because of inefficient use. If the supply of biomass can be improved by using efficient end-use devices such as improved parboiling boilers and improved cookstoves, then several million Tons of agricultural waste can be made available for other uses. The biomass gasfier can then be profitably employed to generate electricity.

Matrix 05: Invest Options in Power Sector

OUTCOME	IMMEDIATE ACTIONS	RESPONSIBLE INSTITUTIONS	LONG TERM ACTIONS	RESPONSIBLE INSTITUTIONS	NOTE
Efficiency Improvement of the Power Sector: Increase the average heat-rate of BPDB gas-firing plants	Start the road map for efficiency improvement of gas-firing power plants.	MOPEMR	Implement the plant for efficiency improvement.	MOPEMR BPDB	Road Map Preparation is assisted by development partners under Coal-firing MP. This may continued to be supported by development partners.
	Establish the unit to disseminate the TQM (Total Quality Management) activity to the all public power plants.	BPDB	Identify the rehabilitation needs of the power sector.	BPDB	
	Expedite the implementation of priority projects to updrage the nationwide distribution network	MOPEMR REB	Legislate the scheduled major maintenance of power plants	MOPEMR	
	Complete the basic study to optimize the gas supply	MOPEMR GTCL		REB	Basic study to be done.
Better control the power demand for improved use of power			Corporatize the North-East Zone Power Distribution Company (Central Zone) to strengthen the operational efficiency.		This is mentioned in the GOB's New Initiative for Generation Expansion as DSM Meausre.
Enhance sustainability of the power/energy sector			Start implementation of the rehabilitation of power distribution network in 33 PBSs.		
			Introduction of SCADA system for better gas supply	MOPEMR BERC	
CDM Promotion in the power sector	Conduct capacity building through support for PDD Preparation		Formulate the Action Plan for promoting energy auditing	MOPEMR GTCL Petrobangla	
Renewable Energy	Establishment of SEDA		Implement the adjustment of the electricity retail tariff		Need to confirm the current status of SEDA

3.3 Key Uncertainties and Methodological Limitations

Weaknesses in Data/Information and Projections

Like in most developing nations, data in Bangladesh is weak and, in some instances, contradictory and dated. In fact, in many cases data sources are not properly organized and, in some cases, they are inconsistent. Despite the inconsistencies in the data, institutional responses as well as data/inventory support were by and large moderately good especially with respect to the plan documents in the power sector, the coal use forecasts, in the analysis of the brick sector and to a lesser degree in the transport sector.

The projections developed in the analysis are based on existing technologies and cost factors. For instance, in the power sector, the load forecasts are based on target GDP growth rates, technology mixes and the probabilities of finding additional domestic gas and expected relative costs of fuels on international markets. The generation expansion plan is based on the evidence suggesting that there is a linkage between demand for electricity and economic activity. The plan assumes a high GDP growth scenario to calculate the need for generation plants and then it uses a least cost model that evaluates all systems operation costs, including fuel, O&M, capital costs of new plants, and the cost of un-served energy to detail the fuel and location mixes. The model calculates the present worth of all these costs at a reference point such as the plan period start date to evaluate the best options. . All these assumptions could vary in the long run and, therefore, the planned and projected plans and consequent investments may also vary to the extent that the assumptions change. Hence, in the outer years the plans may change depending on changes in the parameters.

The long term generation expansion and technology mixes for the years 2015 to 2020 and for the period 2020 through 2030 are projections based on the assumptions implicit in the PSMP for the period 2010 through 2015. This may understate the need for more generating plants in the outer years because of the linearity assumption and/or the technology mix assumptions may change over time depending on relative changes in costs and supply chains.

Nevertheless, the baseline reflects

- Current sectoral and national plans and programs
- Expected socioeconomic trends
- Expected investments and operating costs projections.

4. REFERENCES

Methodology Guidebook for the Assessment of Investment and Financial Flows to Address Climate Change, Version 1.0, UNDP.

Reporting Guidelines for the Assessment of Investment and Financial Flows to Address Climate Change, Version 1.0, UNDP.

Final Report, Assessment of Investment and Financial Flows to Mitigate Climate Change in the Electricity Demand Sector in Turkmenistan, May, 2010.

Towards Revamping Power and Energy Sector: A Road Map' Prepared By Ministry Of Finance, Gob, June, 2010.

Draft Final Report, Activity 3: Programmes Containing Measures to Mitigate Climate Change for the Preparation of SNC, BCAS, November, 2010.

Work plan, Assessment of Investment and Financial Flows, UNDP.

National Issues Report On Key Sector of Energy (Mitigation), IIFC, November, 2008.

Statistical Yearbook, Different Years, BBS.

Power System Master Plan Update, Nexant, February, 2006.

Indicators of Energy Use and Efficiency in Bangladesh, Dr. Subrata Kumar Bain.

Annual Energy Outlook, 2008, EIA, US DOE.

Annual Energy Outlook, 2010, EIA, US DOE.

Annual Report 2008-2009, BPDB.

Bangladesh Gas Sector Master Plan, Wood Mackenzie, January, 2006.

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