Power System Master Plan 2010

Power Division
Ministry of Power, Energy and Mineral Resources

Japan International Cooperation Agency

TEPCO
THE TOKYO ELECTRIC POWER CO., INC.

Collaborating with:
Bangladesh Power Development Board
Power Grid Company of Bangladesh Ltd.

February 2011

People's Republic of Bangladesh
Ministry of Power, Energy and Meneral Resources

THE STUDY FOR MASTER PLAN ON COAL POWER DEVELOPMENT IN THE PEOPLE'S REPUBLIC OF BANGLADESH

Power System Master Plan 2010 (PSMP2010)

FINAL REPORT

February 2011

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company, Inc.

IDD
JR
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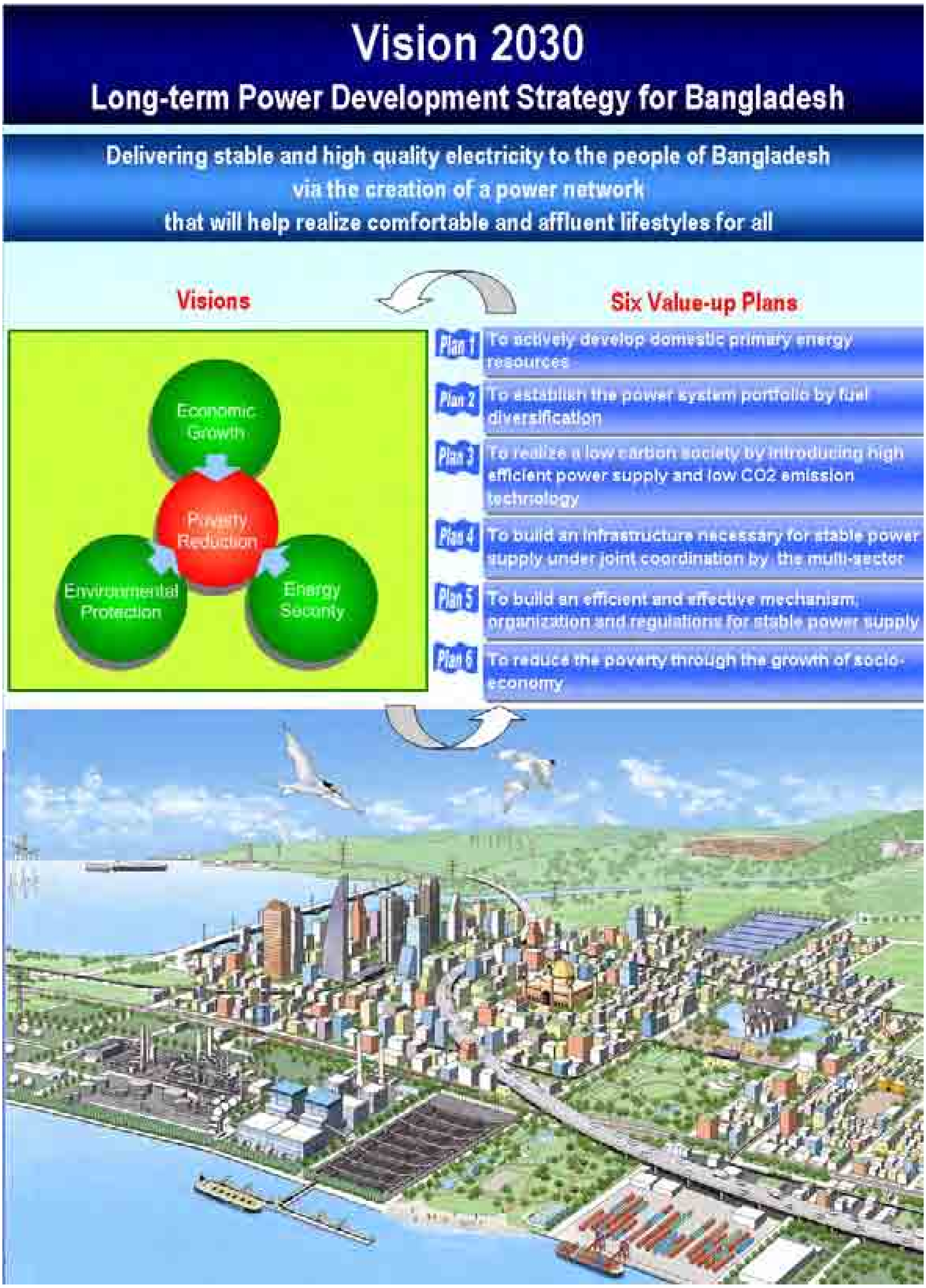
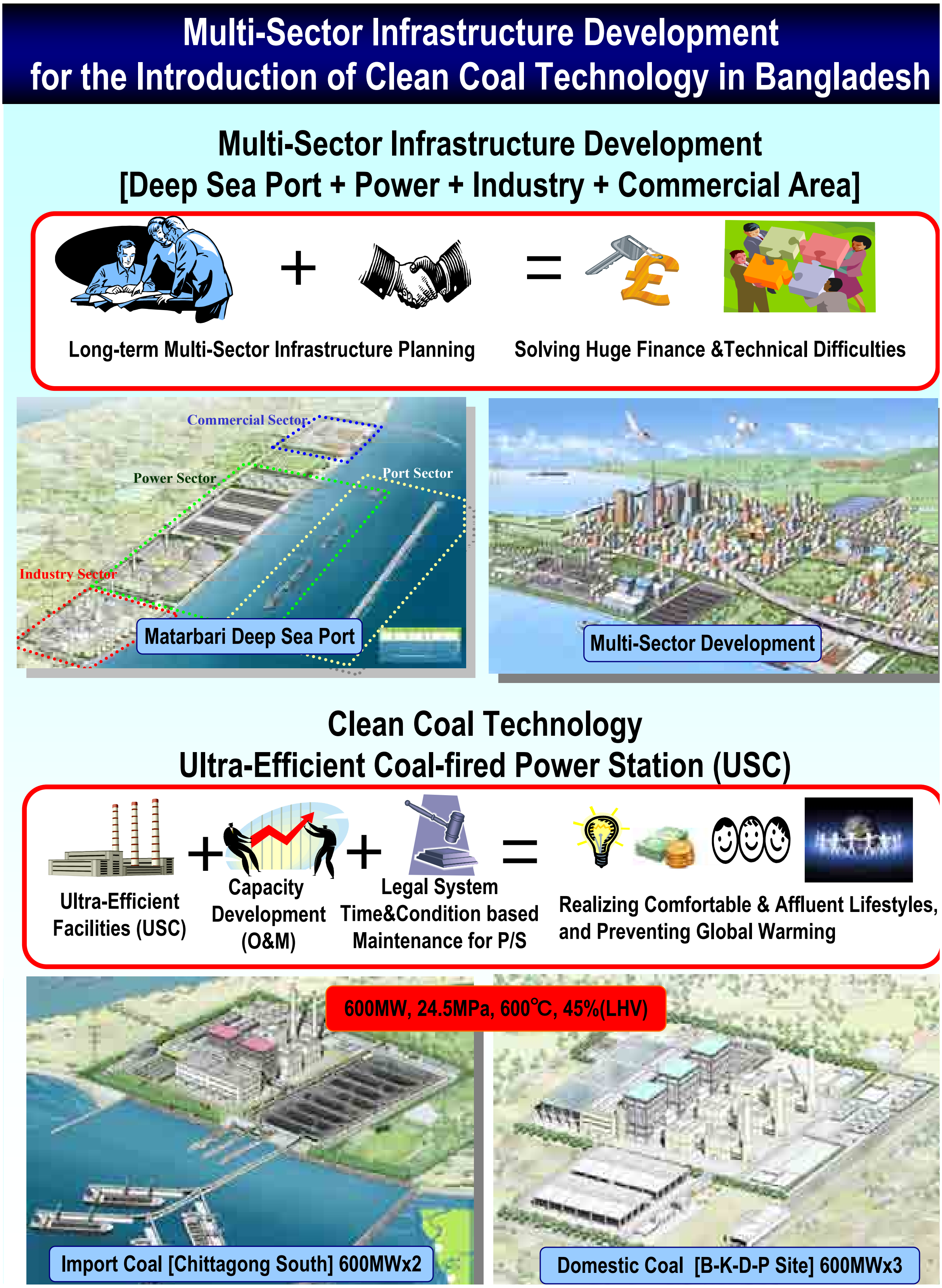


Source: PSMP Study Team



Source: PSMP Study Team

Volume 1 Power System Master Plan 2010

Volume 2 Technical Study for the construction of Coal-Fired Power Station

Volume 3 Recommendations for Future Support Measures

Volume 1 Power System Master Plan 2010, Figure and Table List

Volume 2 Technical Study for the construction of Coal-Fired Power Station, Figure and Table List

Volume 3 Recommendations for Future Support Measures, Figure and Table List

Abbreviations

ADB	Asian Development Bank
ADP	Annual Development Programme
AEC	Asia Energy Corporation (Bangladesh) Pty Ltd
AGA	American Gas Association
AHP	Analytic Hierarchy Process
APSCL	Ashuganj Power Station Company Ltd
A-USC	Advanced Ultra Super Critical
BAPEX	Bangladesh Petroleum Exploration & Production Company Limited
BCF	Billion Cubic Feet
BCFTPP	Barapukuria Coal Fired Thermal Power Plant
BCIC	Bangladesh Chemical Industries Corporation
BCMCL	Barapukuria Coal Mine Company Ltd
BEDL	Barakatulla Electro Dynamics Limited
BERC	Bangladesh Energy Regulatory Commission
BGFCL	Bangladesh Gas Fields Company Limited
BGSL	Bakhrabad Gas System Ltd.
BIFF	Bangladesh Infrastructure Finance Fund Ltd.
BMD	Bangladesh Meteorological Department
BIMSTEC	Bay of Bengal Initiative for Multi Sectoral Technical and Economic
BIWTA	Bangladesh Inland Water Transport Authority
B-K-D-P	Barapukuria-Khalaspir-Dighipara-Phulbari
BMD	Bangladesh Meteorological Department
BMD	Bureau of Mineral Department
BOD	Biological Oxygen Demand
BOO	Build Own Operate
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
BTB	Back to Back
C/P	Counter Part
Cairn	Cairn Energy Plc.
CAS	Country Assistance Strategy (WB)
CBM	Coal Bed Methane
CC	Combined Cycle
CCPP	Combined Cycle Power Plant
CDM	Clean Development Mechanism
CEPZ	Chittagong Export Processing Zone
Chevron	Chevron Bangladesh
CIF	Cost, Insurance and Freight
CNG	Compressed Natural Gas
COBP	Country Operations Business Plan (ADB)
CP	Counter Part
CPI	Consumer Price Index
CPP	Capacity Purchase Price
CR	Critically Endangered
CSR	Cooperate Social Responsibility

CUFL	Chittagong Urea Fertilizer Factory limited
CY	Calendar Year
DC	Deputy Commissioner
DD	Detail Design
DESCO	Dhaka Electric Supply Company Ltd.
DO	Dissolved Oxygen
DOE	Department of Environment
DP	Development Partner
DPDC	Dhaka Power Distribution Company Ltd
DPP	Development Project Proposal
DWT	Dead Weight Tonnage
EAL	Engineers Associate Limited
ECC	Environmental Clearance Certificate
ECPt	Export Coal Price
ECR	Economical Continuous Rating
EGCB	Electricity Generation Company of Bangladesh
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EMRD	Energy and Mineral Resources Division
EN	Endangered
EPP	Energy Purchase Price
EPZ	Export Processing Zones
ESIA	Environmental and Social Impact Assessment
ESP	Electrostatic precipitator
F & I	Freight and Insurance
FGD	Flue Gas Desulfurization
FGD	Focus Group Discussion
FOB	Free On Board
FS	Feasibility Study
FY	Fiscal Year
GDP	Gross Domestic Product
GEF	Global Environment Facility
GNI	Gross National Income
GOB	Government of Bangladesh
GSA	Gas Supply Agreement
GSB	Geological Survey of Bangladesh
GSMP	Gas Sector Master Plan
GT	Gas Turbine
GTCL	Gas Transmission Company Limited
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
HCU	Hydrocarbon Unit, Ministry of Power, Energy & Mineral Resources
HGI	Hardgrave Grindability Index
HIV/AIDS	Human Immunodeficiency Virus and Acquired Immune Deficiency
HPI	Human Poverty Index
I&C	Instrument and Control
IDA	International Development Agency

IDCOL	Infrastructure Development Company Ltd.
IDI	In-depth Interview
IEA	International Energy Agency
IEE	Initial Environmental Examination
IEEJ	Institute of Energy Economics, Japan
IFC	International Finance Corporation
IMCL	IMC Group Consulting Limited, UK
IOC s	International Oil Companies
IPFF	Investment Promotion and Financing Facility
I-PRSP	Interim Poverty Reduction Strategy Paper
IPP	Independent Power Producer
IUCN	International Union for Conservation of Nature
JGTDSL	Jalalabad Gas Transmission & Distribution System limited
JPY	Japanese Yen
KAFCO	Kamaphuli Fertilizer Company Limited
KfW	Kreditanstalt fur Wiederaufbau
kW	kilo-watt
kWh	kilo-watt hour
LAP	Land Acquisition Plan
LCC	Location Clearance Certificate
LDC	Least Developed Country
LIBOR	London Inter-Bank Offered Rate
LNG	Liquefied Natural Gas
LOLE	Loss of Load Expectation
LRMC	Long Run Marginal Cost
MDG	Millennium Development Goal
MM	Million
MMCFD	Million Cubic Feet per Day
MOE	Ministry of Environment and Forestry Affairs
MOF	Ministry of Finance
MOL	Ministry of Land
MPEMR	Ministry of Power, Energy & Mineral Resources
MP	Master Plan
MPA	Mega Pascal
MPL	Meghnaghat Power Limited
MTBF	Medium Term Budgetary Framework
MTMF	Medium Term Macroeconomic Framework
MW	mega-watt
MWh	mega-watt hour
NEP	National Energy Policy
NGFF	Natural Gas Fertilizer Factory Limited
NGO	Non-Governmental Organization
Niko	Niko Resources of Canada, Niko Resources Ltd.
NOC	No Objection Certificate
NOx	Nitrogen oxide
NPD	Norwegian Petroleum Directorate
NSAPR-II	National Strategy for Accelerated Poverty Reduction II

NSW	New South Wales
NWPGCL	North-West Power Generation Company Ltd
NWZPDCL	North West Zone Power Distribution Company Ltd.
O&M	Operation & Maintenance
O/C	Open cast mining
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
OHS	Occupationnal Health and Safety
PBS	Palli Biddyut Samities
PDPAT	Power Development Planning Assist Tool
Petrobangla	Bangladesh Oil, Gas and Mineral Corporation
PGCB	Power Grid Company of Bangladesh
PGCL	Pashchimanchal Gas Company Limited
PLF	Plant Load Factor
PM	Particulate Matter
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PRSP	Poverty Reduction Strategy Paper
PSC	Production Sharing Contract
PSIG	Private Sector Infrastructure Guidelines
PSMP	Power System Master Plan
PUFF	Polash Urea Fertilizer Factory
QHSE	Quality, Health, Safety, Environment
QLD	Queensland
RAP	Resettlement Action Plan
REB	Rural Electrification Board
RMG	Ready Made Grment
RPC	Rural Power Company Ltd
S/S	Substation
SAARC	South Asian Association for Regional Cooperation
SC	Steering Committee
SCADA	Supervisory Control And Data Acquisition
SCR	Selective Catalytic Reduction
SEA	Strategic Environmental Assessment
SGCL	Sundarban Gas Company Limited
SGFL	Sylhet Gas Fields Limited
SoE	State of Environment
SOx	Sulfur oxide
SPM	Single Port Mooring
SPM	Suspended Particulate Matter
ST	Steam Turbine
SZPDCL	Souht Zone Poewr Distribution Company Ltd
Tcf	Trillion Cubic Feet
TCIL	Technoconsult International Limited
TDS	Total Dissolved Solids
TGTDCL	Titas Gas Transmission and Distribution Company Limited
Tk	Taka

toe	tons of oil equivalent
TOR	Terms of Reference
TPES	Total Primary Energy Supply
TSS	Total Suspended Solid
TT	Task Team
Tullow	Tullow Oil Plc.
U/G	Under Ground mining
UCG	Underground Coal Gasification
UFFL	Urea Fertilizer Factory Limited
UNDP	United Nations Development Programme
UNO	Upazila Nirbahi Office
UPO	Union Parishad Office
US$	United States Dollar
USC	Ultra Super Critical
VB	Visual basic
VERL	Venture Energy Resources Limited
WB	World Bank
WTP	Willingness-to-Pay
WZPDCL	West Zone Power Distribution Company Ltd
ZFCL	Zia Fertilizer Company Limited

Volume 1 Power System Master Plan 2010

Chapter 1 Introduction

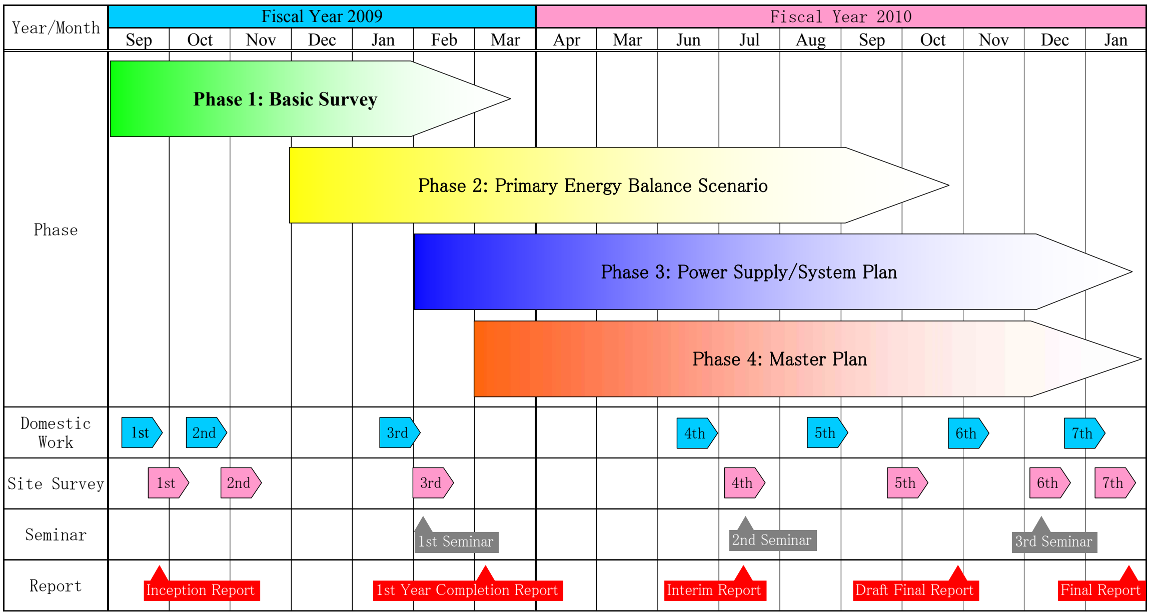
1.1 Objectives of the study

The main objective of this study is to formulate a Master Plan (MP) for the attainment of stable power supply in the People's Republic of Bangladesh up to year 2030 in consideration of the diversification of fuel resources, including an optimum power development plan, power system plan, and identification of the potential power plant sites based on the fuel diversification study. Therefore, this study includes a comprehensive power development master plan where the study of the fundamental conditions of the development (demand forecast, procurement of primary energy resources, optimum power development plan, future optimum power supply structure including the positioning of gas-fired power plants, and so on) are added. In addition, the necessary technology transfer to the Counter Part (C/P) in Bangladesh will be carried out during the study.

1.2 Terms of reference of the study

1.2.1 Schedule of the study

This study for the Master Plan will be carried out over approximately two years from September 2009 to January 2011, a total of 17 months, including seven site surveys. A work schedule and work process for each phase is shown in the following chart.

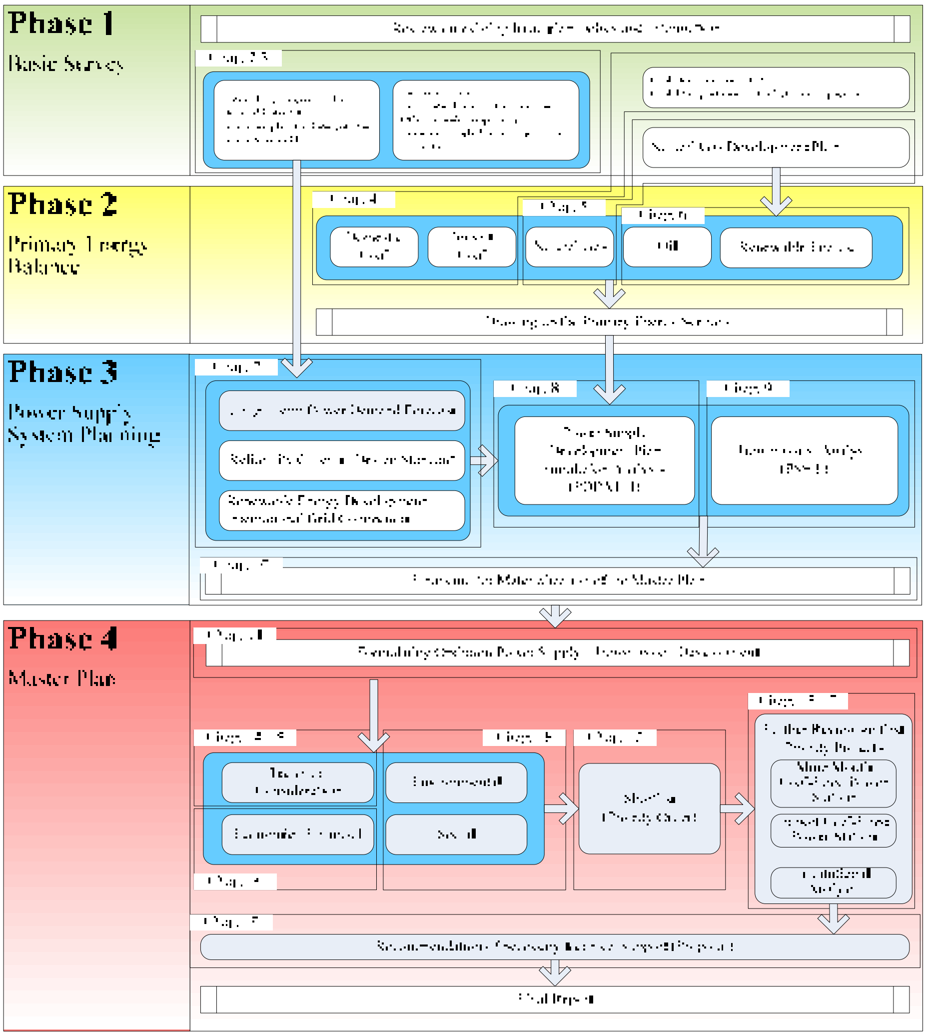


Source: PSMP Study Team

Fig. 1-1 Schedule

1.2.2 Basic work flow

As shown in the basic work flow in Fig. 1-2, the study has been categorized into four phases. The Study will be carried out in close cooperation with each work area to formulate the comprehensive Master Plan on power supply development. In addition, a dissemination workshop will be held at each study stage to reflect the opinions from relevant organizations.



Source: PSMP Study Team

Fig. 1-2 Basic Work Flow

1.2.3 Counterpart organization

- Ministry of Power, Energy and Mineral Resources (MPEMR)
  - ✓ Power Division
  - ✓ Energy and Mineral Resources Division (EMRD)
  - ✓ Power Cell
- Economic Relations Division, Ministry of Finance
- Bangladesh Power Development Board (BPDB)
- Barapukuria Coal Mine Company Ltd (BCMCL)
- Power Grid Company of Bangladesh (PGCB)
- Dhaka Power Distribution Company Limited (DPDC)
- Dhaka Electric Supply Company Limited (DESCO)
- Rural Electrification Board (REB)
- Bangladesh Oil, Gas Mineral Corporation (Petrobangla)
- Electricity Generation Company of Bangladesh (EGCB)
- Ashganj Power Station Company Limited (APSCL)
- North-West Power Generation Company Ltd (NWPGCL)
- Geological Survey of Bangladesh (GSB)
- Ministry of Environment and Forestry Affairs (MOE)

1.2.4 Experts and respective area of the study

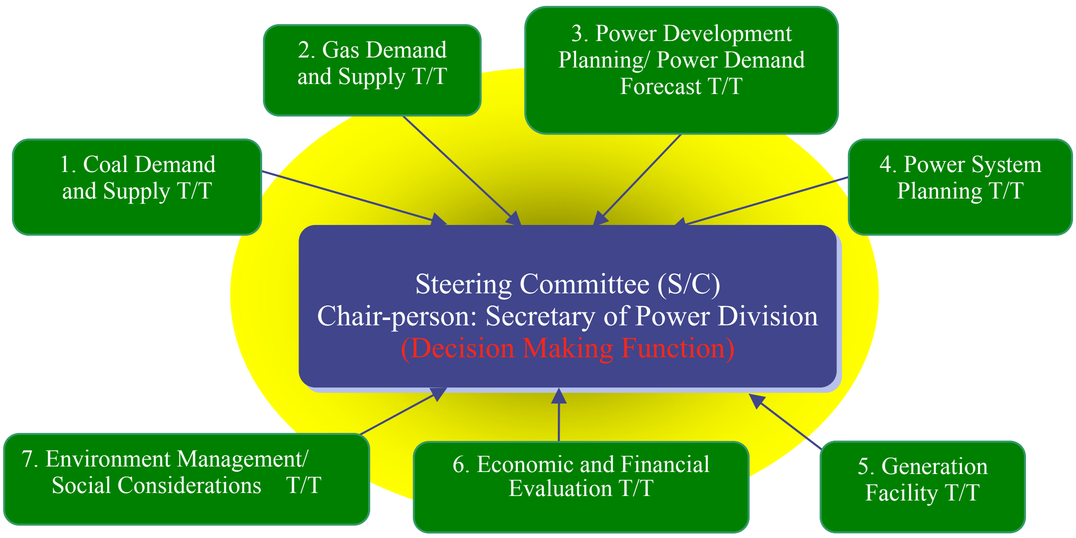
Expert list and its role of work are as follows:

(1) Expert list

Team Leader / Coal-fired Power Generation System	Nobuteru TAKEDA
Sub-Leader/ Power Development Planning / Demand forecast	Toshiyuki KOBAYASHI
Renewable Energy Development	Noboru SEKI
Coal Development/ Supply system A	Hajime ENDO
Coal Development/ Supply system B	Atsushi KAKIZAKI
Natural Gas Supply System A	Kiyoshi KATAOKA
Natural Gas Supply System B	Hideo MATSUSHITA
Natural Gas Supply System C	Chikanobu NAKAMURA
Civil/ Fuel Transportation	Genshiro KANO
Coal-fired Power Generation System/ O&M Management System	Yoichiro KUBOTA
Power Transmission Line and Substation Facilities/ Power System Planning A	Shinichi FUNABASHI
Power Transmission Line and Substation Facilities/ Power System Planning B	Masaki KUROIWA
Economic/ Financial Analysis/ Organization Structure A	Atsumasa SAKAI
Economic/ Financial Analysis/ Organization Structure B	Yasuhisa KURODA
Environmental Management	Takahisa ITO
Social Considerations	Junko FUJIWARA

(2) Steering Committee (SC) and Task Team (TT) Structure

Based on the discussion with C/P, Steering Committee (SC) as decision making board and seven Task Teams as discussion group at working level under SC are formed. The structure of SC and TT is shown in Fig. 1-3. SC is held properly in line with the progress of the Study. The items discussed within individual TTs are brought up at SC, shared amongst both parties, and made decision.



Source: PSMP Study Team

Fig. 1-3 Structure of Steering Committee and Task Teams

1.3 Information sharing and cooperation with Development Partners

Throughout the first to the 5th site survey, the PSMP Study Team has endeavored to share its information with the Development Partners (DP) and discussed the content of the study and the principle by holding individual and joint meetings and attending the forum and official meeting hosted by DP, including the following events.

- The first site survey: from Saturday, 3rd October to Friday, 9th October 2009, Explanation of Inception report, TOR, schedule, principle of the report
- The second survey: from Wednesday, 28th October to Friday, 13th November 2009, track record and progress of the power sector projects supported by DPs as a part of the study.
- The third survey: from Saturday, 30th January to Friday, 19th February, the first Seminar, the report and discussion on the site survey and its findings
- The fourth survey: from Saturday, 3rd July to Friday, 23rd July 2010, the second Seminar, the explanation and discussion of the Interim Report and its concrete context.
- The follow-up survey: from Friday, 3rd September to Tuesday, 7th September 2010, discussion on the comments from World Bank
- The fifth survey: from Saturday, 2nd October to Sunday, 17th October 2010, the joint discussion with DPs and governments regarding the official comments for Interim Report

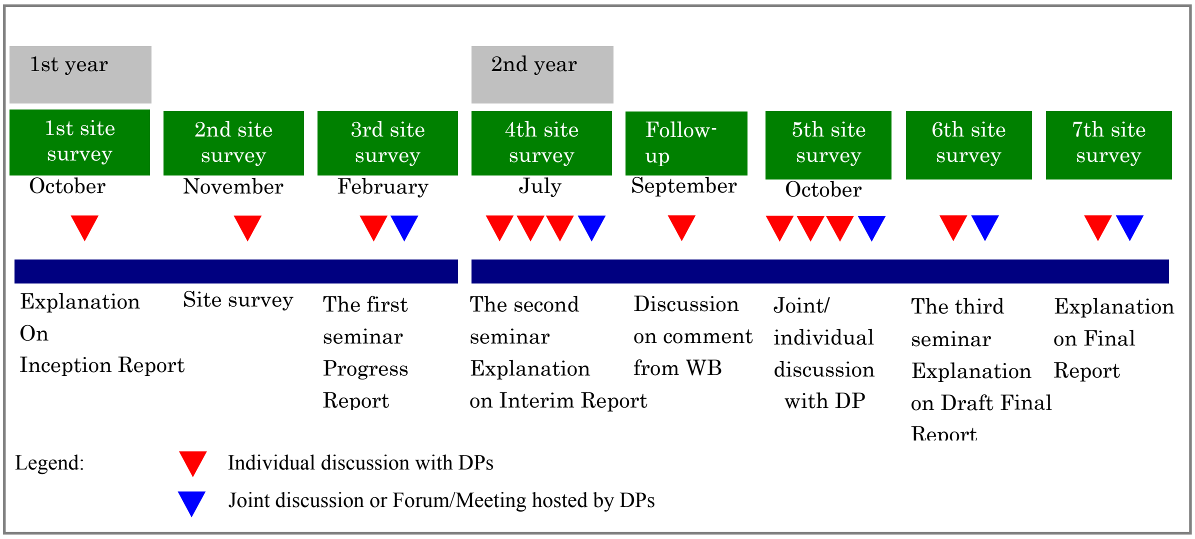


Fig. 1-4 The track record of the discussion with Development Partners


Individual Discussion (every survey)


Bangladesh Development Forum (2010.2)


DP meeting (2010.7)


Joint meeting (2010.10)

Source: PSMP Study Team

1.4 Seminars

1.4.1 The First Seminar

(1) Date: Wednesday 3rd February 2010, 10:00-16:00

(2) Venue: Lakeshore Hotel , conference room

(3) Outline:
The first seminar was held at the Lakeshore Hotel conference room on 3rd February, 2010. The seminar was composed of two parts; the first part was for those at the working level to discuss the context of the survey, and second part was for about 40 persons from the Additional Secretary of Power and Energy Division, DPs including ADB to explain the purpose, principal, schedule, technical transfer and progress of this study. PSMP Study Team and CPs from Bangladesh confirmed the direction of this study via a live discussion during the question and answer session at this Seminar.



Source: PSMP Study Team

1.4.2 The Second Seminar

(1) Date : Sunday 11th July 2010, 14:00-17:00

(2) Venue: BPDB conference room

(3) Outline:
The second seminar was held at the BPDB conference room on 11th July 2010. The main purpose of the seminar was to explain and discuss the Interim Report. The Honorable Adviser to the Prime Minister was attended as the representative of the Bangladesh Government and discussed the primary energy scenario, power demand forecast, the potential sites of the prioritized coal fired power station projects. Bangladesh CP and PSMP Study Team jointly confirmed the direction of the Study hereafter.



Source: PSMP Study Team

1.4.3 The Third Seminar

(1) Date : Monday 13th December 2010, 10:00-17:00

(2) Venue: Sheraton Hotel Ball Room

(3) Outline:
The third seminar was held at the Sheraton Hotel on 13th December 2010. The seminar was composed of two parts; the first session for the high level officials and the second session for the working level. The Honorable Adviser to the PM was attended as the representative of the Bangladesh Government, and the Ambassador of Japan was also attended in the first part, to discuss about outline of the Draft Final Report, and second part was for detail discussion about each expert at the working level. PSMP Study Team and CPs from Bangladesh confirmed the direction of this study via a live discussion during the question and answer session at this Seminar.



Source: PSMP Study Team

1.4.4 Final Report Consultation Meeting

(1) Date: Sunday 30th January 2011, 10:00-13:30 (Lunch session after 12:00)

(2) Venue: Dhaka Sheraton Hotel Ball Room

(3) Outline:
Final Report Consultation Meeting was held at the Dhaka Sheraton Hotel on 30th January 2011. Secretary Power Division and related persons attended this meeting and discuss about the treatment for comments of Draft Final Report, and the contents of Final Report was shared to finalize the report.



Source: PSMP Study Team

1.5 Technical transfer

1.5.1 Technical transfer through Task Team meetings

During Task Team meetings, the technical transfer was proceeded by working analysis and investigation together.



Source: PSMP Study Team

1.5.2 Group training

(1) Power development simulation software (PDPAT) training

The group training for power development simulation software (PDPAT) was held by lecture style.

(1) Date: Saturday, July 10, 2010

(2) Venue: BPDB conference room


Source: PSMP Study Team

(2) Power system planning software (PSS/E) training

The group training for power system planning software (PSS/E) was held by lecture style.

(1) Date: Thursday, July 8, 2010 (Part 1), Monday, January 31, 2011 (Part 2)

(2) Venue: PGCB conference room



Source: PSMP Study Team

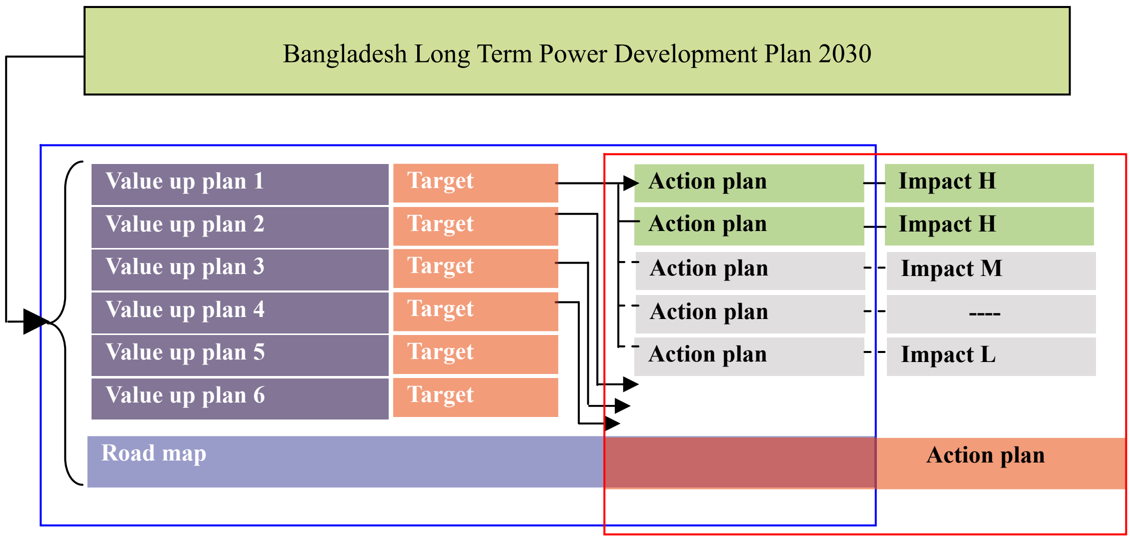
Chapter 2 Viewpoints and Objectives of the Master Plan

2.1 Viewpoints and objectives of the Master Plan

When reviewing the Power System Master Plan (MP), the fundamental objective is to formulate the Master Plan for the attainment of stable power supply by achieving the 3Es; Economic Growth, Energy Security and Environmental Protection simultaneously. The government of Bangladesh set the maximum target to reduce poverty in a period as swift as possible by achieving high economic growth. Planning electrification via the stabilization and efficiency of the electric power supply system can be expected to reduce poverty. This Master Plan will aim to promote development that will provide a self-reinforcing cycle of poverty reduction and 3E simultaneous achievement. In addition, this Master Plan will propose the vision in line with Government energy policy, and stipulate 6 value-up plans to achieve the vision.

2.2 Structure of the Vision, Road map, Action plan and Target

The structure of the Vision, Roadmap, Action Plan and Target is shown in the following figure. The Vision is proposed as Bangladesh's long term strategic power development vision 2030. To achieve this Vision, 6 value-up plans have been stipulated, where each value-up plans have their own targets to achieve the plans. There are Action Plans to achieve the Targets, where each Action Plan indicates the action agents and potential impact. The Roadmap shown in this chapter extracts the Action Plans that will result in high potential impact, and describes the details.

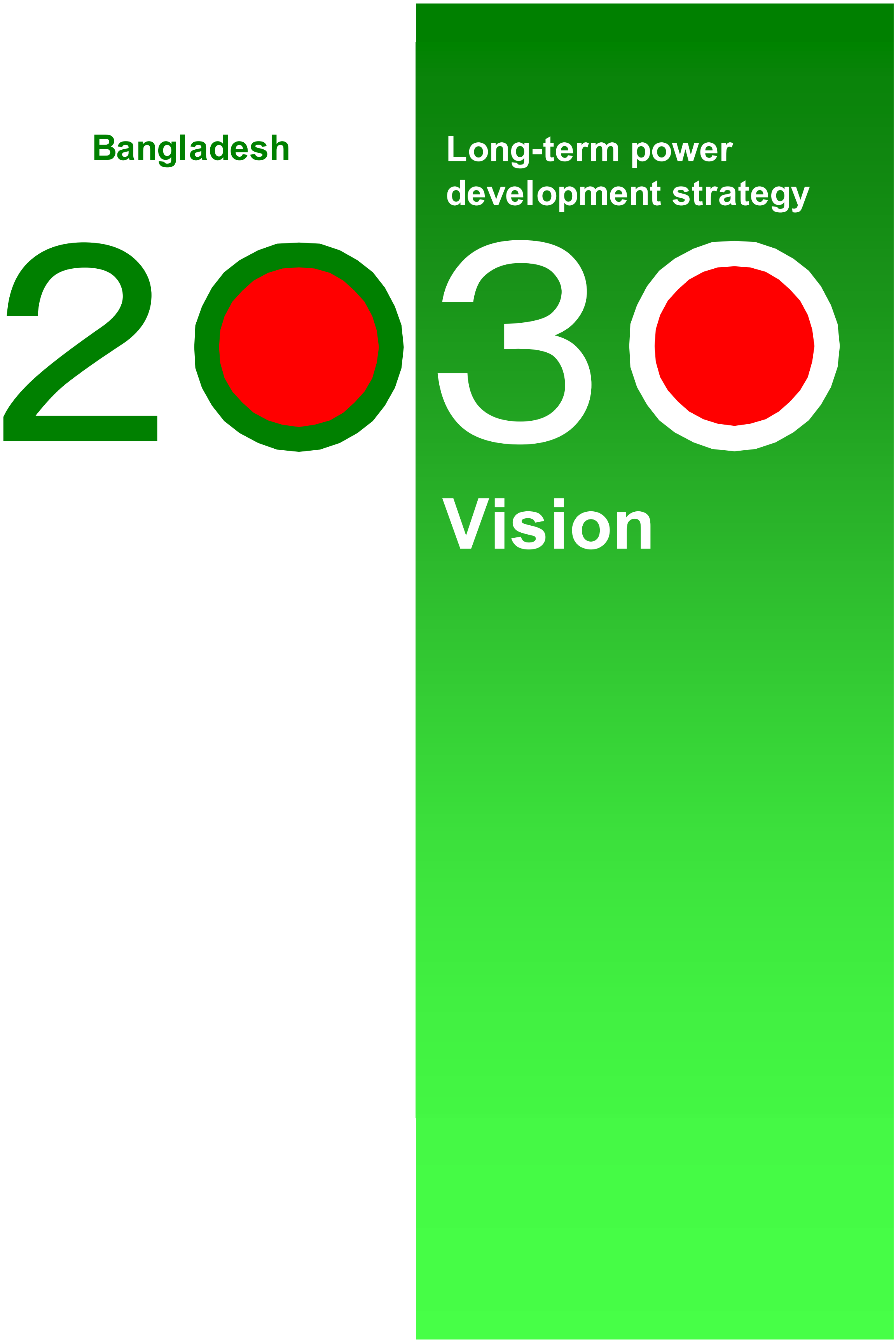


Source: PSMP Study Team

Fig. 2-1 Bangladesh Long Term Power Development Plan 2030

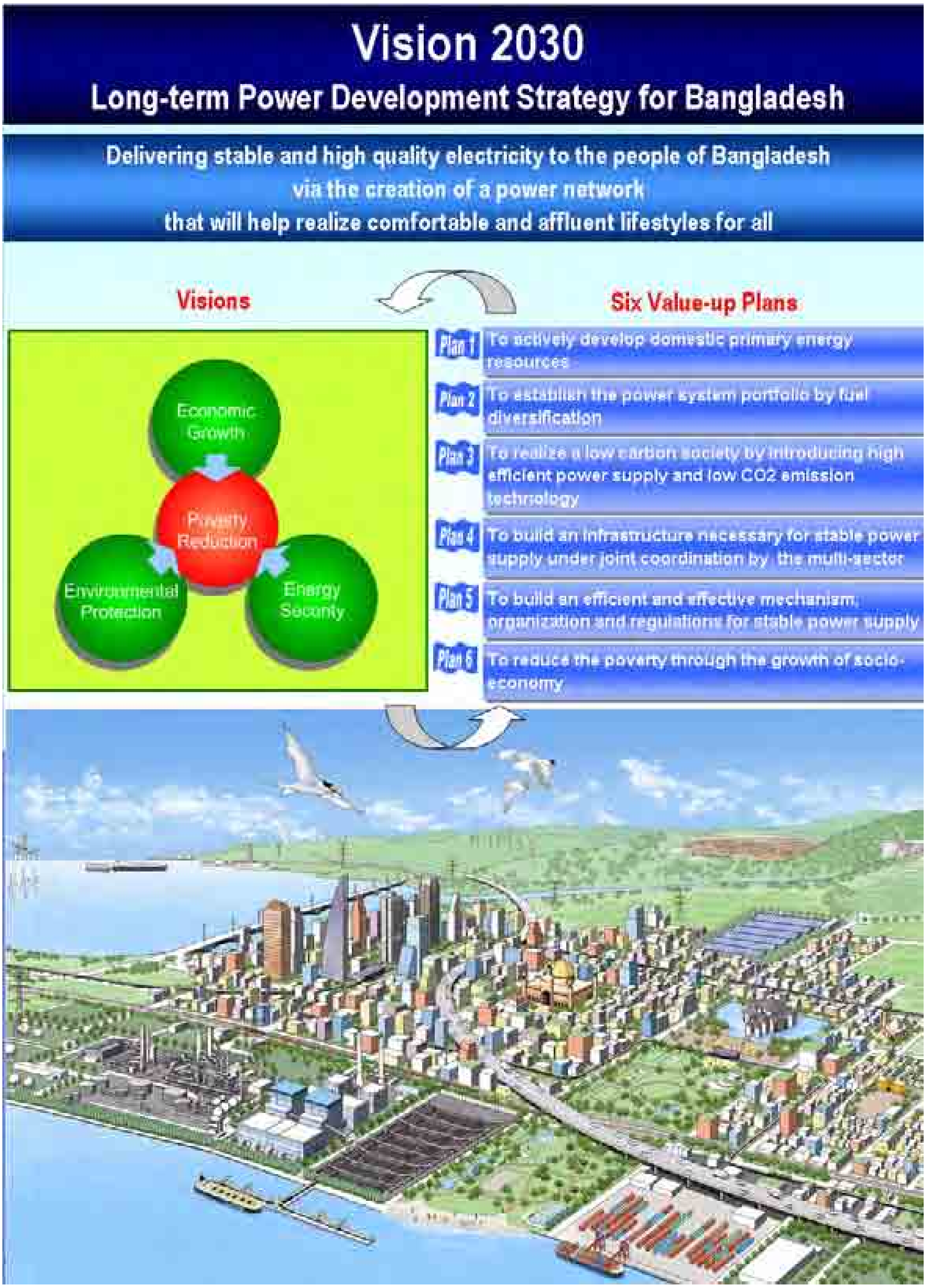
2.3 Vision Paper

The Vision Paper and associated value-up plans are shown as follows;



Source: PSMP Study Team

Vision



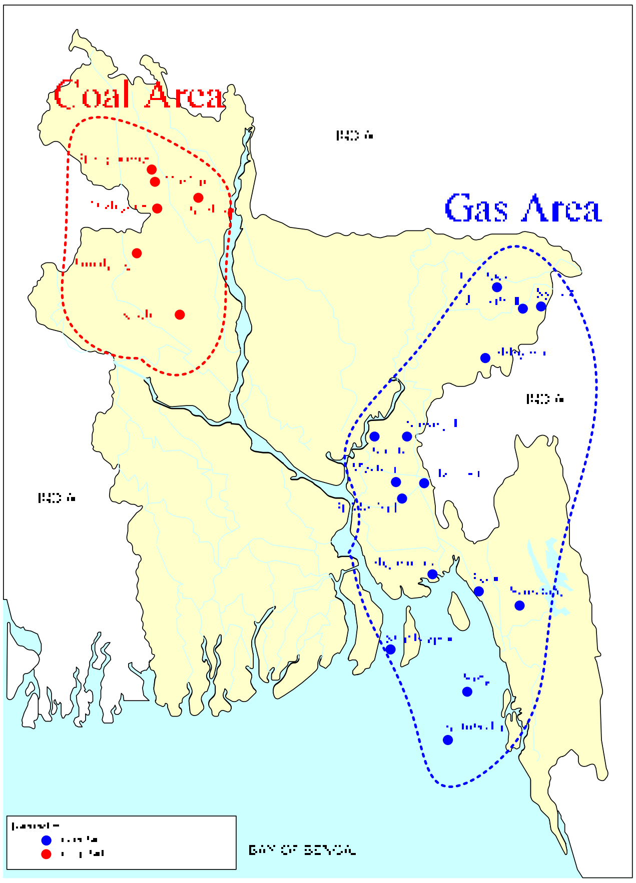
Source: PSMP Study Team

Plan 1 **To actively develop domestic primary energy resources**

Target **To maintain domestic primary energy supply over 50%**

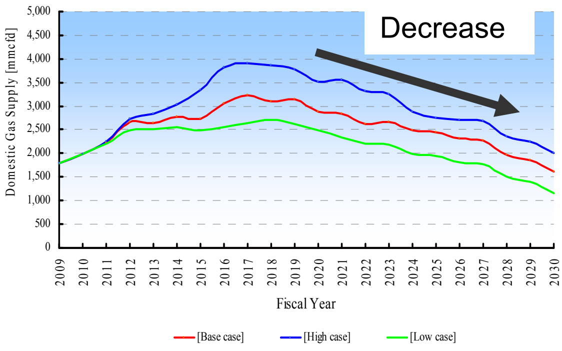
To deal with Bangladesh's rapid economic growth and the accompanying increase of electric power, there is an urgent need to secure a source of energy that is essential to the economy and stability. The active development of domestic primary energy resources is the best and realistic way to supply energy resources.

The main domestic primary energy resources are domestic natural gas and domestic coal. As shown in Fig. 2-2, domestic coal has been unevenly distributed in the Western part of Bangladesh, while natural gas is located in the Eastern area. As shown in Fig. 2-3 and Fig. 2-4, domestic gas supply will be expected to decrease in the near future, while domestic coal supply will increase. In the event that fuel diversification advances during the later years, the Master Plan aims to acquire a 25% share of domestic coal and a 20 percent share of domestic natural gas, and a 5% share of national hydropower and renewable energy, thus ensuring the self-sufficiency of the primary energy resource to be over 50 percent by Year 2030.



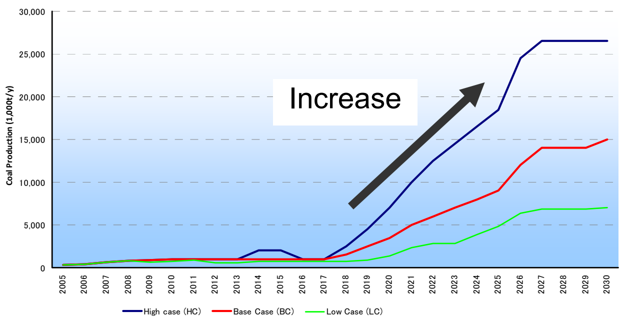
Source: PSMP Study Team

Fig. 2-2 Domestic coal and natural gas production area



Source: PSMP Study Team

Fig. 2-3 Domestic gas supply scenario



Source: PSMP Study Team

Fig. 2-4 Domestic coal supply scenario

(1) Domestic natural gas development

Action plans for domestic natural gas development are as follows;

- Re-evaluation of domestic natural gas reserve: to periodically re-evaluate domestic natural gas reserve in order to forecast future gas supply and justify the development and work over planning.
- Demand forecast for natural gas: to forecast the demand for natural gas on a rolling basis in order to match natural gas production planning.
- Exploration and development of domestic natural gas: to explore and develop domestic natural gas in order to enhance domestic natural gas production from new gas fields.
- Workover of existing natural gas field: to implement the work-over of the existing natural gas field in order to enhance natural gas production from existing gas fields.

(2) Domestic coal development

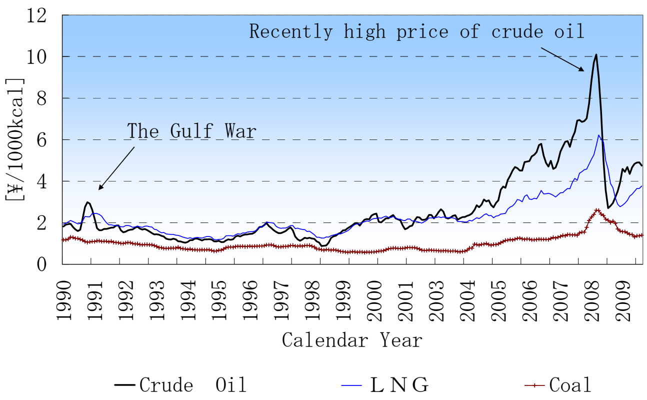
Action plans for domestic coal development are as follows;

- Finalization of Coal Policy: to finalize the current draft Coal Policy and to formulate the laws and/or regulations with regards to domestic coal development or coal mine development.
- Implementation and evaluation of the pilot mining: to implement and evaluate the pilot mine in order to judge the open cast mine feasibility, including the underground water treatment, coal production rate, and social impact.
- Demand forecast for domestic coal: to forecast the demand for coal on a rolling basis in order to match coal production planning.
- Building for the mine engineer training system: to build the mine engineer training system in order to stand upon a self-reinforcing mine operation without dependence on foreign country's support.
- Considering the CBM and/or UCG technology: to consider the CBM (Coal Bed Methane) and/or UCG (Underground Coal Gasification) technology in order to promote the utilization of un-used or un-developed domestic coal.

Plan 2 To establish the power system portfolio by fuel diversification

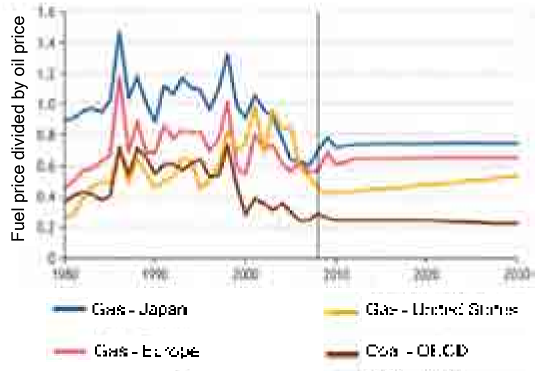
Target **Fuel composition ratio as of 2030: coal 50%, natural gas 25%, others 25%**

As shown in plan 1, the Master Plan prioritizes the use of domestic primary energy sources. However, in the case domestic energy supplies are not enough to fulfill the rapid demand growth for electricity and natural gas, it will be necessary to tap into other power sources from outside the Bangladesh.
To achieve the best mix of energy supply including imported resources, it would be required to use economical and stable power source in consideration of environmental protection. Especially coal will be an important resource as the primary energy supply in Bangladesh hereafter, due to i) its price stability and lower volatility compared with oil and natural gas, ii) longer reserve to production ratio compared with oil and natural gas, and iii) its wide spread availability throughout the world and is expected to be supplied stably, as shown in the following figures.



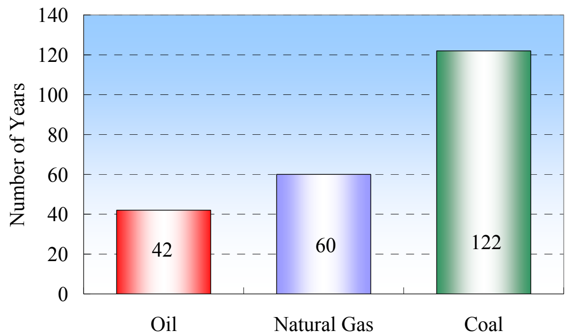
Source: The Institute of Energy Economics, Japan , 2010.4

Fig. 2-5 Fuel price trend



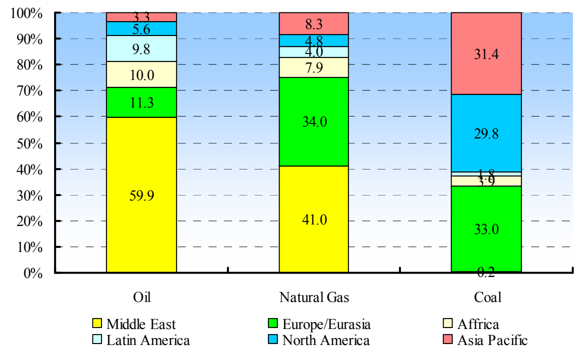
Source : IEA World Energy Outlook 2009

Fig. 2-6 Compare with fuel price divided by oil price



Source : BP Statistical Review 2009

Fig. 2-7 Production reserve ratio of each fuel



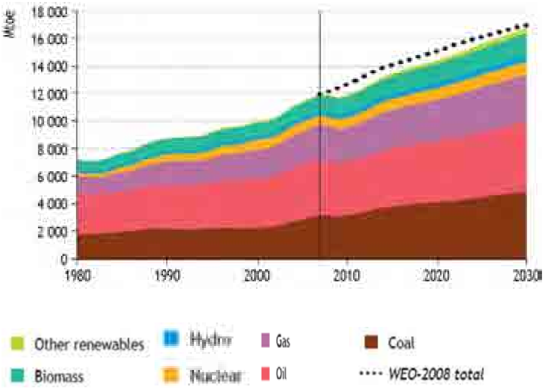
Source : BP Statistical Review 2009

Fig. 2-8 Resource reserve of each area

Reviewed by the International Energy Agency (IEA), while coal consumption in the world was 3,200 billion tons of oil equivalent (Mtoe) in 2007 (26% of primary energy), it will be 4,900 Mtoe in 2030, more than a 50% increase (26% of primary energy). About 90% of increased 1,700 Mtoe can be attributed to increased Asian consumption. The coal consumption share of Asia was about 60% in 2007, and about 70% in 2035. Asia will be center of coal consumption. OECD shares will decrease from 36% in 2007 to 27% in 2035. On the other hand, shares of LDC will increase from 64% in 2007 to 73% in 2035. It is projected that coal will play a major role among primary energy sources in the next decade or so. [1]

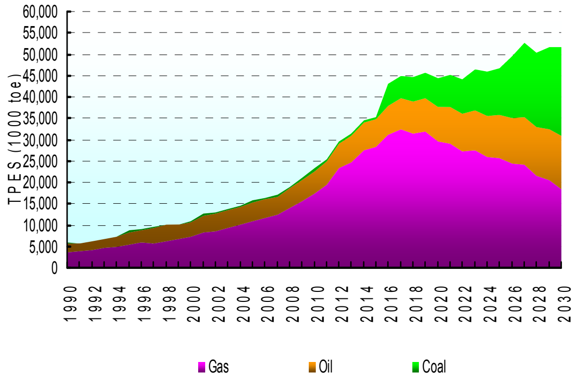
When reviewing world power generation, coal use shares will not change significantly.[2] It indicates that coal currently plays a major role in global power generation and this central role will still remain for some time.

The major primary energy supply forecast in Bangladesh is shown in the figure below, where natural gas supply will decrease after 2017 while coal supply will increase as an alternative source of natural gas. In this Master Plan, the target composition of power supply as of 2030 is set at 50% for domestic and imported coal, 25% for domestic and imported (in the form of LNG) natural gas and 25% for other sources such as oil, nuclear power and renewable energy.



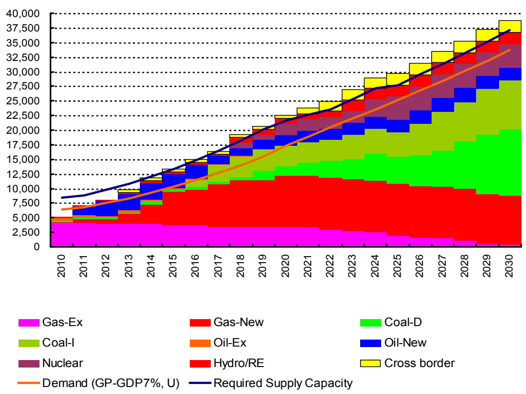
Source: IEA World Energy Outlook 2009

Fig. 2-9 World primary energy balance



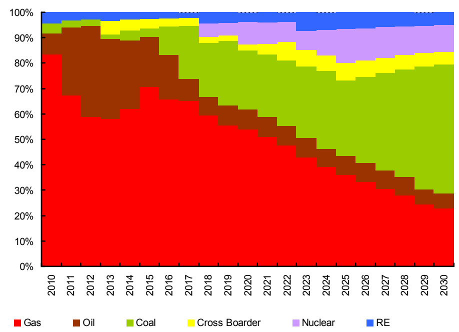
Source: PSMP Study Team

Fig. 2-10 Bangladesh primary energy balance



Source: PSMP Study Team

Fig. 2-11 Power development plan up to 2030 (MW)



Source: PSMP Study Team

Fig. 2-12 Power development plan up to 2030 (%)

(1) Construction of imported coal power station

- FS for imported coal power station: to carry out the FS for imported coal power stations
- DD for imported coal power station: to implement the detailed design reflecting the result of the FS

[1] The Institute of Energy Economics, Japan 2010.04

[2] IEA World Energy Outlook, 2009

- Procurement for imported coal: to examine the method on how to procure imported coal as this is the first time for Bangladesh to import coal by sea
- Establishment of the imported coal chain: to establish the imported coal chain, which provides a seamless coal delivery system from the mine mouth in the exporting country to the banker at the power station in Bangladesh
- Construction of a high efficient USC power station: to construct a high efficient power station by utilizing USC technology in order to prevent global warming.

(2) Introduction of LNG facilities

- FS of the offshore LNG terminal: to implement a feasibility study for the offshore LNG terminal.
- Procurement of LNG: to establish the LNG chain from the gas fields in exporting countries to re-gasification.
- Construction of the offshore LNG terminal: to construct an offshore LNG terminal, if the results of the FS are feasible.
- Consideration of the onshore LNG terminal: to consider the construction of the onshore LNG terminal in order to establish a long term LNG supply chain

(3) Construction of the oil fired power station

- Establishment of an oil-fired power station (Rental Power) as an emergency measure: to establish the oil-fired power station or Rental Power as an emergency measure for the short term solution and to use them during peak demand periods for the long term

(4) Import the electricity generated by hydro power from the neighboring countries or joint development

- There are huge potential of hydro power sources in the neighboring countries such as India, Nepal and Bhutan so they can be utilized in the context of the South Asia Regional Initiative (SARI) for joint development with Bangladesh and the countries of the region.

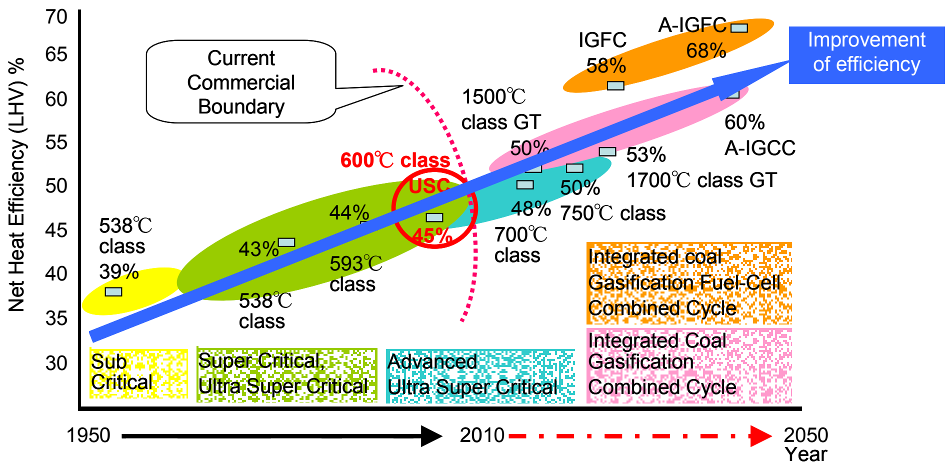
(5) Development of domestic renewable energy (wind and solar power)

- To develop wind and solar power as a domestic power supply source.

Plan 3 **To realize a low carbon society by introducing a high efficient power supply and low CO2 emission technology**

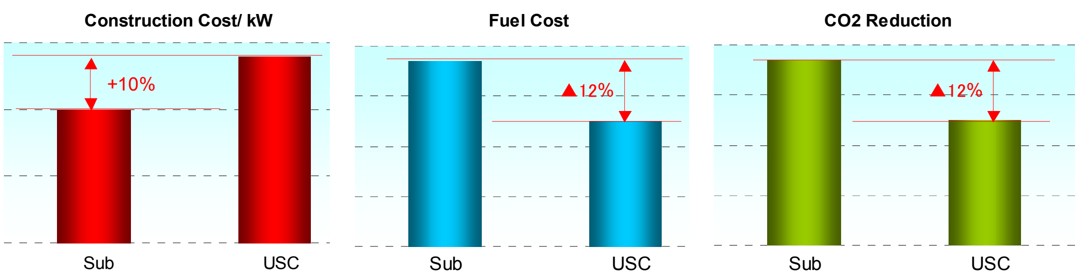
Target **To improve 10 points thermal efficiency on average**

In order to lessen the coal power station's environmental impact, it is essential to improve thermal efficiency by utilizing the proven Clean Coal Technology that has been established in Japan. According to recent coal-fired power station operations, the world class thermal efficiency (45%, LHV basis) was achieved by using Ultra Super Critical (USC) technology as a part of the Clean Coal Technology. By utilizing such technology in Bangladesh, great improvements of thermal efficiency and contributions to reduce green house gas could be achieved, if compared with the situation by using the sub critical technology (40%, LHV basis) widely used in other Asia regions.
In addition, there are environmental measures other than global warming, such as the reduction of NOx, SOx, and particulate matter. With regards to the comprehensive technology transfer regarding the environmental protection and the promotion of the technology, it makes it possible to achieve 3E, especially simultaneous environmental protection and economic growth, even through utilizing coal.



Source: Cool Earth 50 Energy Technical Innovation Program

Fig. 2-13 Efficiency improvement of coal fired power plant



Source: PSMP Study Team

Fig. 2-14 Subcritical vs. USC (image)

Source: PSMP Study Team

Fig. 2-15 Domestic coal fired power station bird's eye view (B-K-D-P site)

Source: PSMP Study Team

Fig. 2-16 Imported coal fired power station bird's eye view (Cittagong South site)

In line with the apparent curtailment of natural gas production, the improvement of gas utilization efficiency has become an urgent matter. To prioritize gas supply for higher efficiency power plants is practically necessary in order to improve the effectiveness of gas utilization in the whole power sector. Therefore, during the construction of a new power station, including the demolishment of the old power station, power expansion planning and system operation planning will be implemented in comprehensive consideration of the stability, environment, economics and operation, in line with the introduction of the world's class efficient combined cycle power station, and high efficiency and low carbon emission thermal power technology.

(1) Higher efficient gas power station

- Higher efficiency of the existing gas power station: to achieve higher efficiency via the re-powering of the existing power station.
- Construction of the combined cycle gas power station: to construct a higher efficient gas combined power station, and to improve the total efficiency via the allocation of gas to a higher efficient power station.

(2) Development of domestic coal power station

- FS for domestic coal power station: to implement the FS for domestic coal power station by using Clean Coal Technology
- DD for domestic coal power station: to implement a detailed design reflecting the result of the FS
- Construction of high efficient USC power station: to construct a high efficient power station by using USC technology in order to prevent global warming.
- Consideration of large scale coal power station: while the initial capacity is 600MW, however, the construction of the large scale power station (1000MW class) will be studied after 2020.

(3) Reviewing O&M scheme

- To reviewing current O&M scheme, in order to reduce the number of unplanned starts and stops, and to improve the load factor.
- To establish the USC O&M scheme.
- To establish the environment and safety scheme

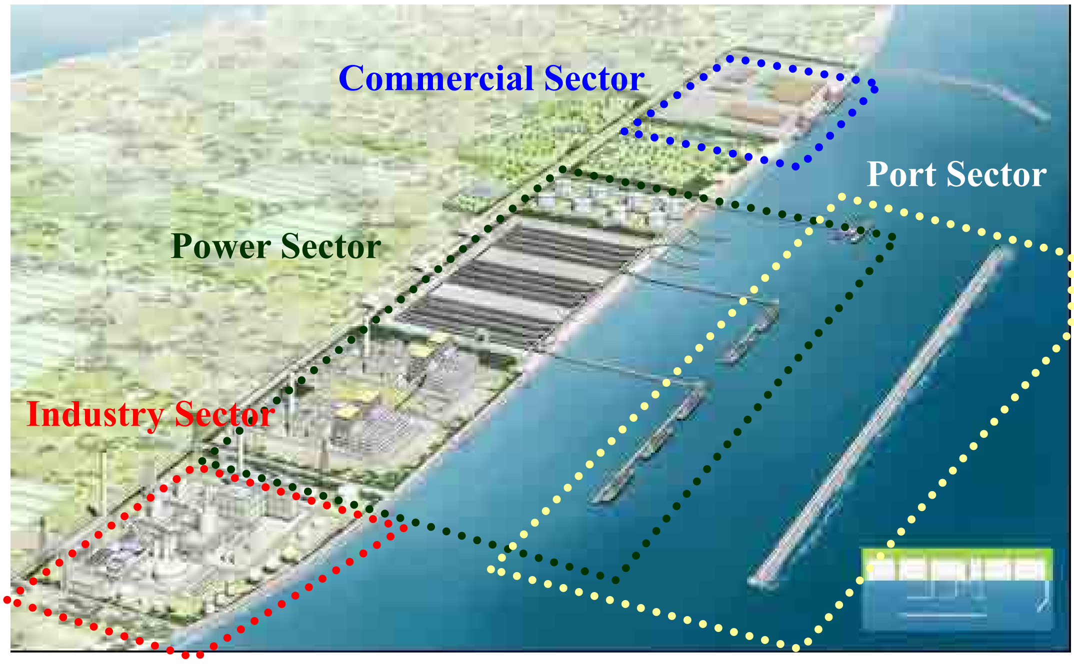
(4) Energy conservation, Demand side management

- To rationalize the load dispatch by prioritization of gas allocation to higher efficient power station in order to reduce CO2 emission.
- To rationalize the customer side by energy conservation and demand side management in order to reduce CO2 emissions.

Plan 4 **To build an infrastructure necessary for stable power supply under joint coordination by the multi-sector**

Target **To jointly build a deep sea port facility by power, industry and commercial sector**

It is clear that the enhancement of power supply will be necessary in line with future power demand growth. As a power supply related infrastructure, it is also necessary to develop a gas transmission line, a fuel center, a deep sea port, a domestic waterway, a railway and so on. Vast amount of investment is required to build these infrastructures. It is impossible for the power sector to bear such huge investment alone. Hence, cooperation with other sectors such as industry and commercial enterprises will be needed to achieve cost reduction and a synergy effect.



Source: PSMP Study Team

Fig. 2-17 Example of deep sea port development

(1) Construction of deep sea port

- As of today, the power sector, commercial sector and industry sector are individually planning to develop the port. However, the multi-sector will harmoniously develop a deep sea port where huge costs are required.

(2) Improvement of the power transmission system

- To improve the power transmission system in line with power supply amount growth
- To develop cross border power trading.

(3) Enhancement of gas transmission line

- To enhance the gas transmission line in line with domestic gas demand growth

(4) Construction of fuel center

- To enhance the gas transmission line in line with domestic gas demand growth
- To implement a coal center FS.

- To construct a coal center.
- To jointly develop a fuel center (receiving facility for imported coal, LNG and oil) via multi sector cooperation.

(5) Strengthening the domestic waterway

- To strengthen the domestic waterway via periodical dredging for internal ships from the coal center to the power station.

(6) Strengthening the railway system

- To strengthen the domestic railway system in order to transport coal from the coal center to the power station.

(7) Construction of Special Economic Zone adjacent to the deep sea port

- To construct Special Economic Zone adjacent to the deep sea port, where comprehensive stable and reliable energy, not only power but also fuel, heat (steam) and water, will be supplied to customers within the zone considering global environmental protection and energy saving, when developing the commercial sector area in order to invite foreign and domestic companies.

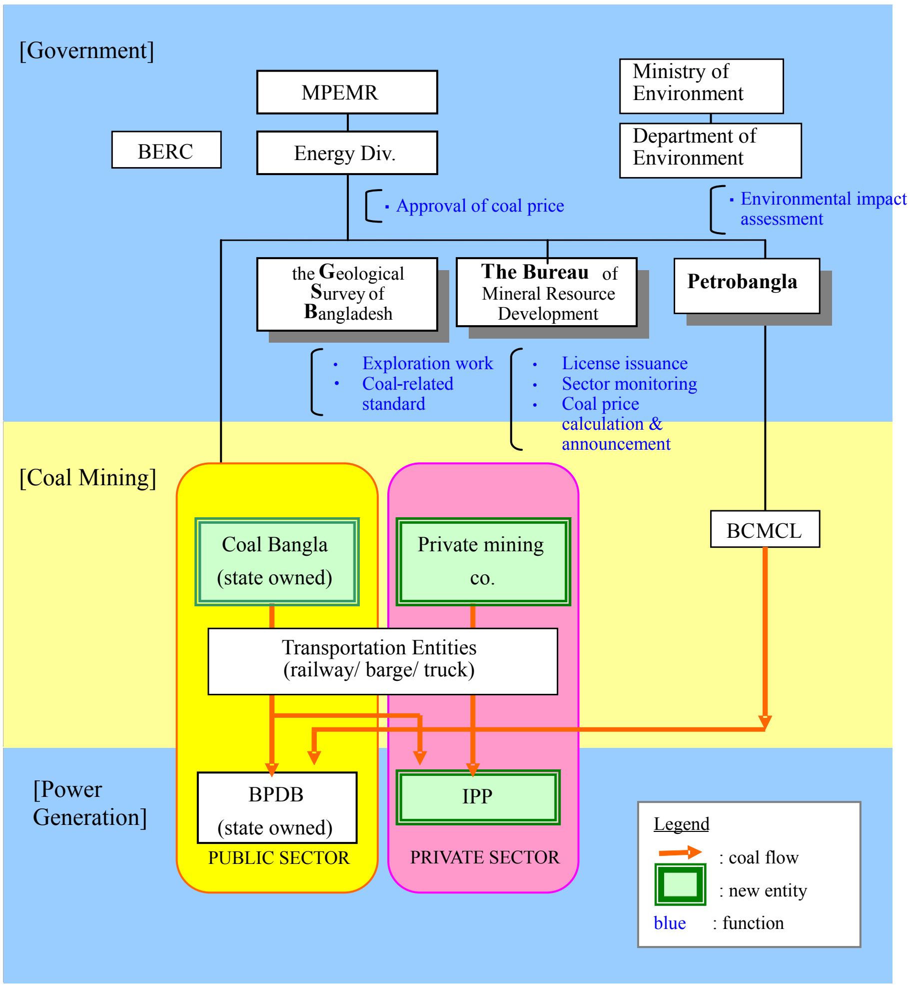
Plan 5 **To build an efficient and effective mechanism, organization and regulations for stable power supply**

As Bangladesh has less experience in dealing with coal power station development, the Master Plan recommend to set up an organization for coal procurement, to strengthen the regulations leading to the sure implementation of regular inspections, to prepare a lucrative investment environment by the private sector, to impose levies for the plant and equipment investments, to create an investment environment for the private sector and to establish an effective and efficient power market.

Target **To establish an organization for long-term stable fuel supply security**

(1) Organization for coal procurement

As Bangladesh has less experience in dealing with coal power station development, the Master Plan recommended to set up a new organization for coal procurement to smooth the way towards its realization. The following figure is an organizational example of domestic coal procurement.



Source: PSMP Study Team

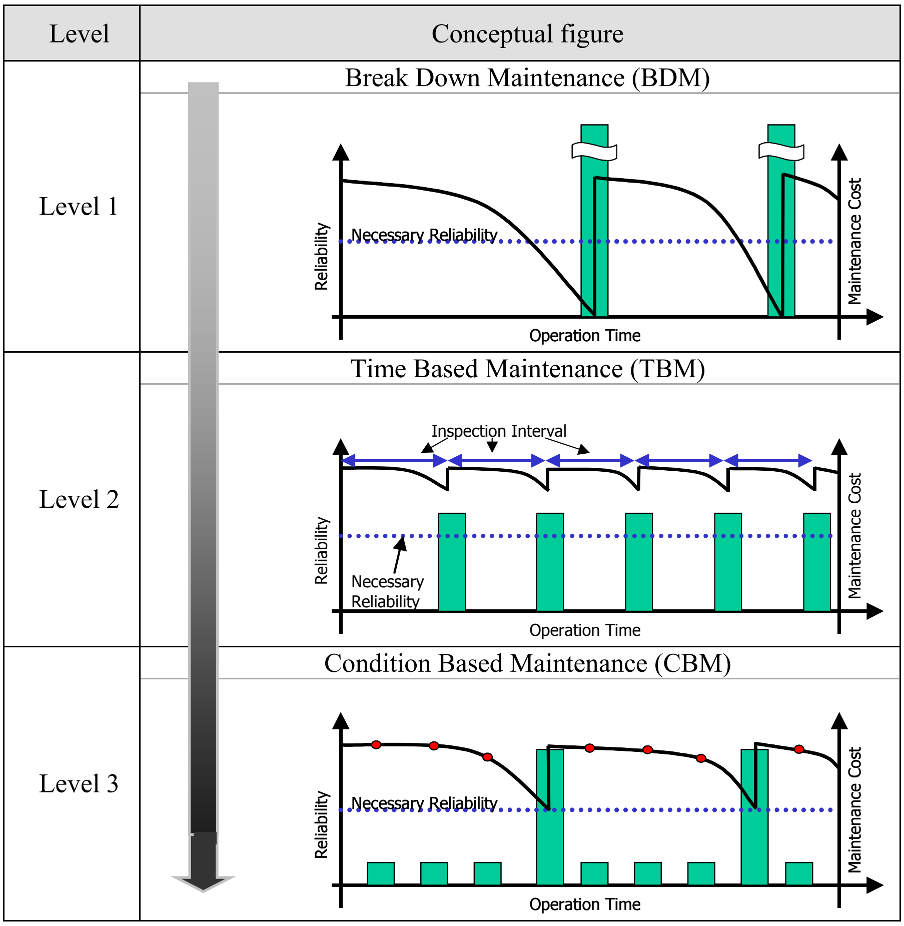
Fig. 2-18 Example of the fuel procurement implementation system of coal fired power plant

Target **To formulate regulations for compulsory regular inspection of power stations by leadership of government.**

(1) Formulation of regulations for compulsory periodic inspection and repair of power stations.

So far there is no law or regulation for regular inspections, so that each generator independently carries out its own inspection based on its own judgment. In reality, it is difficult to shut down the plant due to a tight supply-demand situation for electricity and/or lack of inspection funds. This creates a situation of non-stop operations until the equipment breaks down, which has a tendency to lead to more severe damage and longer repair periods; a classic case of “break-down maintenance.”

In order to ensure the implementation of regular inspections, the Master Plan recommends the revision of existing rules and regulations, which enables the maintenance scheme to shift over from break-down maintenance to time-based or condition-based maintenance to maintain the plant at effective level.



Source: PSMP Study Team

Fig. 2-19 Conceptual figure of maintenance management (level-wise)

Target **To revise the tariff structure to recover maintenance costs and future investment for plant and equipment**

(1) Introduction of Power Development Surcharge into the power tariff

The current tariff is politically constrained so that it does not envisage funding for neither appropriate maintenance nor future system expansion. While the prevailing tariff policy adheres to the cost reflection. The Master Plan recommends that the tariff be revised to realize the cost for necessary maintenance to maintain the plant condition at an appropriate level. It is also recommended that the introduction of the power development surcharge into the power tariff be conducted for the purpose of funding the development of the power system and/or energy saving projects.

(2) Promotion of private investment to realize the Master Plan

So far public funding has played a major role in establishing power system development, it is recommendable to promote private investment and develop an environment that allows private funding.

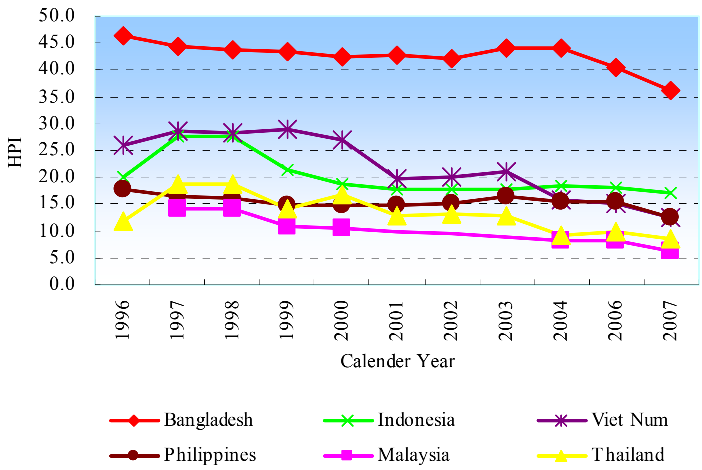
(3) To create an effective and efficient power market

In order to make the power sector more effective and efficient, the Master Plan recommends the introduction of a competitive market where the customer can select power providers.

Plan 6 **To reduce the poverty through the growth of socio-economy.**

Target **To promote the local community and mutual collaboration**

According to the Human Poverty Index (HPI-I) by UNDP, the 36.1% index value, Bangladesh ranks 112th among 135 countries in 2007, and is the third worst in the entire Asian region after Afghanistan and Timor-East. However, when looking at the HPI trend, the HPI-I for Bangladesh improved quickly over the last recent years. The present poverty index of Bangladesh is slightly higher than that of Indonesia and the Philippines 10 years ago. However, it is possible that Bangladesh could rank within the middle range of countries on the HPI within several years, if the present economic growth continues.



Source: United Nations Development Programme [Human Development Report 1998] – [Human Development report 2009]

Fig. 2-20 Human poverty index trend

(1) To spread stable and sustainable power supply

Stable and sustainable power supply will be essential for Bangladesh to continue economic growth and switch the industry structure over to export processing. Power expansion planning and transmission planning shown in the Master Plan should surely be implemented.

(2) To promote remote area electrification

Through power system expansion and power transmission development, the power system all over Bangladesh will be enhanced, as a result, local electrification will also be promoted.

(3) To promote the local industry, associated employment opportunities and income increases

An ample amount of stable power supply makes it possible to expand into local industries such as garments, developing industrial zones and free trade zones, which lead to massive long term employment opportunities for people in the region. In the operation of power stations, 250 to 300 operators and engineers are required per power station. In addition, 1,000 personnel per day are needed for the construction, 1500 to 2000 contractors per day for the regular overhaul and other outsourcing resources for regular services are also required. When the construction of the power station is implemented according to this Master Plan, 6,500 to 8,000 regular employees and 80,000 to 150,000 of non regular manpower will be required as a whole for the generation industry. These people will be preferentially employed from within the local community. This momentum contributes to economic growth with macro-economic improvements which ultimately enhances social and economic inclusion, integration of marginalized people and the reduction of poverty.

(4) To promote mutual collaboration between the power station and the local community

For the construction and operation of the power station, the understanding and cooperation of the local community is essential. For security reasons, power stations are normally isolated by a fence so that land providers and local residents are not able to enter the power station's property. In a recent case in Japan, however, the green belt park, playground and swimming pool adjacent to the power station are opened to local community to promote mutual collaboration and exchange between the local people and power station personnel.

When introducing the coal fired power station, it is necessary to reduce environmental impact from environmental equipment. In addition, it may be required to disclose measured data from pollution, noise, vibration, land subsidence etc. to gain the understanding of the local community. It is also recommended to employ local people and promote mutual collaboration between the power station and the local community by using the power station's facilities.

2.4 Road map and Action plan

A roadmap for the Master Plan regarding sound implementation guidance has been created based on the discussion with counterparts and the PSMP Study Team. The roadmap indicates implementation timing on short, mid and long term basis for each item and also indicates targets to be achieved, so that the GoB is easily identify what and when the minimum requirements should be implemented by whom. A certain implementation of activities in line with the designated roadmap by the designated time frame is highly recommended.

For reference, an action plan with activities corresponding to this Master Plan is proposed in order to achieve further good practice. Among activities on the action plan, which are described on the roadmap, are highlighted with ID numbering. On the action plan, concrete implementation measures in line with the corresponding references are expected for utilization for the GoB.

Road Map

Road map toward 2030

Value-up Plan	Action Plan	ID No.	Short term (2010～2015)	Mid term (2016～2020)	Long term (2021～2030)
Plan 1 To actively develop domestic primary energy resources	■Domestic coal development		Finalization of Coal Policy		**Target** Domestic primary energy supply over 50%
	・Finalization of Coal Policy	DR-1			
	・Implementation and evaluation of the pilot mining: to implement	DR-3			
	・Demand forecast for domestic	DR-6			
	・Building for the mine engineer training system	DR-8			
	・Considering the CBM and/or UGC technology	DR-4,5			
	■Domestic natural gas development				
	・Re-evaluation of domestic natural gas reserve	DR-10			
	・Demand forecast for natural gas	DR-11			
	・Exploration and development of the domestic natural gas	DR-14			
	・Workover of existing natural gas field	DR-14			
Plan 2 To establish the power system portfolio by fuel diversification	■Construction of imported coal power station			2017 Commencement of imported coal P/Sfirst unit	2021Development Target ■20,000MW ■Electrification 100% ■600kW per capita
	・FS for imported coal power station	ERD-19			
	・DD for imported coal power station	ERD-14			
	・Procurement for imported coal	ERD-15			
	・Establishment of imported coal chain	ERD-16			
	・Construction of high efficiency USC power station	ERD-20			
	■Introduction of LNG facilities			2012 Commencement of LNG receiving facility	**Target** Fuel composition ratio ■Coal 50% ■Natural gas 25% ■Others 25%
	・Procurement for LNG	ERD-4			
	・FS of offshore LNG terminal	ERD-17			
	・Construction of offshore LNG terminal	ERD-17			
	・Consideration of the onshore LNG terminal	ERD-17			
	■Construction of the oil fired power station				
	・Establishment of the oil fired power station (Rental Power) as emergency measure	ERD-8			
	■Import the electricity generated by hydro power from the neighboring countries or joint development	ERD-9			
	■Development of domestic renewable energy (wind and solar poewr)	ERD-9			
Plan 3 To realize a low carbon society by introducing high efficient power supply and low CO2 emission technology	■Higher efficient gas power station				**Target** To improve thermal efficiency 10 points on
	・Higher efficiency of existing gas power station	EEU-7			
	・Construction of combined cycle gas power station	EEU-8			
	■Development of domestic coal power station				
	・FS for domestic coal power station	ERD-18			
	・DD for domestic coal power station	ERD-20			
	・Construction of high efficient USC power station	ERD-20			
	・Consideration of large scale coal power station	ERD-21		2018 Commencement domestic coal P/S first unit	
	■Reviewing O&M scheme				
	・To reviewing current O&M scheme, in order to reduce the number of unplanned start and stop, and to improve the load factor	EEU-4			
	・To establish the USC O&M scheme	EEU-5			
	・To establish the environment and safety scheme	EEU-6			
	■Energy conservation, Demand side management				
	・To rationalize the load dispatch by prioritization of gas allocation to higher efficient power station in order to reduce CO2 emission	EEU-7			
	・To rationalize at customer side by energy conservation and demand side management in order to reduce CO2 emission	EEU-11			
Plan 4 To build an infrastructure necessary for stable power supply under joint coordination by the multi sector	■Improvement of the power transmission system				
	・To improve power transmission system in line with the power supply amount growth	I-7			
	・To develop cross border power trading	I-7		2013 Commencement of cross border trading	
	■Enhancement of gas transmission line	I-1			**Target** To build deep sea port facility by power, industry and commercial sector jointly
	■Construction of fuel center				
	・To implement coal center FS	I-5			
	・To construct coal center	I-5			
	・To jointly develop fuel center (receiving facility for imported coal, LNG and oil) by multi sector cooperation	I-5			
	■Construction of deep sea port	I-4			
	■Strengthening the domestic waterway	I-6			
	■Strengthening the railway system	I-8			**Target** To establish an organization for long-term stable fuel supply security
Plan 5 To build an efficient and effective mechanism, organization and law for stable power supply	■Legislation of the law for compulsory periodic inspection and repair at power station	PN-1			**Target** To legislate the law for compulsory regular inspection at power station
	■Organization for coal procurement	PN-2			
	■Introduction of Power Development Surcharge into the power tariff	PN-3			**Target** To revise the tariff structure to revover maintenance and future investment for plant and equipment
	■Promotion of private investment to realize the Master Plan	PN-4			
	■To create effective and efficient power market	PN-5			
Plan 6 To reduce the poverty through the growth of socio-economy	■To spread stable and sustainable power supply	TFE-1		2020 from least developed country in Asia to middle income country	
	■To promote remote area electrification	TFE-2			**Target** To change the organization toward the self-improvement
	■To promote the local industry and associated employment opportunity and income increase	TFE-3			

Source: PSMP Study Team

Action Plan

Plan 1 To actively develop domestic primary energy resources

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
DR-1	O			4.1	Finalization of Coal Policy	High	GoB
DR-2	O			4.2	Disision of mining method for 2nd slice	Midium	GoB, Petrobangla
DR-3	O			4.2	Implementation of Pilot mining	High	Petorbangla
DR-4			O	4.2	Considering the CBM project	High	Petorbangla
DR-5			O	4.2	Considering the UGC project	High	Petorbangla
DR-6	O	O	O	4.2	Formulation of domestic coal scenario	High	Petorbangla
DR-7	O	O	O	4.5	Formulation of domestic coal price scenario	Midium	Petorbangla
DR-8		O		4.2.2	Building for the mine engineer training system	High	Petorbangla
DR-9	O			5.1	Formulate gas sector development	Midium	GoB
DR-10	O	O	O	5.2	Re-evaluation of domestic natural gas reserve	High	GoB, HCU
DR-11	O	O	O	5.3	Demand forecast for natural gas	High	Petorbangla, GTCL
DR-12	O	O	O	5.4, 5.5	Formulation of domestic gas supply plan	Midium	Petrobangla
DR-13	O	O	O	5.6	Formulation of imported gas supply plan	Midium	Petrobangla
DR-14	O	O	O	5.7	Mid-long term gas evaculation plan	High	Petrobangla
DR-15	O	O	O	5.9	Forecast for natural gas price	Midium	Petrobangla
DR-16	O	O	O	5.9	Formulation of gas development plan	Midium	Petorbangla
DR-17	O	O	O	14.3	Site sellection for domestic coal P/S	High	BPDB
DR-18		O		14.3	Implementation domestic P/S FS	High	BPDB
DR-19		O		14.2	Decision of domestic coal P/S spec	High	BPDB

Plan 2 To establish the power system portfolio by fuel diversification

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
ERD-1	O	O	O	4.3, 4.4	Forecast for imported coal	Midium	Petrobangla/BPDB
ERD-2	O			4.5	Forecast for imported coal price	Midium	Petrobangla/BPDB
ERD-3	O			4.6	Forecast for domestic/import coal supply	Midium	GoB
ERD-4	O			5.1	Formulate of LNG introduction plan	High	GoB
ERD-5	O	O	O	6.1	Formulation of imported oil plan	Midium	BPC
ERD-6	O	O	O	6.1	Formulation of oil supply plan	Midium	GoB
ERD-7	O	O	O	6.1	Formulation of oil price scenario	Midium	BPC
ERD-8	O	O	O	8.4	Formulation of oil P/S plan	High	BPC/BPDB
ERD-9	O	O	O	8.7	Formulation of renewable energy scenario	High	GoB
ERD-10	O	O	O	6.2	Risk analysis of renewable energy	Midium	GoB
ERD-11	O			14.3	Sellection of desing coal	Midium	BPDB
ERD-12	O			14.3	Decision of imported coal transportation	Midium	BPDB
ERD-13		O		14.4	Decision of coal import by large vessel	Midium	BPDB
ERD-14	O			4.4, 17.3	DD for imported coal power station	High	BPDB
ERD-15	O			14.3	Procurement for imported coal	High	BPDB
ERD-16	O			13.3	Establishment of imported coal chain	High	GoB
ERD-17	O			5.7	Decision of LNG facility spec	High	Petrobangla/BPDB
ERD-18	O	O	O	14.3, 14.4	Implementation of domestic coal P/S FS	Midium	BPDB
ERD-19	O	O	O	14.3	Implementation of imported coal P/S FS	High	BPDB
ERD-20	O	O	O	15.1	Planning for construction schedule	High	BPDB
ERD-21			O	14.3	Considering large scale power plant	High	BPDB
ERD-22	O	O	O	15.2	Estimation for P/S construction cost	Midium	BPDB

Plan 3 To realize the low carbon society by introducing high efficient power supply and low CO2 emission technology

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
EEU-1	O	O	O	11.3	Introduction of USC technology	high	BPDB
EEU-2	O	O	O	12.1, 12.2, 12.3,	Formulation of optimum power supply	high	BPDB
EEU-3	O	O	O	14.2, 14.3	Decision of P/S major equipment/layout	high	BPDB
EEU-4	O			17.1	Establish P/S maintenance scheme	high	BPDB
EEU-5	O			17.1	Establish the USC O&M scheme	high	BPDB
EEU-6	O			17.2	Establish the environment and safety scheme	high	BPDB
EEU-7	O			8.3	Considering conversion to higher efficient gas P/S	high	BPDB
EEU-8	O			8.4	Considering construction of combined cycle gas P/S	high	BPDB
EEU-9		O	O	6.2	Development of domestic renewable energy	high	BPDB
EEU-10		O	O	6.2, 19.6	Joint Development of hydor with neighbour countries	high	BPDB
EEU-11	O	O	O	7.5	Energy conservation, Demand side management	high	BPDB

Plan 4 To build infrastructure necessary for power stable supply coordinated by multi sector jointly

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
I-1	O	O	O	5.10	Enhancement of gas transmission line	High	Petrobangla, GTCL
I-2	O	O	O	6.1	Construction of oil receiving facility	High	BPC
I-3	O	O	O	11.1	Formulation of infrastructure construction road map	High	GoB
I-4	O	O	O	11.2	Construction of deep sea port	High	GoB
I-5	O	O	O	13.1	Construction of fuel center	High	BPDB、BPC、Petrobangla
I-6			O	13.3	Strengthening the domestic waterway	High	GoB
I-7	O	O	O	9.2	Improvement of the power transmission system	High	PGCB
I-8	O	O	O	14.3	Strengthening the railway system	High	GoB

Plan 5 To build the efficient and effective mechanism, organization and law for stable power supply

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
PN-1	O			17.1	Legislation of the law for compulsory periodic inspection and repair at power station	High	PGCL
PN-2		O		17.3	Establishment of mine management section	High	GoB
PN-3	O	O		10.5	Introduction of Power Development Surcharge into the power tariff	High	GoB
PN-4		O		10.1	Promotion of private investment to realize the Master Plan	High	GoB
PN-5		O	O	10.1	To create effective and efficient power market	High	GoB

Plan 6 To reduce the poverty through the growth of socio-economy

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
TFE-1	O			8.8	To spread stable and sustainable power supply	High	GoB
TFE-2	O			2.3	To promote remote area electrification	High	GoB
TFE-3		O	O	2.3	To promote the local industry and associated employment opportunity and income increase	High	GoB

Source: PSMP Study Team

Chapter 3 Outline of Bangladesh

This chapter describes the outline of Bangladesh, the macroeconomics, demographic statistics, household economy, and community system development, which are preconditions of this Master Plan. Although the economy of Bangladesh has favorably been changing in recent years, it turns out that the gas and electric power supporting the economic growth are insufficient. Therefore, the establishment of an electric power infrastructure has become an urgent matter.

3.1 Outline of Bangladesh

3.1.1 Topography and population

Bangladesh is located in east of the Indian Subcontinent, and facing Bay of Bengal. Most of the country is covered by the world largest delta, which was formed from three major rivers, the Ganges River (Padma in Bengali), the Brahmaputra River (Jamuna in Bengali), and the Meghna River and their branches, of which the source of the water is from the Himalaya Mountains. Most of the lands are flat lowlands less than 9 meter above sea level, and hilly terrains are limited only in South-East of Chittagong Hill Tracts (the highest peak: Tazing Dong 1280m) and Sylhet, North-East region of the country.

Soil in Bangladesh is fertilized by nutrient carried with flood of three major rivers, which helps to grow major agricultural products such as rice, jute and tea. Fishing and fishery farm in rivers and ponds across the country are thriving. On the other hand, heavy rain and river water inflow from upstream countries often cause wide-spread flood in rainy season, being covered by flood water around one third of the whole country at peak time, which cause considerable damage to people in Bangladesh and the country. In recent instance, the worst flood in Bangladeshi history happened in 1998, submerged two third of the country.

Land area of Bangladesh is 147,500 square kilo meter. The population in Bangladesh is regarded as much as 144.50 million[1], thus the population density is very high, around 1,000 people in one square kilometer. Mean annual growth rate of population is 1.39%, the same degree of India's.

Major race, more than 98% of Bangladesh population, is Bengali, with some minority Buddhist group, e.g. Chakuma and other ethnic groups, who live in Chittagong Hill Tracts near Myanmar border. Official language is Bengali and literacy rate of adult (15 years old or above) reaches 52.5%. (Human Development Report 2008) As for religion, the majority who believe in the established religion is Muslim (89.7%), and the rest is comprised of Hindu (9.2%), Buddhist (0.7%) and Christian (0.3%).[2]

3.1.2 Climate

Bangladesh is located near the tropic Cancer so that its climate is characterized by its tropical weather, i.e. high temperature, high humidity and rain fall varied from season to season. In summer, it continues high temperature from March to June, the maximum temperature during the season is around 24 to 35 Celsius degree, sometimes 40 degree or above. It is monsoon season from June to October, the temperature falls due to rain fall. It is winter season from October to March, however the temperature is mild. The annual rainfall in Bangladesh is about 2,300 millimeter, and around 80% of it is concentrated from June to September.

Major characteristic of Bangladesh natural environment is that 80% of land area is located in alluvial plain, which major rivers, Ganges River (Padma in Bengali), the Brahmaputra River (Jamuna in Bengali) and the Meghna River, form. Along with the rain fall in Bangladesh naturally,

[1] tentative, July 2008, Bureau of statistic in Bangladesh

[2] Bangladesh Census 2001, Japanese Ministry of Foreign Affairs home page

80% of river flow comes from the rain fall in other countries, such as India and Nepal, and domestic rain fall is attributed only 20% of total river flow. A large amount of rain fall water from upstream countries of major rivers causes flood damage in large area of Bangladesh every year.

Natural phenomena such as flood, cyclone, tornado and bore, hit Bangladesh almost every year, which causes not only transient damage but also secondary damage to the country such as deforestation, soil deterioration, land erosion, and so on.[1]

3.1.3 Political system and government structure

Due to religious conflict between Hindu and Muslim as background, in 1947, Bangladesh once became independent from United Kingdom's colonial occupation together with present Pakistan in the form of East Pakistan when India became independent from UK. Afterward, in 1971, East Pakistan became independent again from Pakistan in the form of Bangladesh due to 1800km long distance divided country to East and West, different languages, and other many contradictions.

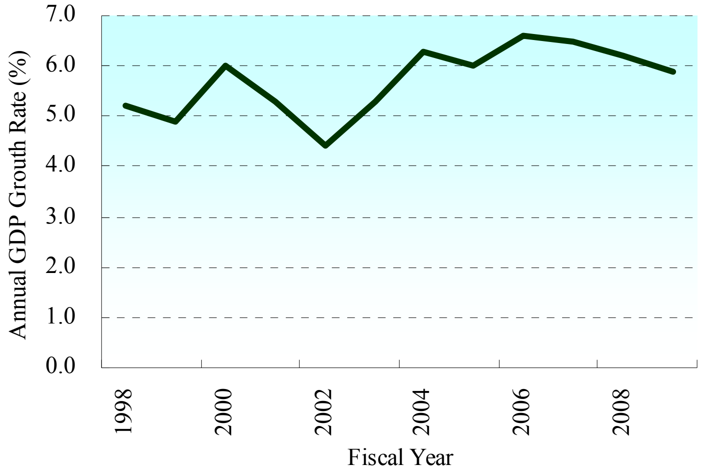
Bangladesh had established the presidential system since its foundation in 1971. They revised the Constitution in order to change the presidential system to the single chamber parliamentary cabinet system (345 seats, 6 year term), when Bangladesh Nationalist Party (BNP) led by Madam Begum Khaleda Zia came into power in 1991. At present, Parliamentary System of government prevails in Bangladesh. The tenure of this system is five years. As part of that, His Excellency Mr. Md. Zillur Rahman is the President of Bangladesh. He is the head of the state. Her Excellency Sheikh Hasina, is the Prime Minister of the People's Republic of Bangladesh since January 2009. She is the head of the government.[2]

3.2 Macro economy of Bangladesh

3.2.1 Economic overview

(1) Economic overview

Bangladesh's economy has grown steadily over the recent years. Its annual GDP growth rate has been maintained at around 6% since the fiscal year 2003/2004, overcoming the world financial crisis in 2008 (Fig. 3-1).



Source: Asian Development Bank (ADB) Key Indicators, Asian Development Outlook 2009 Update)

Fig. 3-1 Nominal annual GDP growth rate of Bangladesh

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1 The Preparatory Study for Project for the Study for Master Plan on Coal Power Development in People's Republic of Bangladesh

2 JETRO homepage and others

The World Bank estimates[1] that Bangladesh will join middle-income countries in or relatively soon after 2016, though the country is presently categorized as low-income nation. In fact, the nominal GDP per capita as of 2007 has doubled since 1975, soon after the country's independence year. According to the World Bank's report, the country's poverty rate has decreased to below 20 % in the 1990s. Its unemployment rate has also decreased from 30% to 4%. Table 3-1 reveals the major indicators of the country's macro economy

Table 3-1 Major macro economy indicator[2]

Fiscal year	2004/05	2005/06	2006/07	2007/08	2008/09
National account	**(Incremental rate to the previous year except notification)**				
GDP(Nominal: billion Taka)	3,707	4,157	4,725	5,458	6,149
Real GDP growth rate	6.0	6.6	6.4	6.2	5.9
Average inflation (CPI)	6.5	7.2	7.2	9.9	6.7
Saving/ Investment	**% of GDP**				
Savings	25.8	27.7	25.9	25.1	26.2
Investment	24.5	24.7	24.5	24.2	23.3
Saving-investment balance	1.3	3.0	1.4	0.9	2.9
Foreign account	**Billion US$**				
Export	8.6	10.4	12.1	14.2	15.6
Import	11.9	13.3	15.5	19.5	20.3
The share of workers' remittance in total trade balance	3.8	4.8	6.0	7.9	9.7
Current balance	-0.6	0.6	1.0	0.7	2.5
Foreign exchange reserves	2.9	3.5	5.1	6.1	7.5
International debt balance(% of GDP)	32.0	31.0	29.1	25.6	24.1
Import coverage (month)	2.2	2.3	2.7	3.1	3.6
Others					
Exchange rate （Taka /US$: Ave.）[3]	61.39	67.08	69.03	68.52	69.06

Source: IMF, "Bangladesh: Staff Report for the 2009 Annual Consultation with Bangladesh", December 2009)

The country's gross national income (GNI) per capita is, however, 520 US dollars (2008), which ranked 186th out of 210 countries. Therefore, the country has been ranked as the least-developed country in Asia (Table 3-2).

[1] Bangladesh: Strategy for Sustained Growth, World Bank, 2007

[2] The Bangladesh's fiscal year starts in July of the previous year and ends in June of the current year.

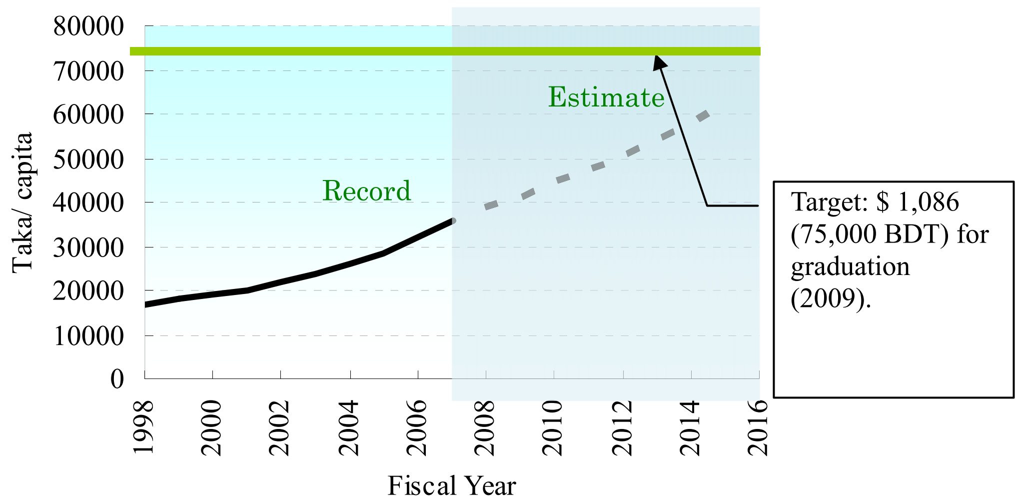
[3] Bangladesh Bank, "Major Economic Indicators: Monthly Update", February 2010

Table 3-2 Social and Economic indicators of Bangladesh and South Asia countries

Country	GNI/capita (nominal value)	GDP Growth rate	Average inflation rate	Electricity consumption per capita	GDP (current)	Population
	(US$)	(%)	(%)	(kWh/capita)	(Bil. US$)	(million)
Base year[1]	2008	2006-2010	2006-2010	2007	2008	2008
Bhutan	1,900	8.9	5.5	211	1.4	0.7
Sri Lanka	1,780	6.1	11.9	417	40.7	20.2
India	1,070	7.7	5.1	498	1,217.5	1,140.0
Pakistan	980	4.3	11.7	435	168.3	166.0
Bangladesh	520	6.1	7.5	174	79.0	160.0
Nepal	400	4.0	8.8	78	12.6	28.6
Myanmar	-				26.2	49.2

Source: The PSMP Study Team has developed based on the following references: US CIA, "World Fact Book"; World Bank's website, value as of 2008. "Key Development Data & Statistics"; Bangladesh Ministry of Finance "Economic Review 2008")

This fact is explained by the fact that its average annual GDP growth rate before 1990 was just 1.2% primarily due to political instability which arises immediately after a country's inception, though the rate has jumped to 3.3% in average after 1990. The aforementioned World Bank report recommends that Bangladesh needs to keep and accelerate its growth speed in order to join the middle-income countries (Fig. 3-2).[2]



Source: ADB Key indicator (2008).

Fig. 3-2 GNI per capita[3]

[1] The figures for Bhutan are as of FY2009, while those for Sri Lanka are of FY2008's estimate. Those of the rest are of FY2007's estimate/ record.

[2] The value of 3.3 % is almost triple that of many low income countries

[3] The estimate after 2008 assumes 7% of growth rate. The value of criteria to graduate from low-income countries is cited from UN-OHRLLS.)

(2) Economic growth

The country's recent economic growth has been attributed to the increase of exports mainly led by clothing industry, specifically ready-made garment (RMG) as a national main industry, as well as the high growth of the service industry as well as the main and manufacturing industry, the growth of which has been driven by the increase of overseas workers' remittance. At the same time, Bangladesh's economy reveals its structural fragility. That is, the economy heavily depends on such a ready-made garment industry and workers' remittance. Such dependence has made the country's economy vulnerable to global depression like the recent one. In fact, due to the global economic downturn in the fiscal year 2008/2009 (from July 2008 to June 2009), its domestic economy was said to have slowed down mainly because of the decrease of workers' remittance growth rate as well as of the slowing growth rate of exports to Europe and US. As a result, the fiscal year's nominal GDP growth rate remains at 5.9%, which is below that of the previous year, 6.2%.

The reason Bangladesh's infrastructure has been targeted for improvement is because its present immature infrastructure is regarded as one of the obstacles impeding the country's further economic growth. It is said that severe electricity shortage as well as the bottleneck of the transportation sector such as at ports and railways have kept further investment and trade with neighboring countries away.

Hence, it has been pointed out that such an immature economic infrastructure has kept private enterprises away from more investment in the country, and this fact has resulted in national savings in order to maintain a constant share of the total GDP, compared to national investment to lose its share.

For these reasons, Bangladesh needs to overcome two challenges for its even more economic growth, namely the improvement of basic infrastructure such as electricity networks, roads and ports; and the restructuring of its economic structure, e.g. by diversification of its products and export destinations. The next sections will discuss the detail and the contribution of electricity development to such future economic growth.

Box 3.1. The assumption of Bangladesh's economic growth rate in the long term

This Master Plan assumed long-term growth rate as 7% up to 2030. The ground for the assumption is described as follows:

1. Long-term estimate by authorized organizations

International Monetary Fund (IMF), whose estimate is referred to as a trustworthy economic indicator in general, announced the country's latest rate in the long term in October 2008. The IMF estimates the rate as 7.0% on average until 2028. As a reference, the Fund's short-term estimate for years 2013 and 2014 was 6.0%, which was announced in February 2010. The downward revision may have resulted from the recent global financial crisis. Other international financial authorities such as the World Bank and Asian Development Banks announce only short-term estimates.

The Bangladesh Government publishes the rate's long-term estimate as the government's target. The current Administration sets the target figures as 8 % in 2013 and 10% in 2017 respectively in its party's manifesto, Vision 2021. The country's national development plan, "Moving Ahead: National Strategy for Accelerated Poverty Reduction II (Oct2008)" forecasts 7.0% in 2010 and 7.2% in 2011.

As shown above, it has been confirmed that the long-term estimates by authorized organizations and the Bangladeshi Government has fallen into the range between 7 to 10 %.

2. Historical trend

The average GDP growth rate in the past 5 years is almost 6%. In the coming years this is expected to increase because of the following reasons: first, the figure has been achieved under unfavorable circumstances, e.g. natural disasters due to large floods and cyclones in 2007 which have severely damaged the agriculture industry and the global-wide high inflation of food and crude oil. Secondly, although the recent global economic downturn has influenced Bangladesh's economy which depends largely on overseas demand, the downturn has been foreseen as a temporal one, as authorized institution like the Asian Development Bank says. Thirdly, the World Bank's renowned "Doing Business," the world ranking in investment qualification, places the country at higher than the middle-income nations in terms of business environment. The World Bank expects that the country's manufacturing industry, which is the country's key economic driver, would take a great leap once the country's infrastructure is well developed. Lesson from the middle-income Asian nations has also shown interesting data to support the country's future. When GNI per capita of those countries were around 500 dollars, same as the one of the current Bangladesh, many of those countries achieved an economic growth rate of over 7%, achieving GNI per capita of middle-income nation level within 10 years since the achievement year: Vietnam (in 2004, 7%), China (in 1994, 10 to 15%), Indonesia (in 1998, 7 to 8 %), India (in 2003, 7 to 10%): the figures in the parenthesis shows the year to achieve GNI per capita of 500USD and its GDP growth rate then.

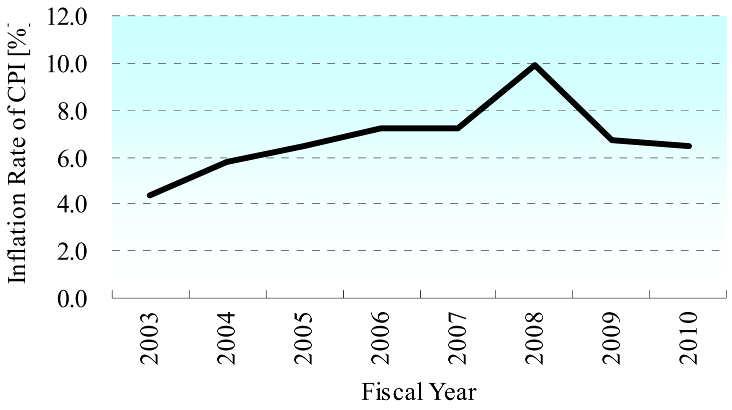
As seen, the past records and trends also supports the Bangladesh economy's possibility to grow at a rate more than 7%.

3. Conclusion

For those reasons, this study has adopted a 7% GDP growth rate as the base case, the value which the Government also sets as the country's official target.

3.2.2 Consumer price

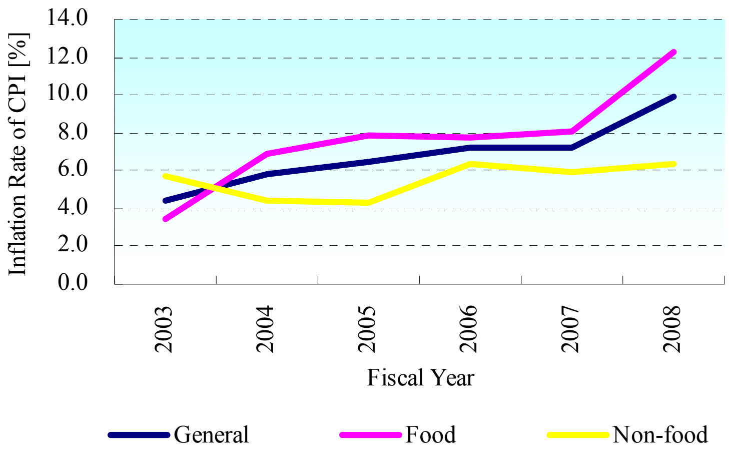
The inflation rate of the consumer price index (CPI) has steadied at around 5 to 7 % in the past five years. (Fig. 3-3). Although the CPI rose sharply in fiscal year 2008[1], it dropped sharply after the middle of 2008 due to the stabilized food price as well as the drop of crude oil prices. Since March 2009, partly because the Bangladesh Bank took the monetary easing policy, the CPI has stayed back at around 6 %, which is in the same level as that before the sharp increase.



Source: Developed by The PSMP Study Team based on the following references: ADB Key Indicators, ADB Outlook 2009 Update)

Fig. 3-3 CPI inflation rate

Because Bangladesh's CPI consists primarily of food prices (around 60%), this index is subject to events related to food, e.g. weather and the international market (Fig. 3-4).



Source: "Annual Report 2007-2008," Bangladesh Bank, Dec. 2008

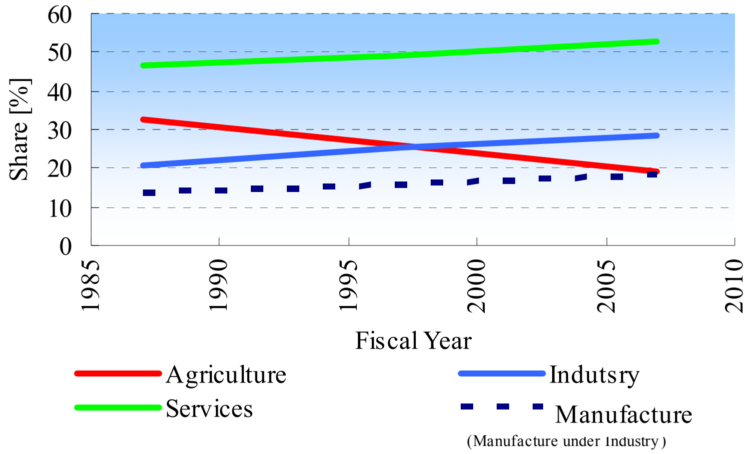
Fig. 3-4 Inflation rate of food price

3.2.3 Transition of industrial structure

As shown in Fig. 3-5 (the structure of the Bangladesh's economy), the growth of the industry sector, specifically the manufacturing sector, is eminent. While the service sector occupies more than half of the total share due to steady retail, transportation, and telecommunication (mobile) sectors, the

[1] In the fiscal year 2008, the inflation rate reached 9.9 % due to damaged agricultural products by large-scale cyclones as well as the global wide price inflation of food and energy, which has resulted in the increase of import products.

agricultural sector has continued to lose its share. Although the work force of agricultural sectors remains at the top as 48 % of the total as of 2006, its GDP share has given way to the industrial sector since the mid 1990s.



Source: ADB Key Indicator2008; Bangladesh's Bureau of Statistics)]

Fig. 3-5 The share of GDP by industrial type (nominal value)

To be mentioned here is that the GDP of the manufacturing sector in the fiscal year 2008/2009 has grown almost 3.04 times as much as that of the fiscal year 1999/2000, exceeding the growth rate of the total GDP during the same period, 2.59. This fact tells that the manufacturing sector has led the country's economy. Though the sector once consisted of agricultural products like jute products, the sector's current main product is RMG and knit ware which occupies 75% of the country's export amount. This trend appears to be continuing. For products from the manufacturing sector other than clothing products is the chemical sector which is represented by fertilizer made of natural gas. Besides these products, the medicine manufacturing sector is also expected to grow in near future. As the scale of the sector is the largest among the 50 least developed countries (LDC), the country exports the products to over 60 countries. Table 3-3 shows a shift of the products shared in the industrial sector.

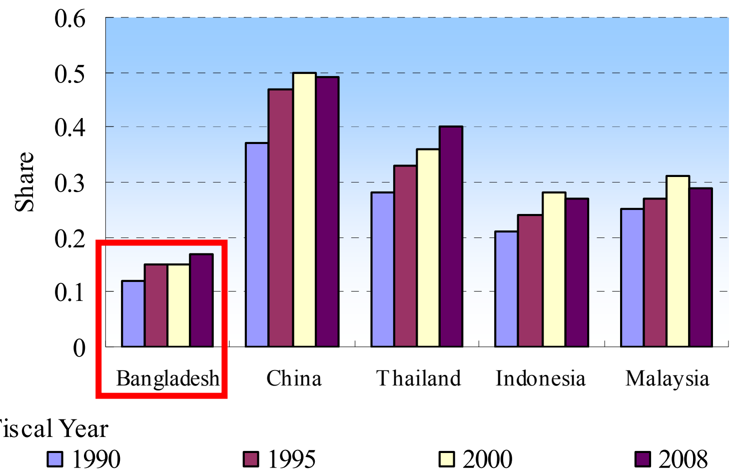
Table 3-3 Export amount by product

(Unit: Billion Taka)

Fiscal year	1994/95		1999/2000		2008/09	
	Amount	Share (%)	Amount	Share (%)	Amount	Share (%)
Raw Jute	2.6	2.0	3.7	1.5	9.2	0.9
Jute goods	13.7	10.4	11.3	4.5	23.5	2.4
Tea	1.3	0.9	0.9	0.4	0.8	0.0
Leather	8.8	6.7	7.6	3.0	19.6	2.0
Fish, shrimp	13.2	10.0	18.1	7.3	31.3	3.2
Readymade garments	74.4	**56.7**	157.2	**63.1**	672.6	**69.0**
Oil products	0.5	0.4	0.6	0.2	6.6	0.7
Fertilizer	3.1	2.4	-	0.0	7.1	0.7
Others (EPZ)	13.8	10.5	49.8	20.0	203.7	21.0
Total	131,3	100.0	249.2	100.0	974.4	100.0

Source: "Monthly Economic Trends," February 2010, Bangladesh Bank)

Table 3-3 tells that the ready-made garments dominate total export products. Its share has grown to 69.0 % in fiscal years 2008/2009 from 56.7% in fiscal years 1994/ 1995. Besides this, the share of others like export processing zone (EPZ) products have also grown rapidly from 10.5% in fiscal years 1994/95 to 21.0% in 2008/2009. In contrast, Bangladesh's traditional products like jute products have lost its share from 12.4% in fiscal years 1994/95 to 3.3% now. Likewise, the share of fish and shrimps has also decreased from 10.0% to 3.2%. The same trend applies to the share of leathers, too. As seen, there has been a large transition in Bangladesh's economic structure during the last 15 years. Bangladesh's export economy is expected to be driven by such ready-made garments and EPZ products for the time being. The aforementioned World Bank's report predicts that it is essential for the country's sustainable economic growth to have the manufacturing sector lead the economy. The report refers to the other East Asian nations' cases saying that those countries have transitioned from low-income countries to middle-income countries as the share of the manufacturing sector of the GDP has increased. These cases emphasize that the manufacturing sector plays a key role in countries' economic growth (Fig. 3-6).



Source: Bangladesh: Strategy for Sustained Growth, World Bank; and 2007 ADB Key Indicator.

Fig. 3-6 The GDP share of manufacturing industry

For these reasons, it is essential to the growth of Bangladesh's economy to promote the manufacturing sector. The next sub-sections delve into electricity development's contribution to the promotion of the manufacturing sector.

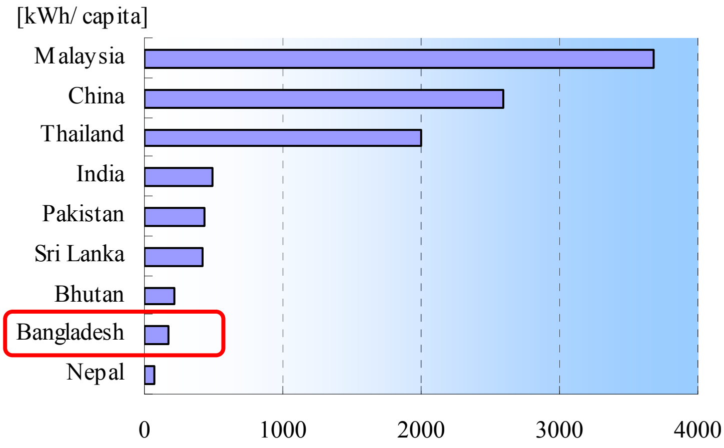
3.2.4 Development of electricity infrastructure to assist economic growth

The aforementioned World Bank's report[1], "Bangladesh: Strategy for Sustained growth," raises seven measures for the manufacturing sector to lead the country's economy. One of them is to ease the energy shortage, which is an emerging issue in Bangladesh (others include the shortage of port capacity, specifically Chittagong port, and of the inland transportation infrastructure). As Bangladesh gathers attention from the international community as one of the emerging countries of NEXT 11, regarded as next to BRICs, the country is well equipped with conditions to entice foreign investment, such as an inexpensive labor force and an excellent environment for business and new enterprises. This sub-section analyses how the current electricity infrastructure impedes the country's economic growth, and examines the economy's growth potential by improving the electricity infrastructure.

[1] Bangladesh: Strategy for Sustained Growth, World Bank, 2007

(1) Electricity shortage

As seen in Fig. 3-7, Bangladesh's electricity consumption per capita is small compared with other nations (174kWh/ Capita). Its electrification rate is 44% in terms of population (National census in 2005).



Source: "Key Development data," the World Bank; and "Fact book," US CIA.)

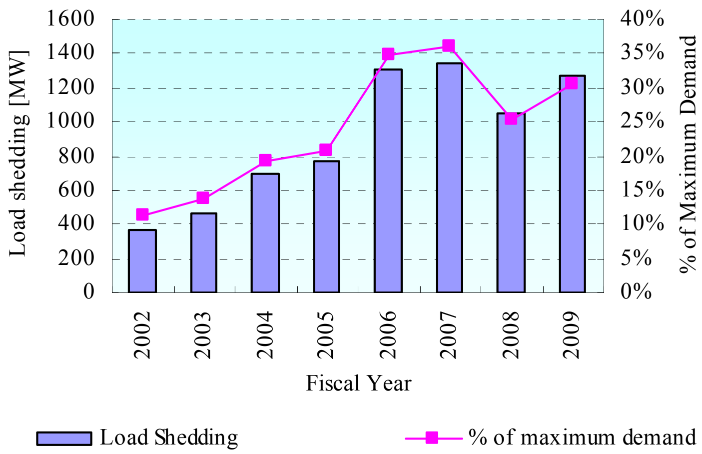
Fig. 3-7 Electricity consumption per capita

Box.3.2 Lesson in Japan

During the 1960s in Japan, the era with an average 9% GDP growth rate, the industrial sector which consumes large amount of electricity (*) occupied around 60 % of the total GDP (figures from TEPCO's service area). Therefore, once the power shortage issue is dissolved in Bangladesh, those above the sectors might take a great leap. With the improvement of the quality of supplied electricity, further industrial sectors such as the automobile assembling industry and the semiconductor industry might take a next leap.

*: steel, pulp, chemistry, ceramic (cement), and non-iron metal (aluminum).

The World Bank report estimates that the productivity of the average enterprise falls by 10% as the number of blackouts per year increases by 1%. It even happened once that 30 % of total demand during peak hour was not supplied (Fig. 3-8). The cumulative blackout duration was 82 hours and 5 minutes (358 days) in fiscal year 2008, and was 76 hours and 22 minutes (351 days) in fiscal year 2009.



Source: BPDB Annual Report 2008-2009)

Fig. 3-8 Annual load shedding/ restriction [MW]

(2) Impact caused by power shortage

(a) Economic cost

Due to the chronic power shortage, over 80% of the manufacturers are equipped with captive power, mostly gas-fired thermal engines. That is, there is redundant investment occurring in Bangladesh, by power companies and by manufacturers. The generation cost of such captive power is estimated to be 1.5 times higher than the usual grid's electricity tariff, even though they are able to purchase the fuel, natural gas inexpensively due to a government's subsidy. This situation has obviously undermined the international competency of the manufacturers, leading to immense economic costs paid.

(b) Obstacle of investment

According to a report by the World Bank in 2003[1], around 70% of the interviewed enterprises answered that electricity supply is the obstacle blocking potential investments, largely exceeding the amount of the whole south Asian region, 40%. Taking into account that the other investment environments are superior to that of middle income countries such as China and India[2], it is expected that any industry which requires stable power supply would experience a lasting leap upwards once the power shortage issue is solved.

(3) Issues and countermeasures

As seen above, it has been confirmed that the development of electricity infrastructure would be an essential factor to the growth of Bangladesh's economy including the manufacturing sector. There are, however, some obstacles which makes it hard to develop an electricity infrastructure. Above all, the highest hurdle is finance. As will be mentioned later, the current electricity-related entities are state-owned enterprises like BPDB. Their financial status shows that more or less there is some difficulty in running their business. This is partly because the electricity tariffs have been set lower than the supply cost, and partly because collecting fees for outstanding electricity bills have been delayed. Moreover, the resulting deficits have been supplemented by the Government's budget. For example, the net loss of the Bangladesh Petroleum Corporation (BPC) in 2006 was estimated to be about 1 % of the total GDP, which was one of the reasons for the tight national budget. The World Bank's study in 2003/2004[3] examined the countermeasures to improve the then industry's

[1] "Investment Climate Assessment Survey," World Bank and Bangladesh Enterprise Institute, 2003

[2] Doing Business, World Bank

[3] "Power Sector Financial Restructuring and Recovery Plan, Final Report," Aug. 2006,

business structure, recommending the introduction of an early bird discount for advanced payment. Specifically, the update of electricity tariffs is expected to bring about a positive side effect of encouraging natural gas suppliers to invest more in production facilities, leading to the increase of gas production.

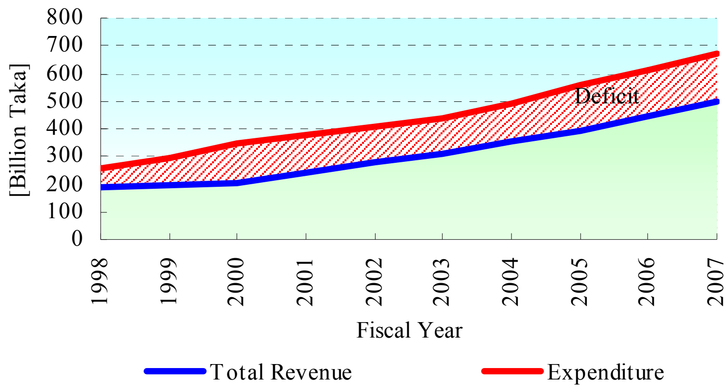
As seen above, the restructuring of the state-led electricity business is one of the important steps to improve the electricity infrastructure. For this purpose, the Government is looking into utilizing private financing. They aim to dissolve the power shortage issue by encouraging private investors to invest in power development projects e.g. the IPP .

If these measures are successfully implemented, the development of an electricity infrastructure would be promoted, contributing to the growth of the manufacturing sector and ultimately leading to the acceleration of the nation's economic growth as a whole.

3.2.5 Finances of the state

(1) Structure of revenue and expenditure

The finances of Bangladesh are characterized by the fact that the expenditure demand has outgrown the revenue, resulting in chronic deficit(Fig. 3-9).



Source: ADB Key Indicator

Fig. 3-9 Revenue and expenditure

Although the amount of financial deficit against GDP had decreased since 2000 due to the saved annual development expenditure, the introduction of VAT, and the increase of tax revenue, the amount has expanded from 3.7% of fiscal year 2008 to 6.2% (Table 3-4). Such chronic financial deficit is said to be attributed to the Government's weak revenue base, weak tax collection capability, and the compensation of state-owned enterprises' deficit whose management is inefficient.

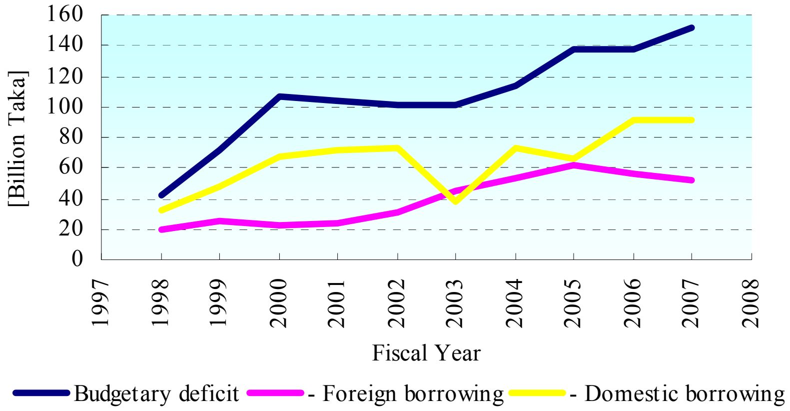
Table 3-4 The finances of the state

(Unit: billion Taka)

Fiscal year	FY05	FY06	FY07	FY08	FY09[1]
Revenue	**392.0**	**448.7**	**494.7**	**605.4**	**693.8**
Tax revenue	319.5	361.8	392.5	480.1	567.9
Non-tax revenue	72.5	86.9	102.2	125.3	125.9
Expenditure	**556.3**	**610.6**	**668.4**	**936.1**	**999.6**
Current expenditure	336.7	370.6	444.1	574.2	667.5
Annual Development Program	205.0	215.0	216.0	225.0	256.0
Others	14.6	25.0	8.3	136.8	76.1
Balance (incl. Grant)	-137.9	-137.3	-152.0	-286.8	-242.3
BUDGET BALANCE (EXCL. GRANT)	**-164.3**	**-162.1**	**-173.7**	**-255.5**	**-305.8**
Budget Balance (deficit)/ GDP (%)	**-4.4**	**-3.9**	**-3.7**	**-6.2**	**-5.0**
Grant	26.4	24.8	21.5	43.9	63.5
Financing	137.9	137.1	152.1	286.8	242.3
Net Foreign finance	137.9	137.1	152.1	286.8	242.3
Loan	89.0	89.6	90.5	130.2	114.6
Repayment	-27.1	-33.8	-38.7	-42.7	-42.2
Domestic financing	76.0	81.4	100.3	199.2	170.7
Banking system	36.0	49.1	65.3	104.0	135.0
Non-Bank Borrowing (Net)	40.0	32.3	35.0	20.0	35.0

Source: "Annual Report 2007-2008, "Bangladesh Bank

Currently, the deficit has been supplemented by foreign development assistance as well as domestic borrowing. The share of foreign grants has decreased by almost 50% in the 1990s to 10% in recent years. In contrast, domestic borrowing has gained its share to almost 60%. The rest, foreign loans has stayed around 20 to 30%. Fig. 3-10 depicts the past trend of the financing Source:s.

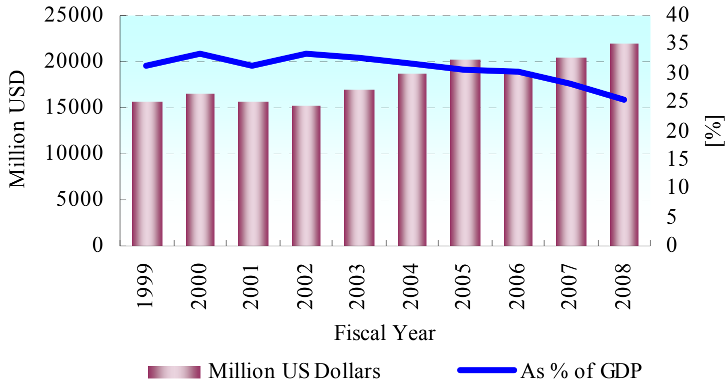


Source: ADB Key Indicator

Fig. 3-10 Financial deficit and financing Source's

Fig. 3-11 shows the trend of the external debt.

[1] Budget estimate



Source: "Annual Report 2007/2008," Bangladesh Bank; and ADB Key indicators.

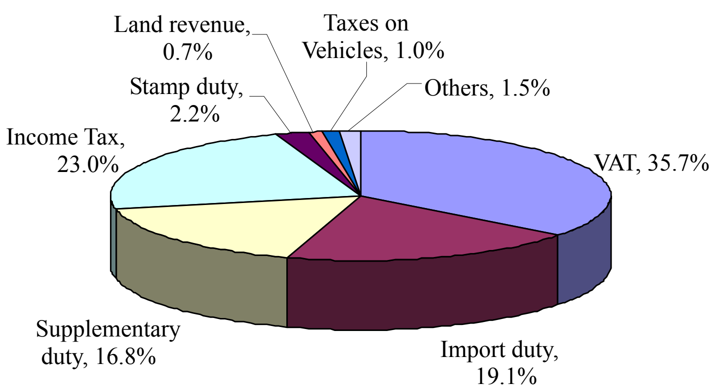
Fig. 3-11 External debt

Although the amount of external debt has been increasing, the debt ratio against the GDP is low, 23.2%. This is mainly because the country is the least developed country where the share of grants has been relatively large in the official assistance development. As the debt service ratio has also been declining (8.6% in 2000 to 5.2 % in 2004), the country's debt burden is also estimated to be small. The debt is comprised of public mid- and long-term borrowing by more than 90%. Among them, 80% are from multi-lateral development agencies like the World Bank.

(2) Challenge of revenue

This section mentions the revenue's characteristics and its issues.

Fig. 3-12 depicts the composition of revenue for fiscal year 2009. Firstly, VAT occupies the largest portion, 35% of the total, followed by the income tax (23%), import duty (19%), and supplementary duty (17%). The structure has remained almost the same in the past 5 years. The ratio of tax revenue to non-tax revenue has also remained around 4 to 1.



Source: Economic Review 2007/2008

Fig. 3-12 The composition of FY2009's revenue collection.

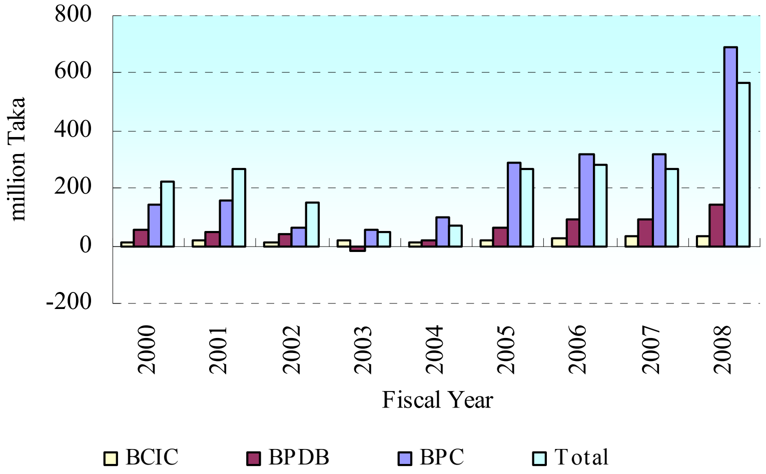
As mentioned above, the Government has strengthened its tax collection policy as the improvement of tax collection capability is linked to the improvement of its financial balance. Individual measurements include the expansion of the taxation base by tax reform, and efficiency improvements of the tax administration. The financial budget of 2009 sets an ambitious target, an 18% increase of tax revenue from the previous year. The GOB emphasizes the strengthened domestic tax collection and the transition from the current structure dependent on import duties. Although the revenue ratio against GDP has increased in long run, the figure is still around 10%, which is lower than that of the other south Asian nations.

(3) Expenditure and the assistance to state-owned enterprises

Bangladesh's budget is composed mainly of the Revenue Budget and the Annual Development Budget. For the 2010 budget, the former amounts to 786.6 billion Taka, while the latter amounts to 305.0 billion Taka, 1,1,38.2 billion Taka in total. The budget increased by around 20% compared to the previous year. Its Annual Development portion allocates a higher budget to areas of transportation, electricity, and water resources because the Government revised its plan to focus on infrastructure development and rural area development. Within the Annual Development Budget, nine sectors have been targeted for enhancement, including two sectors related to electricity, namely rural electrification (including the installation of renewable energy) and electricity energy. Specifically for the latter topic, the GOB aims to solve the emerging issues of power shortage by increasing generation capacity and encouraging private investment. Besides this, the topic integrates electricity imports, the installation of coal-fired power stations and the development of the coal mining industry in addition to the increase of gas supplies by gas well development as well as the expansion of gas pipelines.

The expenditure budget has two issues, the delay of the budget execution and the supplements of the state-owned enterprises' deficit. For the former issue, the Government examines measures such as monitoring expenditures and improving administration (e.g. simplification of the approval process and governmental documents). For this purpose, the GOB has introduced the Medium-Term Budgetary Framework: (MTBF) since the fiscal year 2006. The framework is designed to allocate the 3-to-5 year budget to the prioritized areas and a policy target. This is to allow ministries to plan, organize, and execute their budget corresponding to the prioritized matters in the national development paper, "Poverty Reduction Strategy Paper (PRSP)". The framework has been introduced to 20 ministries and is planned to be introduced to all the ministries in a couple of years.

The second issue is the supplementary of the state-owned enterprises' deficit. There are a total of 45 state-owned enterprises in seven sectors, called Non-financial Public Enterprises. They include the BPDB, REB and Petrobangla in the electricity and gas sector, the Chittagong port authority in the transportation sector, the BPC in the trading sector, Bangladesh Chemical Industries Corporation (BCIC) in the industrial sector. While some state-owned enterprises run business well so that they can pay a dividend, others face difficulty with their business. BCIC has privatized its four affiliate companies out of the 13, because their performance was not good. Some of the others have also been targeted for privatization. BPC faces difficulty in their operations due to the government-set retail price which does not recover procurement costs. Fig. 3-13 shows the net loss/ profit of the major state-owned energy companies of the total 45 companies.



Source: "Annual Report 2007-2008," Bangladesh Bank

Fig. 3-13 Net loss of major state-owned enterprises

Bangladesh Bank's annual report 2007/2008 points out that such deficit by state-owned enterprises can be partly attributed to the continuous gap between the sales price and the cost. Such circumstances are obvious in the oil, electricity and fertilizer sectors. The report describes BPC as the largest receiver of the Government's supplementary aid, followed by BPDB and BCIC, both of which have faced continuous deficit. Those cumulative deficits have been counted as the Government's expense, which has caused the increase of debt. The Economic Review 2008 by the Ministry of Finance shows that the amount of the Government's supplementary aid amounted to 118.4 billion Taka in 2008 and 136.5 billion Taka in 2009. The share of the supplementary aid has steadied at around 30 % of the total general expenses of the Government's budget between 2005 and 2008.

3.3 National development plan

3.3.1 Outline

In the country Bangladesh five "Development 5-year Plans" for the national development plan had been worked out and carried out till 2002. The 5th "5-year plan" was completed in 2002, and the 6th "Development 5-year Plan (2011–2015)" will start in early 2011. Between the 5th and 6th plans, the National Development Plan is handed over to the "Poverty Reduction Strategy Paper (PRSP)" and carried out. The maximum target of the government of Bangladesh (GOB) is to reduce the poverty in as a short period as possible by achieving high economic growth. The PRSP, the basic policy of the development plan in the country Bangladesh started with the Interim Poverty Reduction Strategy Paper (I-PRSP), which was operated in 2003 to 2005. The budget allotment for the Annual Development Plan (ADP) is in accordance with the PRSP. It was prepared based on the vision of "Bangladesh without poverty," and then, the first version of the National Strategy for Accelerated Poverty Reduction (PRSP-I) was worked out in 2005 and was operated form 2005 to 2008, with the period being extended along the way. The previous political power worked out "Moving Ahead: National Strategy for Accelerated Poverty Reduction II or PRSP-II, Planning Commission, Oct. 2008" in 2008, based on the government basic policy. The current political power (Bangladesh Awami League), which started in 2009, took over the same strategy and worked out the revised PRSP-II (Step Towards Change: National Strategy for Accelerated Poverty Reduction II (Revised) FY2009–11) (PRSP-II (Revised) or NSAPR-II) in December of 2009. PRSP-II (Revised) also shows a total of 10 strategic fields, i.e., 5 main strategic fields such as configuration of essential infrastructure and 5 supporting strategies such as measures for climate change with the purpose of achieving Millennium Development Goals (MDGs). It focuses on poor people more than PRSP-I does.

The budget for 2009 was prepared in accordance with the basic policy; PRSP-II above and the operation started in July of 2008. The budget was prepared in accordance with the allotment of resources to prioritized fields based on the Medium Term Macroeconomic Framework (MTMF), a component of the PRSP-II. Both MTMF and its revised version, MTBF (a Medium Term Budget Framework), are 3-year plans for the country, defining 7%–8% of the GDP growth rate and 6%–7% of the target inflation rate in the period of 2009 to 2011.

Bangladesh Awami League political power, which is led by Prime Minister Hasina and was selected in the general election in December of 2008 after an interval of 7 years, lists the most five important fields including electric power and energy in the election pledge manifesto (Manifesto: Vision 2021: Changed to middle-income country by 2021). The first 2010-year budget established in June of 2009 is also in accordance with PRSP-II and the manifesto. The new politic power declares in the manifesto that 8% of the economic growth is to be achieved by 2013 and 10%, by 2017, recognizes that expanded investment using private funds is required to achieve the high target, and plans to expand Public Private Partnership (PPP) as the available scheme.

3.3.2 Position of power and energy sector in the national development plan

Of the five blocks in the strategic plan above, the 3rd block lists the arrangement of basic infrastructure with an affinity to the reduction of poverty and lists the development of the electric power and energy fields as the most important problem in the 3rd block. The basic policy in the fields is, for the purpose of supplying high-quality and reliable electric power to all the people with a payable price by 2020, to accelerate the improvement of efficiency through electric power development with minimum costs, innovation of institution and organization, and improved introduction of commercial principle. Well-balanced development among generation, transmission, and distribution of power will be promoted, and the power generation department proposes quick completion of projects being built yet, building of new power plants, rehabilitation of aged power plants, planned regular repair and overhaul, and capacity development importance. The development target of the power generation ability is to realize 7,000 MW in 2013, 8,000 MW in 2015, and 20,000 MW in 2021.

The strategic plan shows, in addition to the arrangement of the electric power sector, the basic policy concerning the updating of the "National Energy Plan," reinforced ability in oil/gas fields, and the use of renewable energy. In addition to these, the "Coal Policy" is currently worked out and the effect that preparation for supplying coal for a part of energy demand is in progress is written.

3.3.3 National energy policy (Draft)

The prioritized matter in NSAPR-II is development in the power and energy sectors, and the 10 items below are written as the vision and policy in the power sector:

- Bring the entire country under electrification by year 2020
- Make the power sector financially viable with ability to facilitate growth
- Increase the sector's efficiency
- Make the sector commercially oriented.
- Improve the quality and reliability of electricity supply
- Use available domestic natural gas for power generation and also explore other alternatives like LNG for the same
- Increase private sector participation
- Ensure reasonable and affordable price for electricity by pursuing least cost options and explore options for power trading
- Promote competition among various entities
- Promote regional and sub-regional cooperation

In order to achieve these items, the targets of power generation are set to 7,000 MW by 2013, 8,000 MW by 2015, and 20,000 MW by 2021. Furthermore, in order to achieve them, completion of plants being built, new plant building, maintenance of existing thermal power generation through rehabilitation/regular inspection, and reviewing captive power policy are made important. Urgent 3-year measures include the installation of 500 MW rental power (Phase 1), installation of 800 MW peak power supply, installation of 1250 MW dual-fuel IPP, and installation of 2000 to 2600 MW thermal power generation using imported coal. For the nuclear power generation policy, the GoB refers to the conclusion of the MOU with Russia to build a 700 to 1,000 MW nuclear power plant.

Urgent matters for the energy sector are measures to be taken for exhausted domestic natural gas resources and important items for them are the evaluation of domestic resources, new development of gas/oil well and coal mine, and the change from probable/possible amount of deposits to proven amount of deposits based on investigation. Furthermore, saving and efficient use of domestic resources, saving energy on the demand side, and introduction of private funds are proposed.

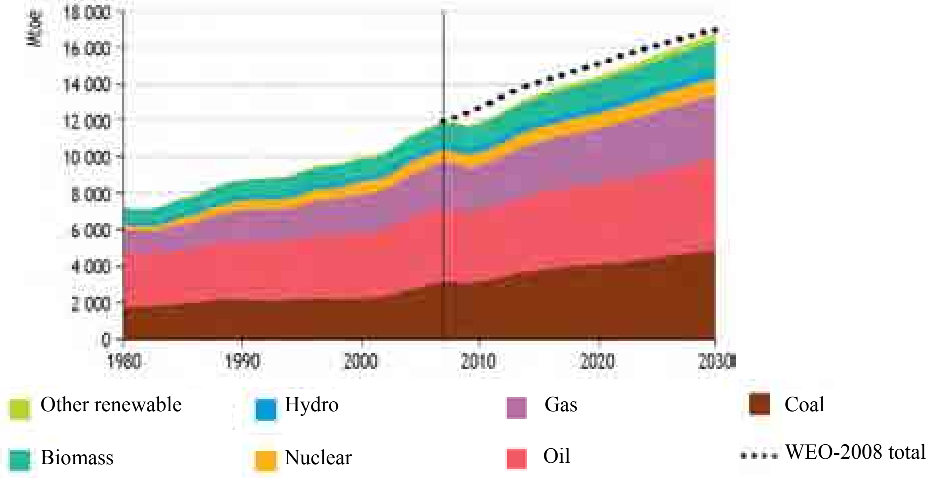
The Coal Policy is currently worked out, and in order to cope with the rapid increase of energy demand, privilege measures for coal mine development are to be introduced so that the efficient use of coal can be promoted and coal fired power stations can be developed.

Since an increased gap between gas supply and demand in the future may obstruct economic growth, the initial introduction of about 500 mmcfd of LNG as an alternative gas fuel and linkage with the international gas pipe line will be examined.

3.4 Current status of primary energy

3.4.1 World primary energy consumption

Reviewed by the International Energy Agency (IEA), while coal consumption in the world is 3,200 billion tons of oil equivalent (Mtoe) in 2007 (26% of primary energy), it will be 4,900 Mtoe in 2030, more than a 50% increase (26% of primary energy). About 90% of increased 1,700 Mtoe will be attributed to increased Asian consumption. The coal consumption share of Asia was about 60% in 2007, and about 70% in 2035. Asia will be center of coal consumption. In particular, China and India will become the two largest coal consumption countries. The share by OECD will decrease from 36% in 2007 to 27% in 2035. On the other hand, shares of LDC will increase from 64% in 2007 to 73% in 2035[1]. It is projected that coal will play a major role in primary energy Source:s in the next decade or so.



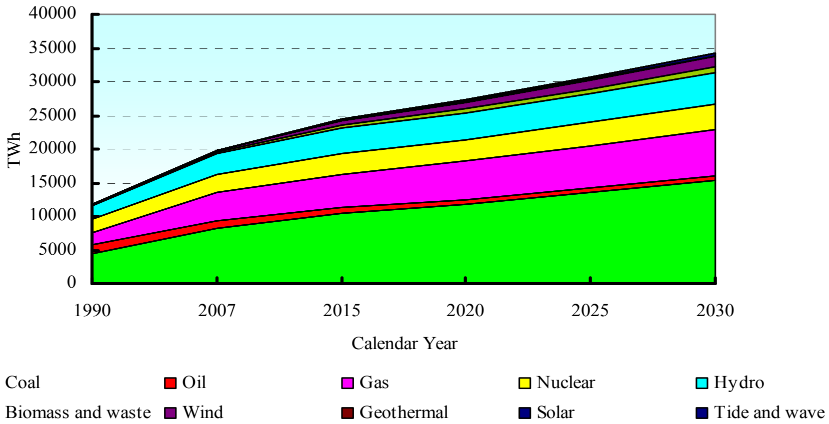
Source: IEA World Energy Outlook 2009

Fig. 3-14 World primary energy balance

[1] "Kaigai Shokoku no Denki Jigyo," Japan Electric Power Information Center, Inc.(2010)

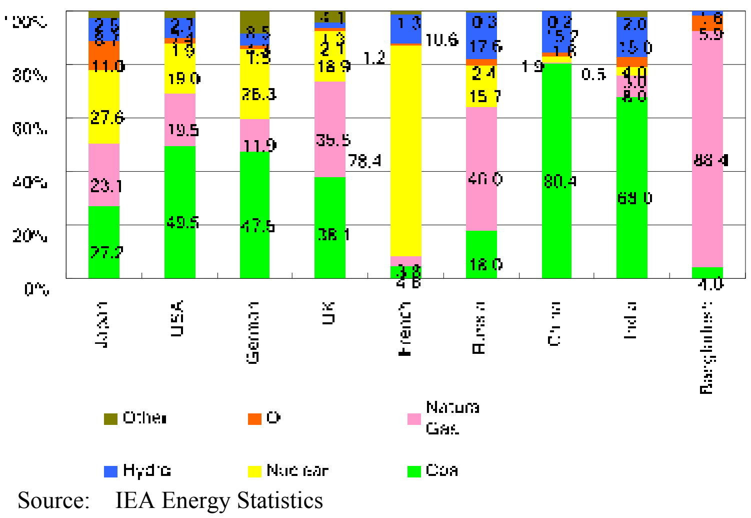
3.4.2 Share of coal use in world power generation

When reviewing world power generation, the share of coal use will increase slightly from 40% in 2007 to 42% in 2030 but will not change significantly, as well as the proportion of other fuels (natural gas 21% to 21%, hydro 16% to 14%, nuclear 14% to 11%, and oil 6% to 2%)[1]. In major developed countries such as the USA and Germany, the coal proportion exceeds 40%. In LDCs, China uses coal for over 80% of its total power generation and India uses it more than 60%. Bangladesh is a rather rare case to use domestic natural gas for major power generation Source:s. In other words, coal currently plays major role in global power generation and this central role will still remain for some time.



Source: IEA World Energy Outlook 2009

Fig. 3-15 World electricity generation by fuel



Source: IEA Energy Statistics

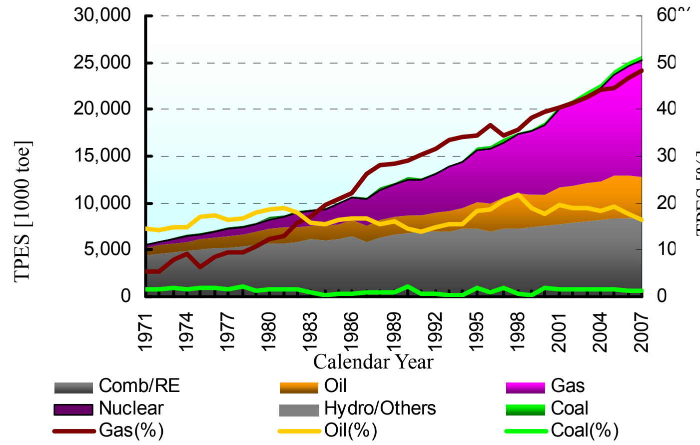
Fig. 3-16 Power generation by fuel in major countries

[1] IEA World Energy Outlook 2009

3.5 Bangladesh primary energy Movement and problem

3.5.1 Total primary energy supply in Bangladesh

The total primary energy supply (TPES) in Bangladesh is shown in Fig. 3-17. In 1971, 78% of the energy supply came from biomass like rice chaff and the proportion from the biomass was decreased due to an increase of natural gas and oil. In 2007, the structure of the TPES was coal 1%, oil 16%, gas 48% and biomass 33%. The consumption of the prime energy was conversion to electricity 27%, industry sector 12%, transportation sector 6% and other sectors 50% (90% for domestic use). Biomass for domestic use is still high, however, the ratio of the biomass is reducing, instead the conversion to electricity is steadily increasing.[1] Reviewing the world and Asian energy supply trends, as IEA projected, it is very likely that coal will play an important role in primary energy supply in Bangladesh.



Source: IEA Energy Balance

Fig. 3-17 Total primary energy supply in Bangladesh

Table 3-5 Energy balance (2007)

(Unit: TOE)

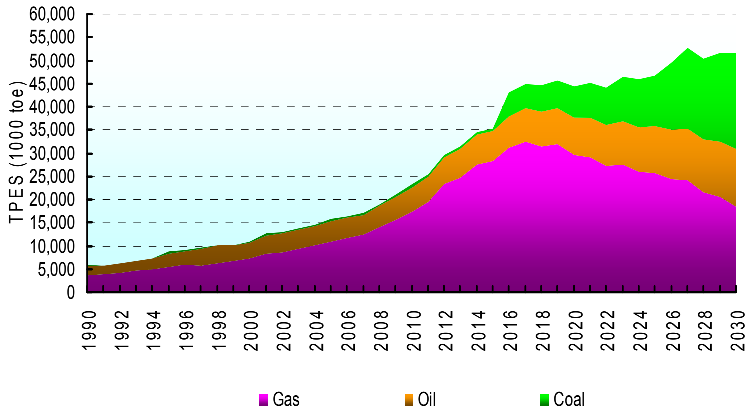
Year 2007 Supply and Consumption	Coal & Peat	Crude Oil	Petroleum Products	Gas	Nuclear	Hydro	Geo thermal	Combust. Renew	Electricity	Heat	Total
Production		86		12470		120		8586			21262
Imports	350	1219	3236								4805
Exports			-132								-132
Intl. Marine bunkers			-35								-35
Intl. Aviation bunkers			-252								-252
Stock changes		1	110								111
TPES	350 (1.4%)	1306 (5.1%)	2927 (12.6%)	12470 (48.4%)	0	120 (0.5%)	0	8586 (33.3%)	0	0	25759
Electricity and CHP plants			-590 -(2.3%)	-6172 -(24.0%)		-120 -(0.5%)			2097		-4785 -(26.7%)
Petroleum refinaries		-1306	1272								-34
Other transformation			-81	-684					-275		-1040
TFC	350	0	3529	5614	0	0	0	8586	1822	0	19899
Industry Sector	350		262	1586					780		2978 (11.6%)
Transport Sector			1638								1638 (6.4%)
Others Sectors			1185	1942				8586	1041		12753 (49.5%)
Non-Energy Use			445	2086							2531 (9.8%)

Source: IEA Statistics, Energy Balances of Non-OECD Countries (2009)

[1] IEA Statistics, Energy Balance of Non-OECD Countries 2009

3.5.2 Bangladesh primary commercial energy supply forecast

Bangladesh main primary commercial energy (Natural gas, Oil, Coal) demand forecast is shown in following figure.[1] The natural gas supply will be decreased from 2017, and coal supply will be increased as an alternate fuel. The coal is treated as main alternate fuel instead of the natural gas in new development plan of this master plan.



Source: PSMP Study Team

Fig. 3-18 Bangladesh primary commercial energy demand forecast

3.5.3 Alternate fuel of natural gas

Bangladesh's primary energy issue is that the nation is overly dependent on natural gas. In order to achieve diversification of primary energy and Bangladesh's continual and stable development, Bangladesh must execute a primary energy shifted from natural gas. It has been confirmed that there are abundant coal reserves that can be used as alternate fuel to natural gas in North-West Bangladesh .The Government of Bangladesh began to develop domestic coal through the preparation of a domestic coal delivery system and by studying how to improve coal fired power plant operations. In this study, basically, domestic natural gas and domestic coal is effectively utilized. However, if it is forecasted that domestic primary energy is not enough to satisfy energy demand in the future, it is believed that primary energy imports will be a necessity for economic development of Bangladesh.

3.6 Organization structure of the energy sector

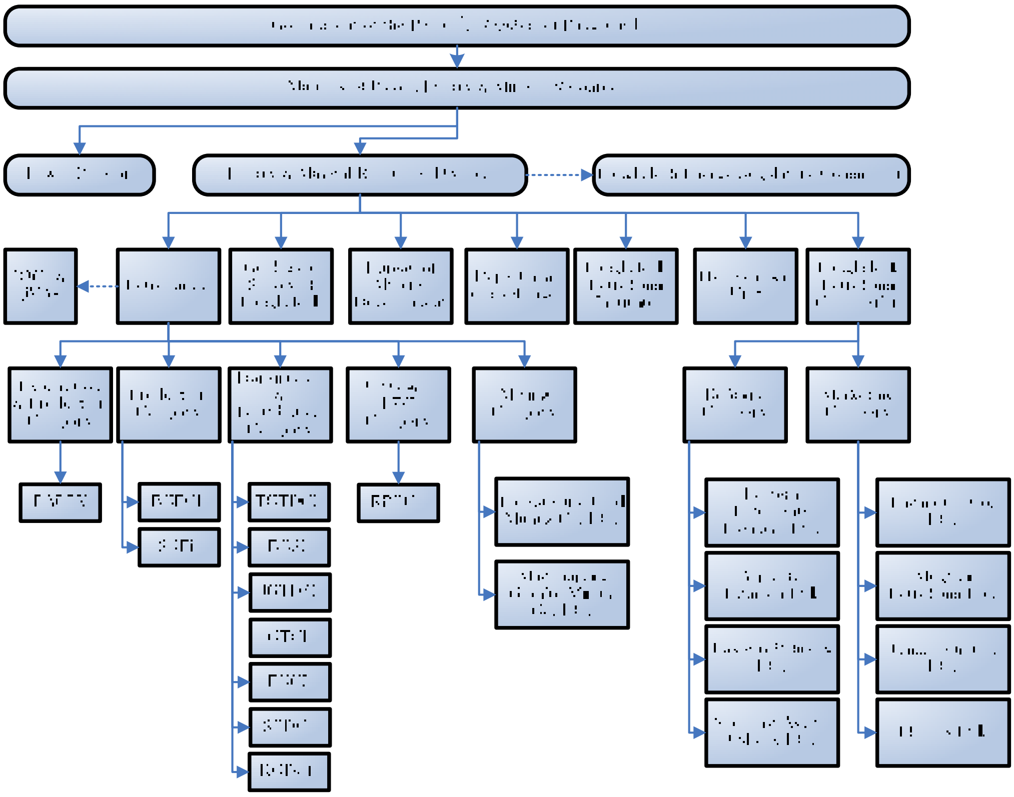
3.6.1 Current status and problems of the energy sector organization

(1) Organizational structure

In Bangladesh, Energy & Mineral Resources Division (EMRD) of MPEMR manages the energy sector. EMRD has two corporations- one is Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), which is responsible for mining, developing, producing, transporting natural gas, and mineral resources, management and arrangement of its subsidiaries, contract conclusion of shared production (PSC) with overseas companies, and performing important projects. Another is Bangladesh Petroleum Corporation (BPC), which is responsible for import, refining, marketing, transportation, and storage of oil.

[1] PSMP Study Team (gas: PSMP Study Team Case 1, Oil: extrapolate with GDP 7% growth, Domestic coal: PSMP Study Team Base case, Imported coal: JICA Study Base scenario, calorific value: assuming Gas 950Btu/scd, Oil 40.1 MJ/kg, Domestic coal 25.5 MJ,/kg Imported coal 21.2 MJ/kg and converted as ton of oil equivalent.)

The gas sector under the control of Petrobangla is divided into companies for exploration and production, transmission and distribution, CNG and LPG and mining. Fig. 3-19 shows 13 companies under Petrobangla control except imported coal, domestic coal is produced/mined by BCMCL under Petrobangla.



Source: Energy and Mineral Resources Committee (2011)

Fig. 3-19 Structure of the energy sector in the country Bangladesh

(2) Current status and problems of the organization concerning the energy sector

MPEMR started to innovate the energy sector in 1994. Every subsidiary under Petrobangla is privatized, i.e., Petrobangla has some degree of influence on them but no direct participation in management. Problems directly faced by the energy sector include discovering/developing new domestic natural gas, reinforced gas transportation system, reduced system losses, and development of domestic coal mines, and current and vital demand cannot be satisfied since gas charge is politically kept low and companies under Petrobangla have insufficient funds for development. In addition, the cost is not reflected on the electricity charge and the cross subsidy among customer categories continues for a long time. Such a low charge on which no cost is reflected may generate an evil in the healthy growth of the electricity business of the country Bangladesh

3.6.2 Current status and problems of the power sector organization

(1) Organizational structure

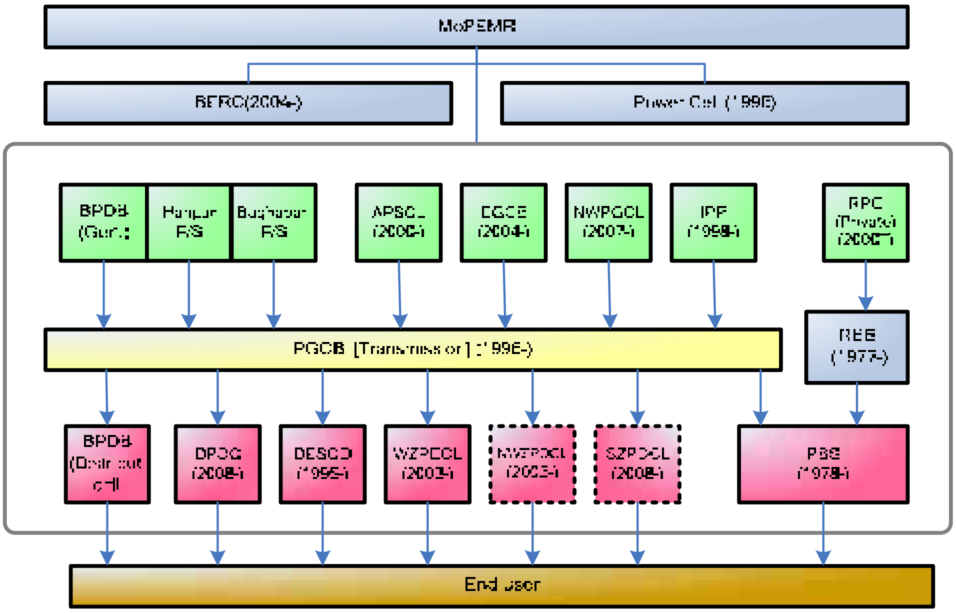
Power Division under MPEMR manages the electricity business. Under its control, the power is generated by the BPDB and its generation subsidiaries, IPPs, and Power is supplied through PGCB's power transmission facilities to the distribution utilities. In the capital city of Dhaka, DPDC and DESCO are responsible for electricity supply to retail consumers. In other urban cities, BPDB and WZPDCL and in rural areas REB supply to retail consumers. Fig. 3-20 shows the structure of the power sector in Bangladesh.

For BPDB power generation department, the Haripur power plant was changed to the Strategic business Unit (BSU)[1] and the Ashuganj power plant was changed to the subsidiary based on the "Vision Statement/Policy Statement (January, 2001)." And then, the Baghabari power plant was changed to the BSU, EGCB who owns Siddirganj Power Station (210MW), and NWPGCL who developed Khulna Power Station (150MW) and Sirajganj Power Station (150MW), and will develop Bheramara Power Station (360MW) were split up from BPDB based on the "Vision Statement/Policy Statement" and "3-Year Roadmap (2006)"

Furthermore, in the power distribution department of BPDB, WZPDCL is responsible for power distribution in Khulna and Barisal areas, NWZPDCL is registered for Rajshahi and Rangpur areas and SZPDCL is registered for Chittagong and Comilla areas based on the "Vision Statement/Policy Statement."[2]

1 SBU (Strategic Business Unit) is a form of the organization which BPDB still owns but transfer the authority to some extent.

2 BPDB Annual Report 2008-2009, "Kaigai Shokoku no Denki Jigyo," Japan Electric Power Information Center, Inc.(2010)



Note: ⟶ Power flow

Abbreviation	List
MPEMR	Ministry of Power, Energy & Mineral Resources:
BERC	Bangladesh Energy Regulatory Commission
BPDB	Bangladesh Power Development Board
APSCL	Ashuganj Power Station Company Ltd.
EGCB	Electricity Generation Company of Bangladesh
NWPGCL	North-West Power Generation Company Ltd.
IPP	Independent Power Producer
RPC	Rural Power Company Ltd.
PGCB	Power Grid Company of Bangladesh
DPDC	Dhaka Power Distribution Company Ltd.
DESCO	Dhaka Electric supply Company Ltd.
WZPDCL	West Zone Power Distribution Company Ltd.
NWZPDCL	North-West Zone Power Generation Company Ltd.
SZPDCL	South Done Power Distribution Company Ltd.
REB	Rural Electrification Board
PBS	Palli Biddyut Samities

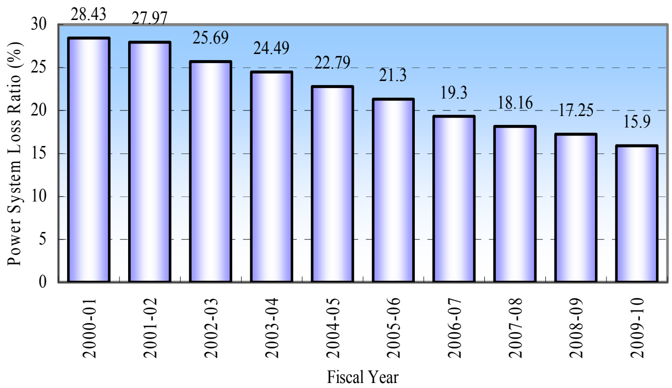
Source: "Electric Energy Situations in Foreign Countries" Vol.2 (2010) JEPIC BPDP Annual Report

Fig. 3-20 Structure of the power sector in the country Bangladesh

(2) Current status and problems of the power sector

MPEMR started to reform the electric power sector in 1994, allowing participation of IPP, unbundling and corporatization of BPDB. The "Private Sector Power Generation Policy of Bangladesh" was formulated in 1996 to facilitate power generation in the private sector. The "Vision Statement/Policy Statement" was announced in 2000, showing the target such as "to deliver quality electricity at reasonable and affordable prices with professional service excellence," and "to make electricity available to all citizens on demand by the year 2020" and indicating the direction of the electric power innovation. Furthermore, the "Energy Regulatory Commission Act" was enacted in 2003 to establish the independent energy regulatory commission. Bangladesh Energy Regulatory Commission (BERC) was established in 2004..

Problems in the future include improved electrification ratio targeted to 100% by 2021 (47% in 2009), reduction of insufficient electric power supply and power failure caused by insufficient gas, aged facilities, improper maintenance, reduction of power system (transmission/ distribution) loss ratio (15.9% in 2009, which has improved gradually but in the high level yet).
In addition, GOB has a plan to introduce the first domestic nuclear power plant, which may start in 2017 at Rooppur about 200 km from Dhaka, with a total generation capacity of 2000MW two units, each 1000MW..



Source: BPDB

Fig. 3-21 Power system (transmission/ distribution) loss

Chapter 4 Coal Sector

4.1 Draft Coal Policy

4.1.1 Outline of Draft Coal Policy

The Draft Coal Policy (version 1) was published on 1st December 2005 by the Energy and Mineral Resources Division of Ministry of Power, Energy and Mineral Resources. After that it was revised several times. The latest one described in the details is the Bangladesh Draft Coal Policy −June 2007, which is presently being submitted to the government. Coal Policy has been drafted and uploaded at the website of the Energy and Mineral Resources Division for public opinion. After evaluating the public opinion, this draft would be finalized and be placed to the cabinet for approval.

4.1.2 Outline relating to this study

The new Draft Coal Policy (June 2007) outlines gas shortage, power generation, coal development, investment for coal sector, import coal, environment and etc in Bangladesh. Therefore this policy will become useful data in relating the domestic coal supply for this Study.

The brief summary of the Policy is attached in APPENDIX-1. This policy states that coal will be used for power generation instead of gas as an alternative fuel to maintain national energy stability. Power supply and demand is based on Power System Master Plan 2006. PSMP Study Team comments pertaining to the Policy will be described below and each item is quoted from the Coal Policy Draft.

(1) 2. BACKGROUND AND CURRENT STATUS

In the case of an annual 8% GDP growth rate, a domestic coal supply is over 30 million tons per year from 2019 and 75 million tons per year in 2025, but this number is the quantity of demanded coal supply for power stations per the calculation. The domestic coal supply is assumed to be from 4 coal fields minus Jamalgonj with the deep coal seam. However, there are thick coal seams in each coalfield, and there are the thick aquifer, rice fields and villages on the top.

In an open cut mine, countermeasures to surface subsidence around the mining area, the drying up of the subsurface water by dewatering and countermeasures to bench slope stability in the unconcluded aquifer formation are necessary. (Refer to Appendix-3: Pilot O/C Coal Mine)

Furthermore, in the case of an underground mine as seen in Barapukuria, mining technology for an average 36m thick seam to exploit the safety, high efficiency, and high-recovery rate has not yet been established. Hence, the surface of the mining area would cause subsidence.

When considering these, if there is no new discovery of coal fields, it is difficult to realize a coal supply of more than 30 million tons per year with domestic coal alone.

(2) 2.2 ENSURE ENERGY SECURITY BY DEVELOPING THE COAL SECTOR

Coal recovery rates of many open cut mines currently working overseas are more than 90%. Most of the mines are shallow and start operation from coal outcrops or sub- outcrops. In the case of deep coal seams, an underground mining method has been adopted. According to the above comment, there are a few cases of coal mines which have unconsolidated aquifer, rice fields and villages on top of the coal seam.

In consideration of Bangladesh's geological conditions, it is necessary to further research economically mineable depth as there is a large gap between expectations and reality. (Refer to Appendix-3: Pilot O/C Coal Mine)

(3) 3.5 REGULATION OF COAL EXPORT

There is a shortage of coking coal in the world. The price difference between thermal coal and coking coal per unit of heating value is always great. If the high quality coal of Bangladesh is consumed only for power generation as a heat source, it is just not only the country, it is very uneconomical in the world.

As an extreme example, if thermal coal is 100 $ / ton, coking coal is 150 $ / ton at the same heating value and ignoring the fare, 1 ton of coking coal for export will be able to import 1.5 tons of coal. The possibility of coal export shall be considered more aggressively.

(4) 5.3 COAL RESERVES

It is very likely that Khalaspir and Dighipara will be developed by an underground mining method because of the coal seams depth. The numbers of exploration borings are very few, 14 and 5 holes respectively, so it is not enough to interpret the geological conditions. Future research should be conducted quickly.

In addition, after collecting the sample, it is necessary to analyze not only the coal quality but also to measure the rock strength of the roof and floor, gas content, porosity, permeability and others, then these results shall be used as materials to study concrete coal mine development..

(5) 6.6 MINE WATER MANAGEMENT

In the Coal Zone, there is the Upper Dupi Tila formation including large amounts of water on top of the coal deposits and it hinders coal mine development. Therefore, it is estimated that such an item was written down independently.

In addition, before carrying out the open cut, not only are pumping tests and computer simulations necessary but also actual measurements of slope stability at the Upper Dupi Tila formation and the countermeasures needs to be studied. After that, it is desirable to carry out trial mining in order to ensure stable production and safety. (Refer to Appendix-3: Pilot O/C Coal Mine)

(6) 9.1 COAL FIRED POWER GENERATION

As mentioned in the preceding Comment, it is difficult to produce more than 30 million tons of coal per year from four coal fields. If there is no new discovery of coal fields, the domestic coal supply is not enough to power stations. Hence, import coal is needed.

(7) 10.2.2 ROYALTY OF LOCAL USE COAL

A simpler calculation of royalties would be better. For example, in Indonesia, it is 13.5% of FOB in CCoW (Coal Contract of Work) regardless of the coal quality, coal class, for domestic and for exports.

(8) 10.3 COAL MARKETING

This Draft Coal Policy has many items assuming an annual rate of 8% of GDP growth. As mentioned in the above comment, domestic coal production is the numbers back calculation from necessary electricity and almost all of the coal is for power stations. Therefore, a coal supply is also difficult for other domestic industries other than exports.

If Bangladesh exports high price coking coal, Bangladesh can import much more thermal coal because of the price difference. This can increase the available energy resources in Bangladesh

(9) 11.3.4 COAL SECTOR DEVELOPMENT COMMITTEE

The necessary items for coal development in Bangladesh are almost all listed in this Draft Coal Policy, and the necessary laws, the government organizations have already existed.

The solution to the problem is to coordinate the existing organizations and leadership seems to be required in order to quickly solve issues according to the current situation.

From this perspective, per the membership of the above table (Coal Sector Development Committee) all the organizations in conjunction with the coal development are covered and this Committee seems to be authorized. However, it is not sure when it will be held and what the theme will be. Excellent staff officers who collect effective proposals and make practical measures as a subsidiary organ of the leaders are necessary to realize policy. The organ will cover not only coal but also electricity, oil & gas, mineral resources and others. The organ will be a permanent institution and can provide practical measures quickly, regardless of the government at the time

(10) 11. 3.8 HUMAN RESOURCE DEVELOPMENT

To implement human resource development and the enhancement of mining education facilities, many high quality educators are necessary. Meanwhile, studying at the university tends to be centered literature in many cases. In order to develop rapidly now the coal industry in such countries like Bangladesh will require leaders who can better understand the field

For example, in the "Training project on coal Mining Technology" of NEDO in Japan, Vietnam and Chinese coal mine executive officers, coal mine engineers and university professors are invited to Japan and they will learn coal production and safety technology in the room and production site.

There is the training that trainees enter underground and they get practical education, and the educational content is very useful for certain relevant people of Bangladesh. It seems that such an education system is necessary for Bangladesh where coal mines will be developed from now on.

In addition, qualified miners and designated miners perform important works for production and safety in Japanese coal mines. An education system for licensed acquisitions seems to be required as well.

(11) 11.3.9 RESEARCH AND DEVELOPMENT

In Japan, explosives and equipment used in underground coal mines have been checked by the authority and this system has prevented gas and coal dust explosion accidents. In Bangladesh, if underground coal mines increase in the future, it is supposed that many imports will be used. Instead of using unchecked imported equipments without, the suitable system for Bangladesh shall be used.

(12) Others

This Draft Coal Policy mainly describes domestic coal development. There is no entry for import coal. For example, high sulfur coal is imported for a brick kiln from Meghalaya in India, adjacent to the north of Bangladesh. For environmental reasons, coal with a sulfur content exceeding 1 percent is presently under an import ban. However, the ban on this type of coal will eventually be lifted. Meghalaya coal is cheap and consumers are welcome. There is also an aspect to suppress the logging of forest resources. In Japan, briquettes were made by mixing with lime stone and high sulfur coal and it has been proven that the sulfur content was reduced by 60%-70% after combustion. Not only to the import ban but also to make environmentally friendly fuels and to use it, it will benefit each other. Since a large amount of import coal will be needed for the power stations, a system of import coal shall be established.

Bangladesh Coal Policy Draft (1)

4.1.3 Review for related coal matters in Power System Master Plan Update 2006

Regarding coal production, PSMP Study Team shows differences of coal production by reconsideration of Develop Plan 2006 and PSMP 2010 .in Table 4-1.

Table 4-1 Comparison between PSMP and this study

Year	PSMP 2006 (1,000t)		Domestic Coal Production in the JICA Study Report (1,000t)		
			(Note: From 2005 to 2008 shows actual production)		
	Domestic Coal	Import Coal	High Case	Base Case	Low Case
2005	0	0	303	303	303
2006	327	0	388	388	388
2007	644	0	677	677	677
2008	635	0	828	828	828
2009	569	0	850	850	640
2010	530	0	1,000	1,000	750
2011	523	0	1,000	1,000	850
2012	1,606	0	1,000	1,000	600
2013	1,654	0	1,000	1,000	600
2014	2,704	0	2,000	1,000	700
2015	3,780	0	2,000	1,000	700
2016	3,835	0	1,000	1,000	700
2017	4,863	0	1,000	1,000	700
2018	5,834	0	2,500	2,000	750
2019	8,095	0	4,500	2,500	850
2020	9,431	0	7,000	3,500	1,350
2021	10,729	1,184	10,000	5,000	2,350
2022	10,688	4,551	12,500	6,000	2,850
2023	10,656	7,645	14,500	7,000	2,850
2024	10,715	10,632	16,500	8,000	3,850
2025	10,839	12,853	18,500	9,000	4,850
2026	(N/A)	(N/A)	24,500	12,000	6,350
2027	(N/A)	(N/A)	26,500	14,000	6,850
2028	(N/A)	(N/A)	26,500	14,000	6,850
2029	(N/A)	(N/A)	26,500	14,000	6,850
2030	(N/A)	(N/A)	26,500	15,000	7,000

Source: Power System Master Plan Update 2006 and PSMP Study Team

4.2 Current situations and issues of supply and demand of domestic coal

4.2.1 Reserves in coal fields, production forecasts, and issues

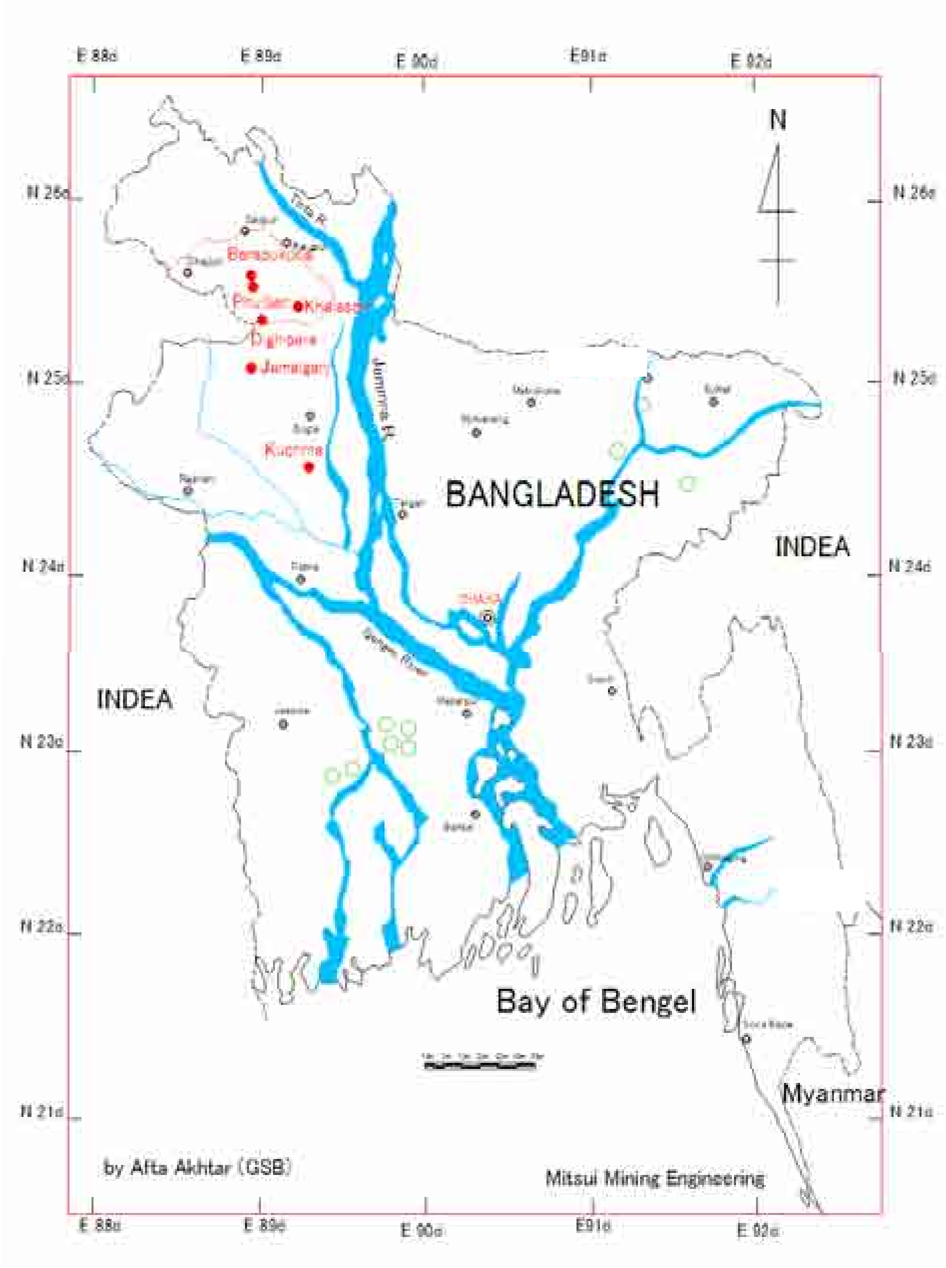
It is well known that the bituminous coal, which is called "Godwin coal" of the Permian Period as well as sub-bituminous coal to lignite of the Tertiary Era occur in Bangladesh. According to the present development data, there are five coal fields in Bangladesh, all of which situated in between the Jamuna River and the Padma River in the northwestern part of Bangladesh. The measured and probable coal reserves total 3.3 billion tons. According to the Draft Coal Policy (June 2007), the measured coal reserve that can be mined for the time being is estimated to be 1,168 million tons, except in Jamalgonj where coal seams are located relatively deep underground. As developments continue, probable coal reserves are likely to increase. Fig. 4-1 indicates the locations of these coal fields, while Fig. 4-2 shows their details.

Coal in Bangladesh is generally characterized as having low ash content and low sulfur content that are in favor of the environment. It is bituminous coal with properties similar to the coal being used by power stations in Japan. Another grade of coal, which is classified into semi-coke (for iron production) whose commodity value is very high in the market, is also available.

Meanwhile, the problem lies in its mining method. For underground coal mines, the thick coal seams (30 to 40m) pose a problem for the mining method and miming rate. For open-cast coal mines, the mining method which includes dewatering technology to prevent inundation and protect the environment has become an issue, because coal deposits accumulate in the relatively deep underground (170 to 450m) and such a coal mine tends to have an aquifer, called "UDT (Upper Dupi Tila)," over the coal seams. Fig. 4-3 shows a typical conceptual model of the conditions of a coal-bearing formation and the upper aquifer in Bangladesh. In particular, rice fields and houses are scattered on the surface above the coal seams. Thus, to relocate local people without trouble will become important. In particular, the suspension of the Phulbari open-cast coal mine development plan has brought about a significant negative impact.

Table 4-2 lists details of six coal fields that were explored and the progress in their development. The Barapukuria Coal Mine is the only operating coal mine in Bangladesh and is undergoing completely mechanized underground mining, the details of which will be described later. An open-cast coal mine development in Phulbari came to a deadlock due to the oppositions by the local people, which will give directions to the coal mine development in Bangladesh. In other words, coal mine development in Bangladesh will depend on whether the Government of Bangladesh can successfully win, as a national policy, consent from people for an open-cast mining method, which is superior to underground mining in terms of stable coal production. The comparison between open-cast mining and underground mining in Bangladesh will be described later.

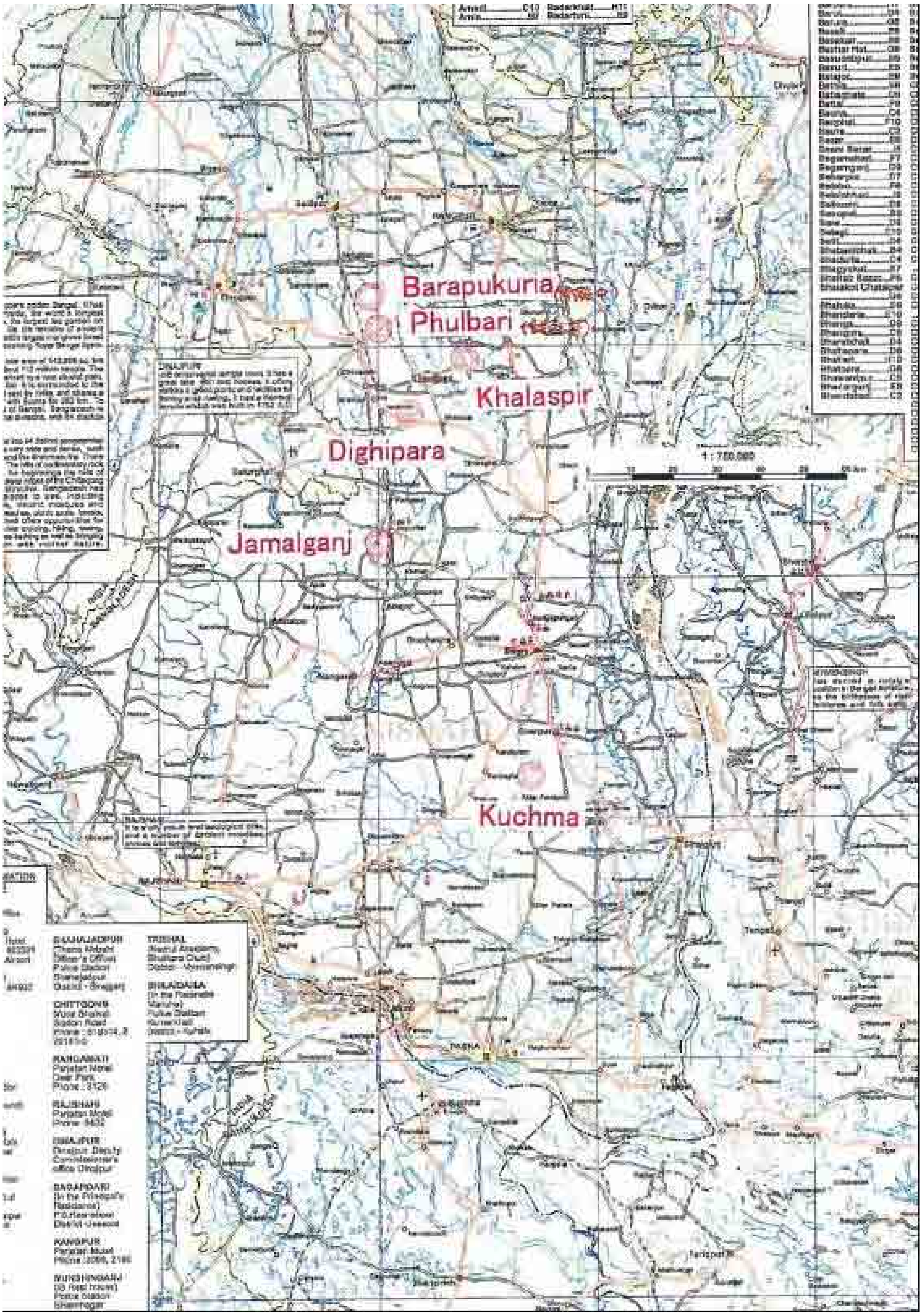
Meanwhile, Bangladesh needs to continue coal exploration to obtain more information on coal fields with better mining conditions. In particular, since Godwin coal is a kind coke of good quality with limited global availability, it has drawn much attention from concerned parties in many parts of the world.



Source: GSB

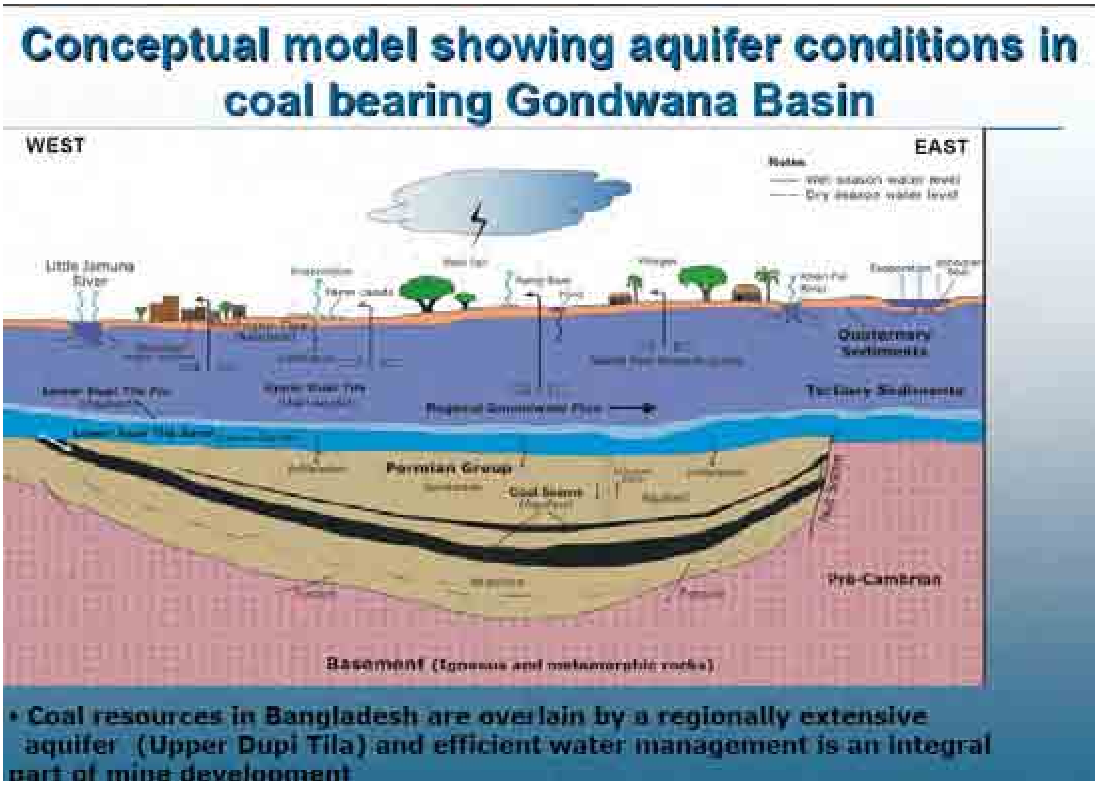
Fig. 4-1 Locations of Coal fields in Bangladesh[1]

[1] 1. Red points indicate coalfields.



Source: GSB

Fig. 4-2 Detailed locations of coal fields in Bangladesh



Source: Asia Energy Corporation (Bangladesh) Pty Ltd (AEC), 2005

Fig. 4-3 Conceptual model of conditions of coal-bearing formation and upper aquifer in Bangladesh

Table 4-2 Coal in Bangladesh present production situations and issues (Barapukuria Coal Mine)

	Coal field name	Develop ment year	Exploring company (Number of borings)	Depth (m)	No. of coal seams	Av. thickness of composite coal seams (m)	Measured coal reserve (million tons)	Measured+ probable coal reserves (million tons)	Remarks
1	Barapukuria (Dinajpur)	1985 -87	GSB (31)	118 -506	6	51	303 (Minable coal reserve by U/G: 64 million tons)	390	・Petrobangla and China National Machinery Import and Export Corporation (CMC) in China concluded an development agreement in 1994. BCMCL was founded in 1998. Capacity designed: One million ton /year ・A small-scale open-cast mining project is feasible. ・A 250MW coal-fired thermal power station is in operation, and a study is on the table to build a new 125MW power station.
2	Phulbari, (Dinajipur)	1997	BHP (108)	150 -240	2	15-70	572	572	・Asia Energy has completed a feasibility study. When the company was going to engage in a large-scale open-cast coal mine development, the development project was suspended in August 2006. ・Although Global Coal Management has succeeded to the development interest, the project is yet be progressed.
3	Khalaspir, (Rangpur)	1989 -90	GSB (14)	257 -483	8	42.3	143	685	・The measured coal reserve is 277 million tons. Since only 14 borings were made, the reliability is low. The developer has submitted a feasibility study for coal mine development by underground mining to the Government of Bangladesh. ・The annual coal production plan ranges from two million to four million tons.
4	Dighipara, (Dinajipur)	1994 -95	GSB (5)	328 -407	5	62	150	600	・GSB made five borings in a 1.25 km2 area and found five coal seams. The initial probable coal reserve is 600 million tons. ・A Korean syndicate has approached Petrobangla for development and investment.
5	Jamalgonj, (Bogra)	1962	GSB (10)	640- 1,158	7	64	1053	1053	・Largest coal field in Bangladesh ・Targeting coal seam gas of CBM (coal bed methane) in deep underground
6	Kuchma, (Bogra)	1959	SVOC	2,380 -2,876	5	51.8			・Targeting coal seam gas of CBM (coal bed methane) in deep underground

Source: PSMP Study Team

4.2.2 Present domestic coal production and issue (Barapukuria coal mine)

(1) Overview

The Barapukuria Coal Mine (BCMCL) is the only coal mine in Bangladesh. It is amazing as compared with other coal producing developing country that mechanized longwall coal mining was able to be successfully introduced to the first underground coal mine resulting to a certain degree in the stable production of coal.

The Barapukuria Coal Mine was developed jointly by Petrobangla and CMC in China (agreement concluded in 1994). According to "the Management, Production and Maintenance" (M&P) Contract, CMC is supposed to transfer technology including the facilities, to Bangladesh by the year June 2011. In addition, the coal mine has concluded a consultancy agreement with IMC Consulting Ltd. in UK until June 2011. All the underground facilities are from China. The vertical shaft is 300m long, and the skip capacity for coal hoisting is set to 3,300t/d. For the coal seam, refer to Fig 4-4, for Under Ground mining (U/G) map, refer to Fig. 4-5, For general view of coal mine, refer to Fig. 4-6, for the vertical shaft refer to Fig. 4-7, and for self advancing support for long wall mining refer to Fig. 4-8.

Coal productions have been stable in recent years. The coal mine produced 0.84 million tons of coal in 2008. The coal production in 2009 remained stable until a power station faced trouble. Meanwhile, mining operations have been suspended by August 2010 due to the collapsed roof accident in May 2010. This accident brought home the difficulty of underground operations.

Table 4-3 lists the coal production results for the years in the agreement. Coal is supplied for two neighboring 125MW Barapukuria Thermal Power Stations. The other remaining coal is primarily supplied for brick constructions and other purchasers in the general industry. At present, although the coal mine has an annual production capacity of approx. one million tons, the mine is studying to reinforce the production capacity to an annual production of 1.5 million tons in the future.

(2) Production plan and results

Table 4-3 Coal production records at Barapukuria Coal mine

FY	Planned coal production (t)	Coal production result (t)
2006	500,000	362,470
2007	770,000	348,200
2008	970,000	611,674
2009	1,020,000	904,659
2010	930,000	709,155
2011	560,000	

Source: EMRD

(3) Issues and recommendation

(a) The collapsed roof accident

A large-scale collapse[1] occurred on May 2010. Hence, subsequent reinforcement work comprising panel road maintenance and counter measures for hanging roofs (appropriately the

[1] Intensive stress by the failure of the ground pressure control at LW1108 suffered from gallery roof by the information that they obtained and exceeded supporting capacity. The roof of about 30m length collapsed and one death, 18 got injured. Production was reopened in August, and it was produced smoothly afterwards, and

falling roof of the mined out area) shall be necessary. Based on these results, there is the possibility of thinking about the remaining appropriate pillars between the mining panels in the area where coal has not yet been extracted.

In the past, many accidents repeatedly occurred in the Barapukuria Coal Mine. Such as sealing work due to spontaneous combustion in the panel, some small scale roof collapses, a big scale roof collapse at this time and others easily occurred inside the underground coal mine. This mine has accumulated valuable experiences by paying close attention. These causes and measures shall be categorized as valuable information and used for new underground coal mines which will be developed and increased in the future. The foundation of a national organized institute for training, including the success of these experiences will be essential in Bangladesh.

(b) Early decision of a mining method for the second (2nd) slice[1] and deeper slice

The contract with China will be cut off in 2011and BCMCL performed an international bid of a mining contract of the next term in January, 2011 and it is the situation waiting for proposal. There is a need to make an early decision on a safe and efficient method to mine coal in the second slice and the deeper coal seams according to the feasibility study. Deciding a mining method for the southernmost mining area is also necessary.

(c) Plan to increase coal production

The second and deeper slice will allow for increased coal production at the working faces via adoption of the following measures. (1) When the top coal caving, which has been successful at the working face of the thick coal seams in China, can be introduced successfully in Bangladesh, a large-scale increase can be expected in coal production; (2) the present working face equipment will be reinforced and coal mining working faces will be expanded; (3) the layout of the galleries in the southern area will be changed so as to grade the inclination in the working face for higher work efficiency. At the same time, in the steep mining area of the southern area, where self-advancing support is difficult to adopt, Room & Pillar mining, for instance, can be adopted.

Meanwhile, the skip capacity of the vertical shaft is as small as 8 tons. If the operation hours of the hoists are extended and if underground coal pockets are expanded, the annual coal production can increase up to 1.2 million tons. If the Barapukuria Mine intends to increase the annual coal production to 1.5 million tons or more, the capacity of the hoists must be enlarged in size, or vertical shafts for coal hoisting must be added to upgrade to the present equipment level. However, such expansion or addition of equipment will need extra cost.

(d) Problems of surface subsidence following underground mining

The effect rate of surface subsidence depends on the mining method, but any method will cause some surface subsidence. The subsidence ratio becomes small when the filling method or Room & Pillar method are adopted, but the mining costs are high or the mining recovery is small. Therefore there are 3 measures utilized to decrease the subsidence ratio as mentioned in the following.

- Room & pillar**:** subsidence ratio is small when the mining recovery ratio is restricted.
- Filling method: subsidence ratio is small, but the mining costs are high.
- Therefore, although it will entail extra costs, the Barapukuria Mine needs to purchase areas within 50 to 60 subsidence limit angles from the ends of the planned mining as well as

this LW was finished in November. Coal is producing now in LW1111 which is the next face.

[1] 2nd slice means secondary mined coal seam when the coal seam is thick so as not to mine at once. At a present technical level, the height of coal seam for one slice by standard longwall method will be max. 4m..

their surrounding areas and houses with little leeway. At the same time, the Barapukuria Mine needs to sufficiently compensate the local people before surface subsidence occurs.

(e) Technology transfer

Technology transfer at Barapukuria Coal Mine is very important to predict the future development and production at underground coal mines in Bangladesh.

- Regarding the methods of Technology Transfer, there is "On the Job Training" and "Classroom within M&P Contract" between China and BCMCL. Safety control items are exceptionally very important in technology transfer program,
  A small number of BCMCL people are being trained in technical knowledge and ventilation control technology by IMCGCL of a consultant company in UK.
  BCMCL personnel have absorbed much technical knowledge through daily OJT with the Chinese workers, but they still want to continue this contract because of a lack of confidence in being able to maintain production,
  Work standard drawings and work boards showing, for example, a work point name, date and shifts, gas concentration, work goal, name of employee in charge of work, and other working staff names at the working points are necessary so that workers can better understand their work and the management becomes easily.
  Although a telephone system is furnished at the mine work points, no mine wireless communication system has been installed. If such a communication system is introduced, an operator at the monitoring room (central monitor room) can grasp mine situations from time to time. In addition, a mine wireless communication system is very useful for an emergency case and to reduce loss of opportunities due to machine failure. Since it is not expensive, such a system should be introduced by all means.
  Disaster drills for mine fire, water burst, gas eruption, and other accidents have been held in Japan. Unless such drills are implemented regularly in ordinary time, workers are likely to become confused in controlling of the state of other workers and in choosing an evacuation route.
- Training institutions for coal mine professional will be necessary.

(f) Coal sector master plan

A coal sector master plan will be necessary to prepare. In conformity with the coal sector master plan, associated coal sector road map and action plan will be also required for implementing new coal mines.

(4) Production forecast

The detail of domestic coal supply forecasts is written on in Section 4.2.6 and general situation is described here.

(a) Underground Mining

In the high case at the 2nd slice and deeper, increased coal production is difficult because of safety problems when the long wall is succeeded whether the Top Coal Caving method succeeds or not. If the increased underground production is persistently expected regardless of high costs, the mining area shall be increased at the Southern area and around the vertical shaft area in order to decrease the deepening rate and the underground structure shall be redesigned.

In the base case at the 2nd slice and deeper, the present production scale (about 1 million tons per year) is appropriate when the long wall succeeds whether the Top Coal Caving method is a success or not.
In the low case at the 2nd slice and deeper, coal production shall be continued under the adopting room & pillar or an other method and there is the possibility of increased work when the long

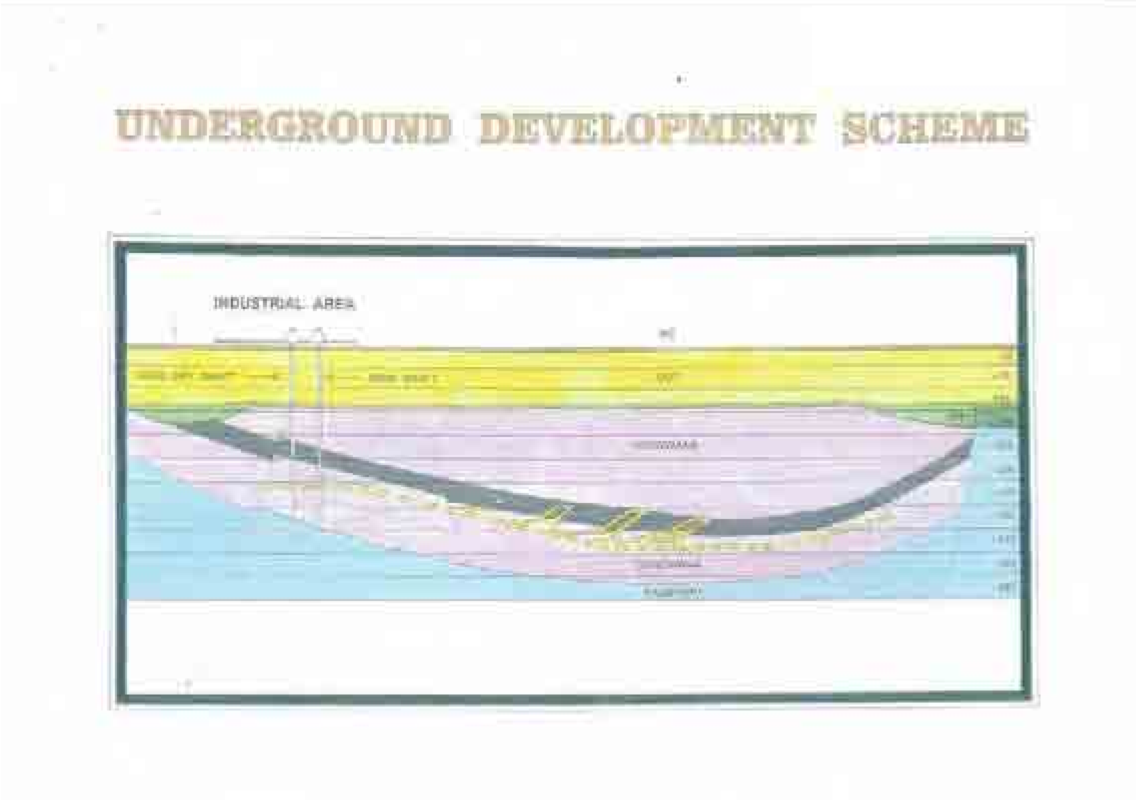
wall method may not be succeeded due to safety problems for earth pressure control, the prevention of spontaneous combustion and other problems.
There may be no room for increasing coal production from U/G as mentioned above.

(b) Open Cut Mining

The O/C mine is considered at the northern area where the coal seams are in a relatively shallow depth when the increased production from U/G will not be expected. In this area, the U/G mine possibility is excluded, because here the low permeability Lower Dupi Tila formation is thin or does not exist and the high permeability Upper Dupi Tila formation comes into direct contact with the Gondowana formation.

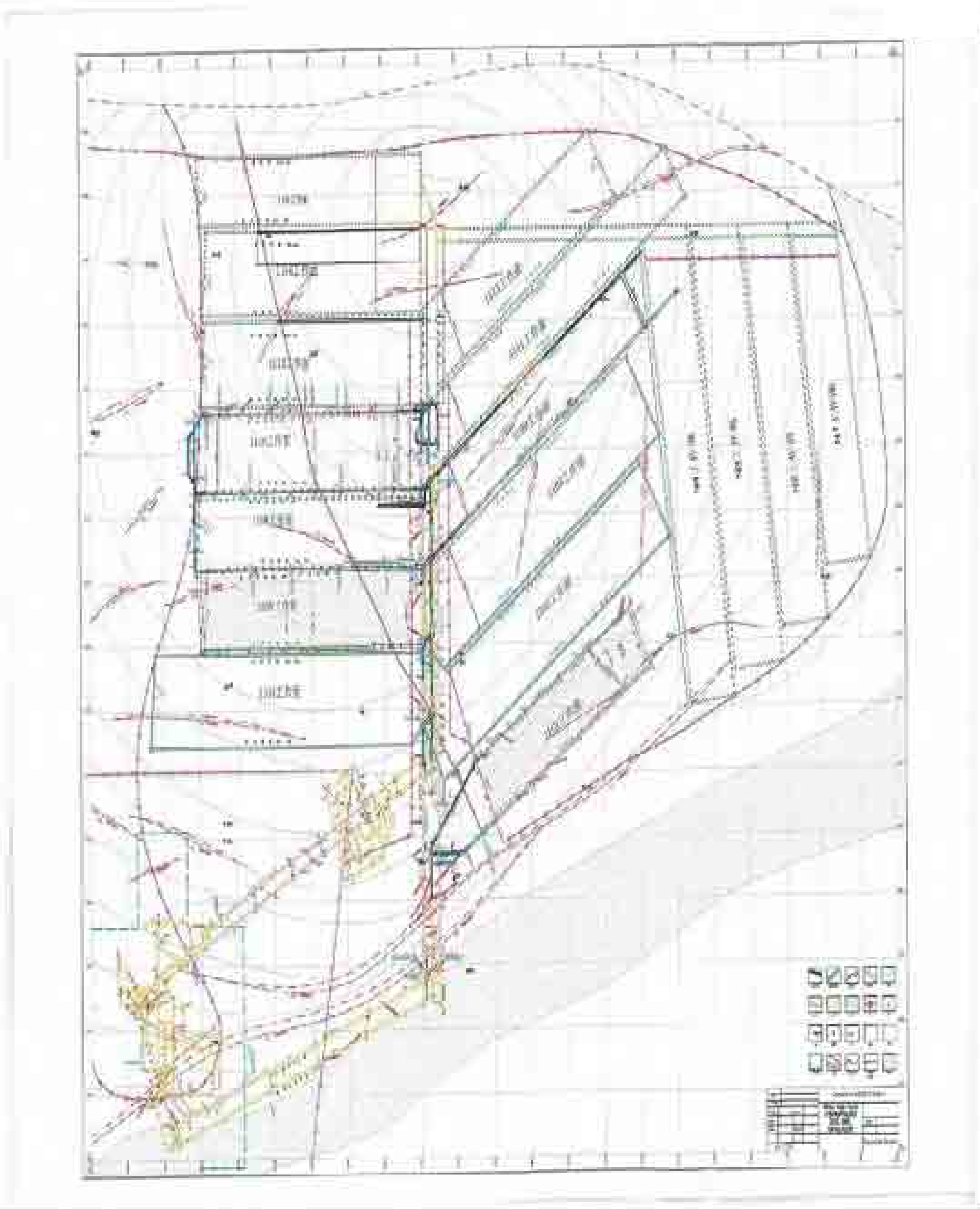
However, there are a few examples of O/C which is mined under highly permeable and an unconsolidated formation. As mentioned in 4.2.4 , the pilot mine shall be necessary. When inhabitants understand the circumstances, after overcoming the different kinds of technical matters, environmental matters, considerable production will be expected. O/C will become feasible not only at Barapukuria but also at Phulbari where the mining activity has been suspended by opposing inhabitants.

But, on the other hand, when the pilot mine cannot overcome kinds of technical matters and is not economical, an O/C mine is not possible. In this case, unfortunately, the conclusion is that the O/C mine may not be possible to develop at coal fields which were discovered in Bangladesh till now. All coal fields will be developed by the U/G method or will become study object for UBC or UCG.



Source: Barapukuria Coal Mining Company Ltd.

Fig 4-4 North-South Longitudinal Sectional View



Source: Barapukuria Coal Mining Company Ltd.

Fig. 4-5 Barapukuria Coal Mine Map[1]

[1] The working face specifications; the face length: 100 to 160m the footage length: approx. 600m At present, the fifth working face is mined out.
The mining equipment: 440t/frame The shearer: 375kw+132Kw, 600t/hr.
Brief history of working faces: The Chinese corporation delivered two sets. One set, delivered to LW No.1110, was once closed down after a spontaneous combustion and reopened recently. The other set mine out No.1101=>1106=>1109=>1103=>1104.

Source: PSMP Study Team

Fig. 4-6 Panoramic view of Barapukuria Coal Mine

Source: PSMP Study Team

Fig. 4-7 Vertical shaft for material and workers and skip shaft for coal hoisting on rear side

Source: PSMP Study Team

Fig. 4-8 Self-advancing support upholding the roof of working faces

4.2.3 Situations of undeveloped coal fields

(1) Phulbari coal mine development

The development history in the Phulbari coal field is a clear harbinger of the future problems awaiting coal development in Bangladesh. The Phulbari coal field development plan originated from the development of the Australian BHP from 1994 to 1997. Afterwards, however, BHP transferred its license and investment agreement to AEC[1] in 1998.

From 2004 to 2005, AEC carried out more than 100 new development borings. The results are as follows: measured reserve: 288 million tons; indicated reserve: 244million tons; inferential reserve: 40million tons; and total reserve: 572million tons. These results were announced by GHD Pty Ltd. in Melbourne. According to the new exploration results, the thickness of the coal seams in total ranges from 15 to 70m; an average thickness of all of the coal seams is 30m; the depth is 150 to 250m. The project is to produce 15 million tons of steam coal and semi-soft coal per year on average. At the same time, the project has also proposed constructing a 500MW coal-fired thermal power station in Bangladesh.

AEC submitted a feasibility study on the Phulbari coal development project to the Government of Bangladesh in October 2005. AEC also implemented and completed an Environmental Impact Assessment (EIA) and an Environmental and Social Impact Assessment (ESIA) in June 2006. According to the project, the area for open-cast mining was set to be 2,000 ha initially and 5,900 ha eventually. The project urged to finally relocate some 40,000 local people. Fig. 4-9 shows a photo of the area to exploit.

Judging from the number of borings made, on the whole, this development project’s proposal seems to be based on an adequate knowledge of the coal reserves, which was obtained through a reliable feasibility study, and in consideration of environmental control measures. Hence, it was regarded in those days as a major coal development project in Bangladesh. However, the project met with local opposition in August 2006, resulting in deaths and injuries. As a result, the development project was suspended. According to newspaper reports in those days, the major reasons for the opposition were environmental problems, eviction of the local people, and resource nationalism against development financed by foreign capital. Afterwards, although Global Coal Management succeeded to the project, the subsequent progress has been undisclosed to this very day.

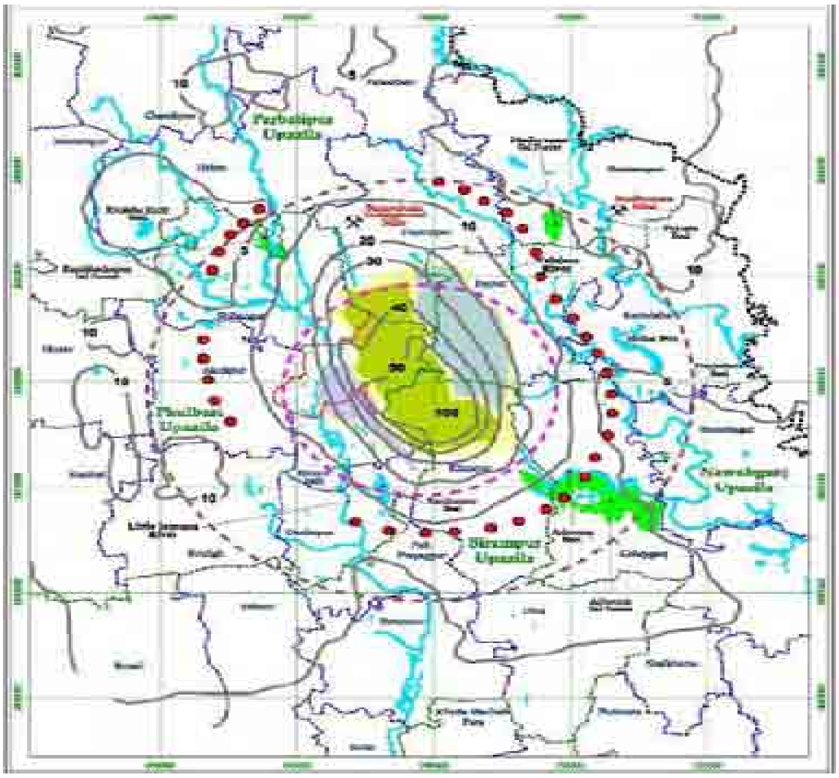
After a study of the project, it is not surprising that a large-scale open-cast development project was difficult to accept in an area where many local people had no knowledge of an open-cast coal mine. In particular, we suppose that the problem lied in the method utilized for the coal mine development approach and inadequate attention paid to the needs and feelings of the local people whose rice fields, inherited from generation to generation, could potentially be destroyed. In hindsight, it seems that the initial plan should have started with small development comprising an annual coal production of one to two million tons. It is certain that the country is endowed with an abundant coal supply that has commodity value. Hence, it is beyond question that coal development in Bangladesh is the key to solving the country’s energy problem.

Fig. 4-10 indicates a sectional diagram of drainage borings in preparation for open-cast coal development and influence lines of water level. In this figure, red dots show locations of drainage borings for the Phulbari Coal Mine development and broken lines on the outer side show the scope of influence. As indicated in the figure, the scope of influence covers quite broad areas.

[1] Asia Energy Corporation (Bangladesh) Pty Ltd

Source: PSMP Study Team

Fig. 4-9 Planned site for Phulbari open-cast coal mine development rice field stretches as far as one can see.



Source: AEC, 2005

Fig. 4-10 Proposed locations of drainage boring for Phulbari coal mine development and scope of influence

(2) Khalaspir coal field

The Hosaf Group submitted a feasibility study report to the Bureau of Minerals Development (BMD) in June 2006. The feasibility study was prepared by China Jinan Mining Development Corporation affiliated with the Hosaf Group. During the feasibility study, Geotech-India, NamNam of North Korea, Geo-Mineral of China, and IMC Group Consulting Limited, UK (IMCL) in the UK extended their cooperation in support of the study.

According to the information obtained in the second on-site survey, the target coal seams for the mining are three coal seams, namely the first, second, and fourth coal seam from the upper of the coal seams. The measured coal reserve in the mining area is 451 million tons, while the potential coal reserve is 277 million tons. After taking into account drainage cost and work time for the Upper Dupi Tila aquifer, underground mining will be adopted. To prevent inundation and to reach the coal quickly, a vertical shaft and long wall mining will be adopted. If the inclination of the coal seams is at two to three degrees as explained and if the coal seams are continuous, the mining conditions will be far superior to the mining conditions at Barapukuria.

Since the coal seams are thick, the introduction of top-caving coal mining, which is a success in China, [1]is being considered. The plan sets the annual coal production at two million tons in the first decade and four million tons thereafter. Given that the PSMP Study Team's available survey time was limited, when the PSMP Study Team visited the site, only checked the boring cores of the second coal seams and some samples of the roof. Since the samples were apparently medium coarse sandstone and its intensity was high, the caving will face difficulty and take much time.

Although seismic, prospecting was conducted, the number of development drilling was limited to 14. Hence, additional borings are necessary to acquire exact knowledge on the geological and coal seam conditions. After that, there is also the need to prepare a production plan, forecast ground subsidence, prepare control measures against ground subsidence, implement security measures, introduce diverse measures for the environment, and prepare measures for local people, and others. Thus, it will take quite a lot of time before production begins to achieve these goals. In the analysis of coal samples obtained in the new borings, gas content measurement is also needed, in addition to the analysis based on the existing method.

Source: PSMP Study Team

Fig. 4-11 Rice field in Khalaspir area planned for mining

Source: PSMP Study Team

Fig. 4-12 Hosaf's site office in Khalaspir

(3) Barapukuria open-cast development project

The Barapukuria Coal Mine, which started in underground mining, will be detailed in another section. This subsection describes an open-cast mining project. The northern area, which is

[1] The top-caving method is the mining technology adopted in long-wall mining, in which coal left on the roof that a miner cannot cut out of thick coal seams is collected from the rear of the self-advancing support, or in which coal spontaneously falling from the upper is collected. This method enables to collect coal that was regarded uncollectible in the past, and thereby improves the mining ratio.

regarded as inappropriate for underground mining because of an anticipated water burst, is the target area for open-cast mining. In this area, the Lower Dupi Tila containing much clay and forming a waterproof layer is thinner or does not exist. This is why the aforementioned development project has arisen. Since the scope of environmental impacts via open-cast mining is likely to extend to a broad range of area, utilizing open-cast mining to cover the entire mining area seems difficult.

Meanwhile, open-cast coal mine development in Bangladesh is an important subject. When the point is taken into account, as a pilot open-cast mine, the development of a part of the mining area in the Barapukuria Coal Mine is expected. Given the results, technical development will be promoted, cost estimates will be possible and a scope of the potential environmental impact and demonstration data will be obtained. Details of the pilot O/C mine are provided later.

(4) Dighipara coal field

This coal field has only undergone five exploration drillings in the past. According to a report in the newspaper, the Daily Star of December 22, 2008, all five drillings were made within a small square area of 1.25 km^2. Therefore, a top priority is to conduct additional and broader exploration drillings and seismic explorations in order to obtain accurate knowledge of the geological conditions in this area. Since these coal seams occur in relatively shallow underground, underground development seems to be a realistic approach. The aforementioned new drillings need to measure gas contents, besides conducting traditional analyses of coal samples obtained in new borings. According to Petrobangla who has exploration rights, Petrobangla has been planning to conduct a seismic survey, exploration borings, and creating F/S over a period of about two years.

Source: PSMP Study Team

Fig. 4-13 Rice field near Dighipara development borings

Source: PSMP Study Team

Fig. 4-14 Private houses near development borings

4.2.4 Production forecasts at exploiting coal field

(1) Issue of undeveloped coal fields

For coal development methods, open-cast mining and underground mining are available. Table 4-4 lists comparison by major decision factor between open-cast mining and underground mining for coal mines in Bangladesh.

(2) New coal mine development flow

To begin coal production in a short period seems impossible in light of the conditions of the undeveloped coal fields as mentioned above. More specifically, it will require going through a lot of different steps, as indicated in Fig. 4-15. Initially, the coal policy must be approved by the Government of Bangladesh as early as possible. Production forecasts based on the PSMP Study Team's site survey are described in Section 4.2.6 based on the flow shown below.

Table 4-4 Comparison between open-cast mining and underground mining

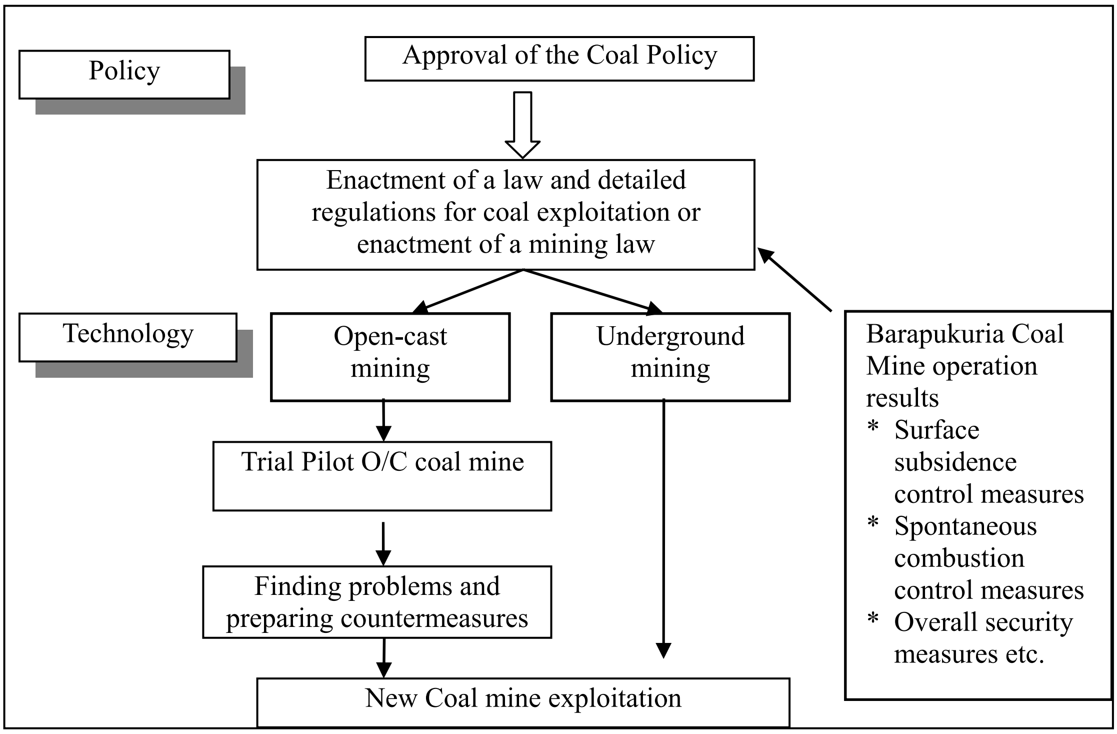
Major decision factor	Open-cast mining	Underground mining
(1) Mining cost	・It depends on the stripping ratio.[1] In general, open-cast mining is easier to adjust production volume and can produce a large volume of coal at a low mining cost. ・In Bangladesh, prior drainage drilling is required to control aquifers. Such boring and operation will cost a lot. Thus, question regarding whether the costs of open-cast mining is lower than underground mining is in the air.	・If open-cast mining cannot be adopted, or if it is unfeasible, or if it is inappropriate in terms of cost, underground mining can be adopted. However, underground mining costs more than ordinary open-cast mining. ・ The range to increase production is determined with the installation capacity of a coal production plan.
(2) Coal recovery rate	・The coal recovery rate[2] is set at approx. 90% of the minable reserve.	・The coal recovery rate is set at 20 to 40% of the minable reserve.
(3) Production stability	・Coal production will be stable.	・ Coal production will be unstable, carrying high risk due to natural conditions.
(4) Environmental control measure	・It requires site areas four times or more of the mining area for mining and dumping area for surface soil. This mining method will have impacts over a broad area. ・It is essential to secure the water sources for people in the surrounding area by prior drainage of the aquifer and to solve surface subsidence problems.	・Surface subsidence will occur and some of the local people living in the area will be requested to relocate themselves, but the area will be limited. ・Underground mining has less impact on the surface than open-cast mining.
(5) Overall assessment in Bangladesh	・To establish open-cast mining technology suitable for Bangladesh is important. To this end, small-scale open-cast mining at a pilot site must be conducted to demonstrate the technology and estimate mining cost. ・Open-cast mining is advantageous to use coal resources effectively because it enables stable coal production and a high coal recovery rate, Bangladesh is encouraged to take this technological leap.	・The Barapukuria coal mine is under demonstration of underground mining technology. To establish mining technology is needed to improve the mining rate for upper coal seams in the future. ・Underground mining is likely to precede to open-cast mining to exploit new coal mines in the future.
(6) Issues and recommendation	・The evaluation of the O/C mine by the early enforcement of pilot O/C mine plan will be mentioned later	・ An early decision of the mining method for the 2nd slice and deeper coal seam after the 2nd slice.[3] ・ Countermeasure for surface subsidence ・ The establishment of a technology transfer method

Source: PSMP Study Team

[1] Stripping ratio: A ratio of the thickness of a coal seam mined to the thickness of the soil stripped, which is expressed, for example, like 1:7.

[2] The coal recovery ratio refers to the ratio between geological coal reserves and actual minable reserves by some mining methods.

[3] A thickness of 3 to 4m is the most efficient thickness for a longwall mining method.



Source: PSMP Study Team

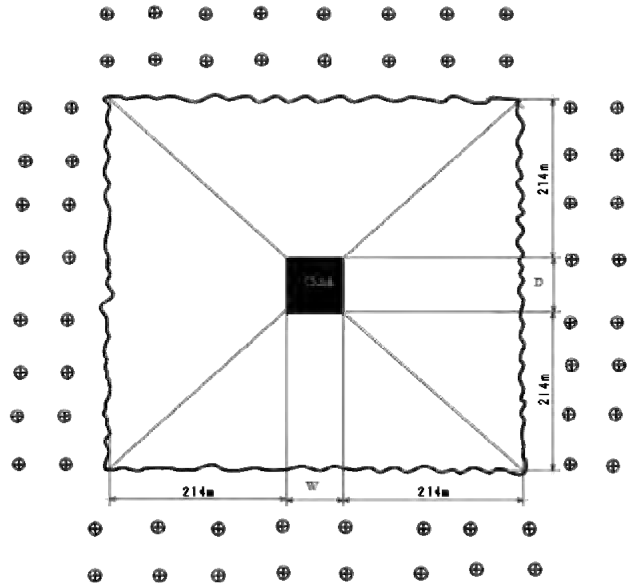
Fig. 4-15 New coal mine development flow

(3) Recommendations of pilot O/C coal mine.

The plan of pilot O/C coal mine aims to examine the possibility of the O/C mining in Bangladesh and understand to inhabitants. Since the mining method of O/C was complete new technology for Bangladesh, the main cause of canceled the development plan of Phulbari Coal Mine is considered that technical distrust, the broadness of the influence range to the inhabitants district, the issue of environmental influence including the subsurface water were big and the operation formation, and they were close-up and the agreement of inhabitants was not provided.

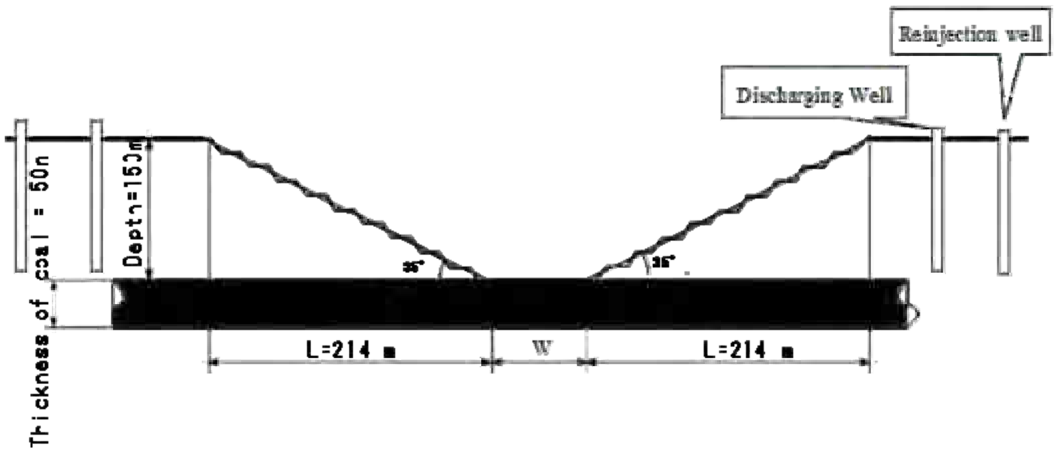
PSMP Study Team recognizes that the O/C coal mine is the most critical issue in order to secure coal resources and proposes that GOB will take the pilot O/C coal mine into effect. PSMP Study Team propose that the pilot plan of O/C mine as a trial mine should be realized and to clarify a technical problem, groundwater measures, a production cost and, besides, this method will contribute to have considerable persuasive power for the understanding of inhabitants.

The PSMP Study Team predict that the O/C mining method would not be able to but give up in Bangladesh if the evaluation of the result of the pilot coal mine should be negative. It is biggest problem that the condition of coal seam is remarkably bad for O/C mining method in Bangladesh comparing with one of many foreign countries and it is grounds of this pilot coal mine proposal. The detail of the pilot O/C coal mine is described at APPENDIX- 3. A top view is shown in figure 4 16 and a cross section to the ground plan is shown in figure 4 17 as a summary here. In addition, the Barapukuria coal mine company has started the examination toward the enforcement of the pilot O/C mining coal mine as of December, 2010.



Source: PSMP Study Team

Fig. 4-16 Top plan view



Source: PSMP Study Team

Fig. 4-17 Cross-section view

4.2.5 Gas recovery of undeveloped coal fields

(1) CBM

The USA and Australia produce natural gas (CBM: Coal Bed Methane) from coal fields where coal has not yet been mined yet. In 2001, the USA produced CBM 1.56Tcf which was 8% of the natural gas production. China also started CBM production which is increasing. Apparently, Government of the Bangladeshi feels that the Jamalgonj coal field is a good candidate for CBM production. The following facts have been extracted the scarce but available data[1].

- The Jamalgonj field was discovered in 1962 thanks to a UN-sponsored coal exploration program. 10 wells were drilled in this area and the coal seams were encountered in 9 out of the 10 wells. Coal seams gently dipped to the east and the depth range is 640m to 1,158m from the surface. There are seven coal seams and they have been named seam 1 to seam 7

[1] 1,The Arabian Journal for Science and Engineering, Volume 27, Number 1A. January 2002

from the upper to lower. The average cumulative coal seam thickness is 64m and the main seams are seams 3 and 7 because of their thickness and continuity.

- Gas content of coal (m3/ton) was not measured in this field. But it was reported that there were gas evolutions in several drill holes when the drillings penetrated coal. Methane gas percentage was unknown and cementation because of the kaolinite content
- It was discovered that there are little gas reserves and gas emissions in the U/G of the Barapukuria Coal Mine. The presumed reason is that there are many cleats in the coal seam (high permeability), high permeability rock (sand stone) and many faults. Therefore, much gas has already separated itself from the coal seams and the surrounding rock.
  On the other hand, in the Jamalgonj field it has been reported that the Gondowana sandstones (course to medium size) of which the sandwich coal seams are effectively impermeable due to high compaction and cementation because of the presence of kaolinite cement. Maybe the sandstones form seals above the gas bearing coal seams such as the caprock. So there is a possibility to recover CBM in this field.

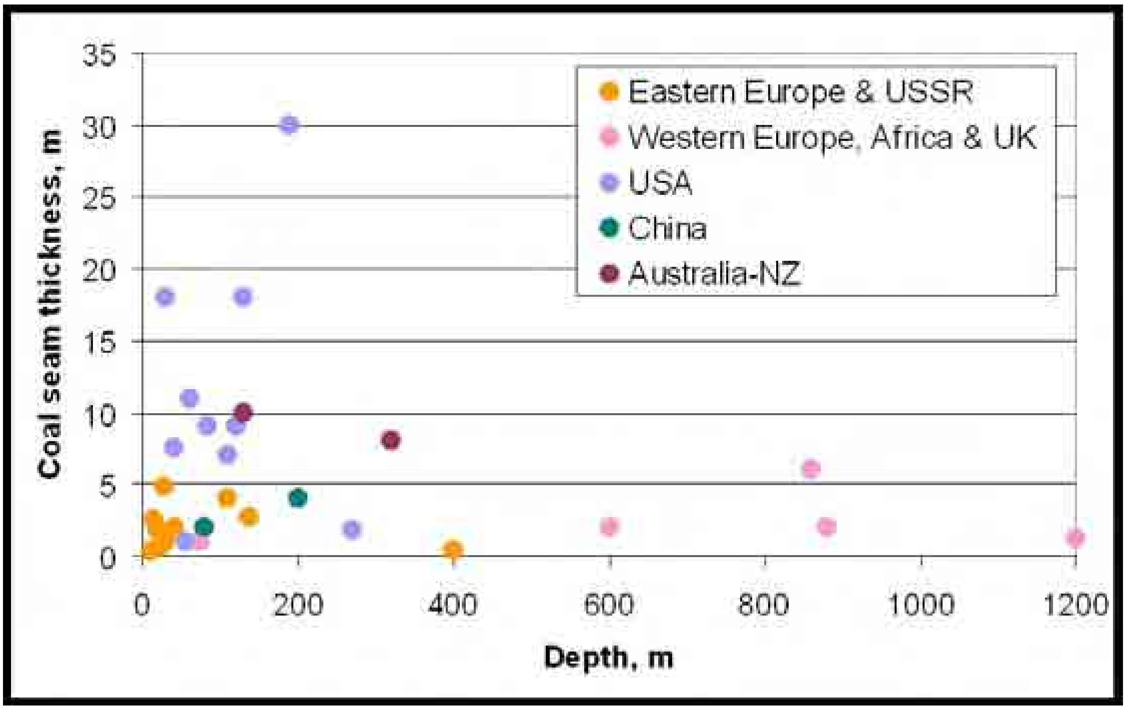
(2) UCG (Underground Coal Gasification)

The present and future situations of UCG are as follows.

- Commercial operation or near commercial operation for UCG.
  Australia, South Africa, China, Uzbekistan
  → Mainly shallow coal seams in depth, which are not proper for the environment. Use at power plants except Australia.
- Countries on the study
  India (a few trials), Canada (deep seams), USA, East Europe countries (deep seams), Vietnam (Japanese trading companies): There is great interest in this matter.
- In recent years, there have been many international conferences, but these main contents are summaries and no open data regarding near commercial operation for UCG.
  → Information related to operation process are very few due to patent problems.
- Commercial operations of UCG at the deep coal seams where it is favorable for environment problems not yet achieved especially raw gas materials.
  A verification test is necessary to prove that UCG is possible for gasification of coal economically and to produce raw material which is required for economic development. (Test at Canada)
- India: UCG is potentially suitable in the area. Energy demand is high, there are about 467 billion tons of possible coal reserves, about 66% of the reserves are in an intermediate depth from the deep part, and there are lots of non-use low grade coals which have a high ash content and low heating value. The realization of commercial UCG is accelerating.
- Via the past UCG examination, most could not run except several examples in the shallow coal seam in depth.
- During many examinations, it was finished at a stage that suggests future possibility.

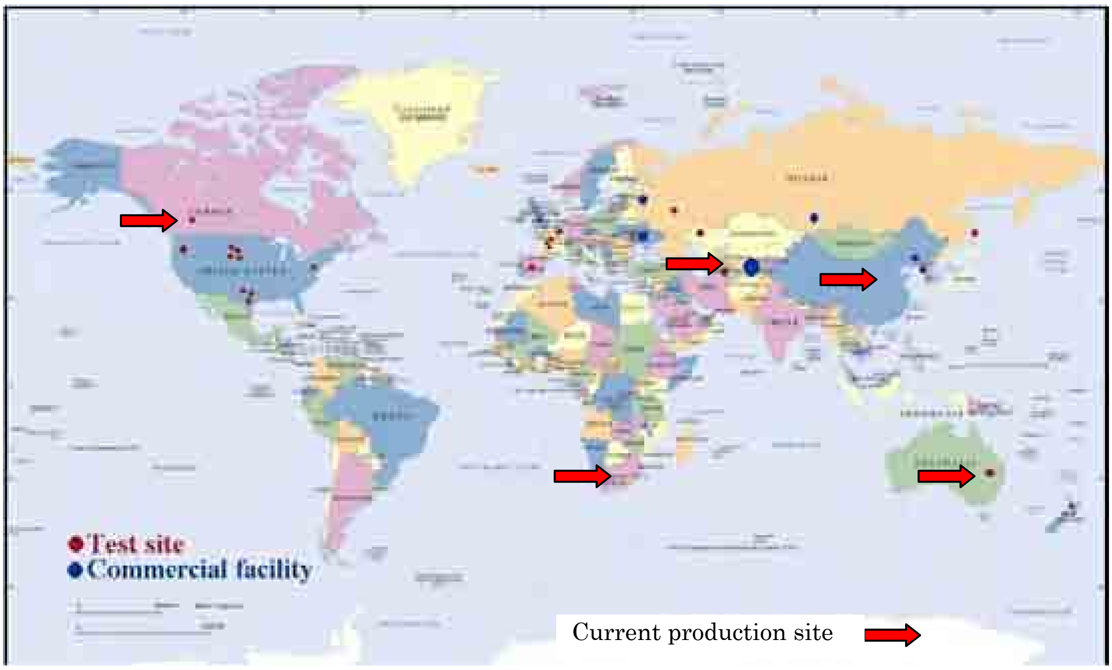
Based on the aforementioned situations, commercialization examples are expected to increase worldwide in the next 5 years, but it will take time to apply this to Bangladesh as the general technology due to problems technical know-how disclosure and the specialty of local differences. In addition, Bangladesh received suggestions towards the enforcement of finance and UGC to be accompanied from Australia for a coalfield of Jamalgonj in December, 2010, and a seminar was held. The Bangladesh side had a high interest.

As Fig. 4-18 shows, the coal seams depth where the UCG was carried out is less than 350m from the surface. Fig. 4-19 shows the current production sites. In Bangladesh as it is with CBM, wide intelligence in consideration of future adaptability of CBM may be necessary.



Source: PSMP Study Team

Fig. 4-18 The feature of coal seam for UCG



Source: PSMP Study Team

Fig. 4-19 Current operation site

4.2.6 Domestic coal supply and quality forecasts, and issues

(1) Domestic coal supply forecasts

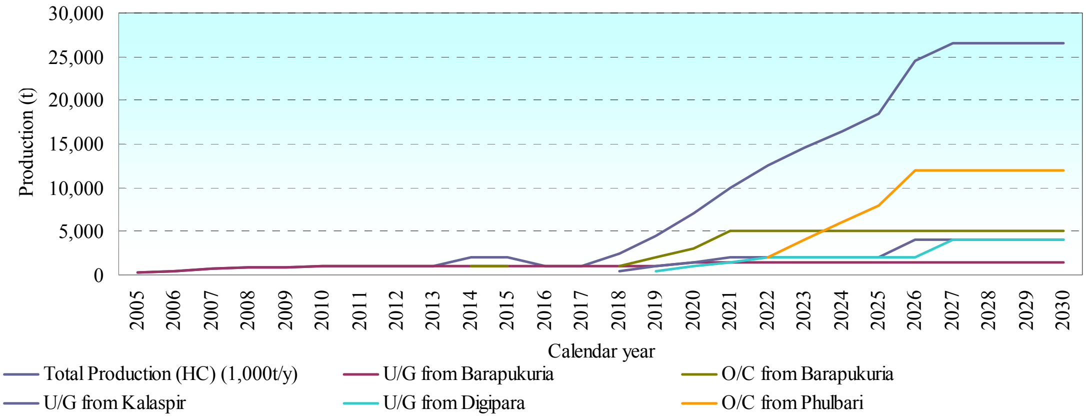
According to the forecast of domestic coal production, a high case, a base case and a low case have been prepared. Table 4-5 shows the studied contents of each case. Table 4-6 indicates the domestic coal production and forecasts the following contents in Table 4-5., Fig. 20, fig. 4-21 and Fig.4-22 shows the total annual production of the high case, the base case and the low case as a graph drawn from Table 4-6.

However EMRD commented after completion of the forecast of domestic coal supply by PSMP Study Team that upon approval of Coal Policy in the year 2011, GOB would look onward for investment for Phulbari Coal Project. Taking into consideration that after getting investment proposal and Government. approval and licenses with preparation time and consideration, production will be forecasted after preparatory work and construction period from the year 2019. Considering all the above factor, reference production figures given by EMRD are shown in a parenthesis in Fig 4-6. These numbers show positive posture for the domestic coal production of EMRD.

Table 4-5 The content of each case in Table 4-6

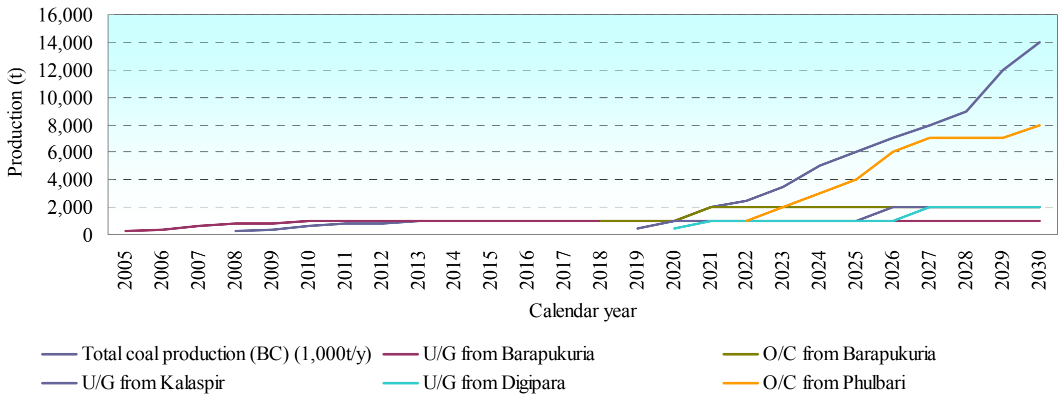
		High Case	Base Case	Low Case
U/G	BCMC	1. Successful Mining method of 2nd slice 2. Completion of new 2nd shaft and f facilities for 1.5mt production 3. Bangladesh people can manage and operation of a coal mine by successful technology transfer program	1. Successful Mining method of 2nd slice (about 50%) 2. Existing facilities are mainly used. 3. Technology transfer ratio is about 75%.	1. Pending of mining method of 2nd slice 2. Existing facilities are mainly used. 3. Technology transfer ratio is about 55%.
	New mine	1. F/S and governmental approvals are carried out on schedule and financial matters are cleared. 2. Preparation and construction works are on schedule. 3. Sufficient technical and management support	1. F/S and governmental approvals are carried out on schedule and financial matters are cleared (about 50%). 2. Preparation and construction works are on schedule. 3. Enough technical and management support	1. F/S and governmental approvals, settlement of financial matters are taking long time. 2. The delay of preparation and construction works 3. Insufficient technical and management support
O/C	New mine	1. Successful result of the pilot O/C mine at BCMC and environmental problems and the resettlement problem are solved for production expansion. 2. F/S and governmental approvals are carried out on schedule and financial matters are cleared. 3. Preparation and construction works are on schedule. 4. Successful operation	1. Some examination remains after operation of the pilot O/C mine and production was about 50%. 2. The delay of F/S and governmental approvals and production plan decrease to about 50%. 3. The delay of initial mining plan	1. The operation of the pilot O/C become difficult and mining method is shifted from O/C to U/G.

Source: PSMP Study Team



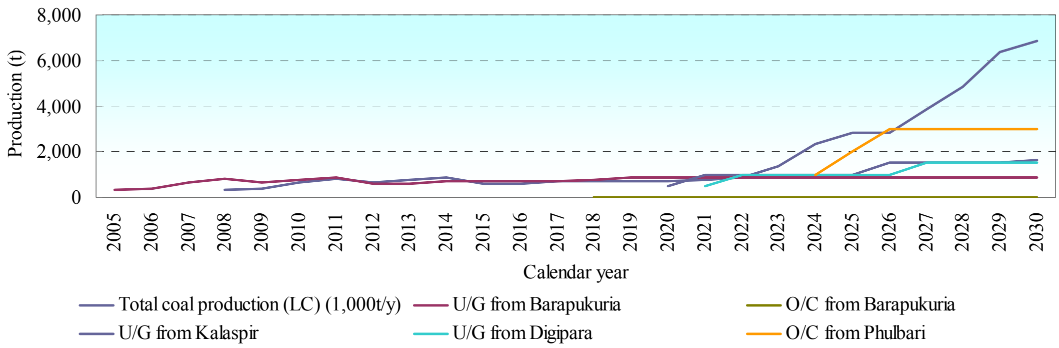
Source: PSMP Study Team

Fig. 4-20 Domestic coal production (high case)



Source: PSMP Study Team

Fig. 4-21 Domestic coal production (base case)



Source: PSMP Study Team

Fig. 4-22 Domestic coal production (low case)

Table 4-6 Forecast of domestic coal production (1,000t/y)

Year	Total coal production (HC) (1,000t/y)	Total coal production (BC) (1,000t/y)	Total coal production (LC) (1,000t/y)	Domestic Coal Mine																			
				Existing Coal Mine & New O/C							New Coal Mine (U/G & O/C)												
				Barapukuria U/G & new O/C							Khalaspir				Dighipara				Phulbari				
				U/G (HC)	U/G (BC)	U/G (LC)	O/C (HC)	O/C (BC)	O/C (LC)	Construction Schedule	U/G (HC)	U/G (BC)	U/G (LC)	Construction Schedule	U/G (HC)	U/G (BC)	U/G (LC)	Construction Schedule	O/C (HC)	O/C (BC)	O/C (LC)	U/G (L. C)	Construction Schedule
2005	303	303	303	303	303	303																	
2006	388	388	388	388	388	388																	
2007	677	677	677	677	677	677																	
2008	828	828	828	828	828	828																	
2009	850	850	640	850	850	640																	
2010	1,000	1,000	750	1,000	1,000	750																	
2011	1,000	1,000	850	1,000	1,000	850				Coal Policy in force				Coal Policy in force				Coal policy in force					
2012	1,000 (1,200)	1,000 (1,200)	600 (800)	1,000	1,000	600	(200)	(200)	(200)	F/S and Preparation				Approval and license				F/S					
2013	1,000 (1,200)	1,000 (1,200)	600 (800)	1,000	1,000	600	'(200)	(200)	(200)	F/S and Preparation				Preparation				Approval and license					
2014	2,000 (1,200)	1,000 (1,200)	700 (900)	1,000	1,000	700	1,000 '(200)	(200)	(200)	Pilot Mining				Const. (1st y)				Preparation					
2015	2,000 (3,200)	1,000 (2,200)	700 (900)	1,000	1,000	700	1,000 (200)	(200)	(200)	Pilot Mining				Const. (2nd y)				Const. (1st y)	(2,000)	(1,000)			
2016	1,000 (11,000)	1,000 (7,000)	700 (3,700)	1,000	1,000	700	(6,000)	(4,000)	(2,000)	Evaluation of O/C				Const. (3rd y)				Const. (2nd y)	(4,000)	(2,000)	(1,000)		
2017	1,000 (11,000)	1,000 (7,000)	700 (3,750)	1,000	1,000	700	(6,000)	(4,000)	(2,000)	Preparation (1st y)				Const. (4th y)				Const. (3rd y)	(4,000)	(2,000)	(1,000)		
2018	2,500 (14,000)	2,000 (8,500)	750 (4,750)	1,000	1,000	750	1,000 (6,000)	1,000 (4,000)	(2,000)		500 (1,000)	(500)						Const. (4th y)	(6,000)	(3,000)	(2,000)		Preparation (1st y)
2019	4,500 (16,500)	2,500 (9,500)	850 (4,850)	1,000	1,000	850	2,000 (6,000)	1,000 (4,000)	0 (2,000)		1,000 (1,000)	500 (500)			500				(8,000)	(4,000)	(2,000)		Preparation (2nd y)
2020	7,000 (18,000)	3,500 (10,500)	1,350 (6,850)	1,500 (1,000)	1,000	850	3,000 (6,000)	1,000 (4,000)	0 (2,000)		1,500 (2,000)	1,000 (1,000)	500 (1,000)		1,000	500	(500)		(8,000)	(4,000)	(3,000)		Const. (1st y for O/C or U/G)
2021	10,000 (22,500)	5,000 (13,000)	2,350 (7,850)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		2,000 (2,000)	1,000 (1,000)	1,000 (1,000)		1,500	1,000	500 (1,000)		(12,000)	(6,000)	(3,000)		Const. (2nd y for O/C or U/G)
2022	12,500 (24,000)	6,000 (15,000)	2,850 (7,850)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		2,000 (3,000)	1,000 (2,000)	1,000 (1,000)		2,000	1,000	1,000 (1,000)		2,000 (12,000)	1,000 (7,000)	(3,000) (3,000)		Const. (3rd y for U/G)
2023	14,500 (24,000)	7,000 (15,000)	2,850 (7,850)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		2,000 (3,000)	1,000 (2,000)	1,000 (1,000)		2,000	1,000	1,000 (1,000)		4,000 (12,000)	2,000 (7,000)	(3,000)		Const. (4th y for U/G)
2024	16,500 (24,000)	8,000 (15,000)	3,850 (7,850)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		2,000 (3,000)	1,000 (2,000)	1,000 (1,000)		2,000	1,000	1,000 (1,000)		6,000 (12,000)	3,000 (7,000)	1,000 (3,000)	500	
2025	18,500 (25,000)	9,000 (15,000)	4,850 (8,350)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		2,000 (4,000)	1,000 (2,000)	1,000 (1,000)		2,000	1,000	1,000 (1,000)		8,000 (12,000)	4,000 (7,000)	2,000 (3,000)	750	
2026	24,500 (28,000)	12,000 (15,000)	6,350 (8,350)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		4,000 (4,000)	2,000 (2,000)	1,500 (1,000)		2,000	1,000	1,000 (1,500)		12,000 (15,000)	6,000 (7,000)	3,000 (3,000)	1,000	
2027	26,500 (30,000)	14,000 (16,000)	6,850 (8,350)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		4,000 (4,000)	2,000 (2,000)	1,500 (1,000)		4,000	2,000	1,500 (1,500)		12,000 (15,000)	7,000 (7,000)	3,000 (3,000)	1,500	
2028	26,500 (30,000)	14,000 (16,500)	6,850 (8,350)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		4,000 (4,000)	2,000 (2,000)	1,500 (1,000)		4,000	2,000	1,500 (1,500)		12,000 (15,000)	7,000 (7,500)	3,000 (3,000)	1,500	
2029	26,500 (30,000)	14,000 (16,500)	6,850 (8,350)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		4,000 (4,000)	2,000 (2,000)	1,500 (1,000)		4,000	2,000	1,500 (1,500)		12,000 (15,000)	7,000 (7,500)	3,000 (3,000)	1,500	
2030	26,500 (30,000)	15,000 (16,500)	7,000 (8,500)	1,500 (1,000)	1,000	850	5,000 (6,000)	2,000 (4,000)	0 (2,000)		4,000 (4,000)	2,000 (2,000)	1,650 (1,150)		4,000	2,000	1,500 (1,500)		12,000 (15,000)	8,000 (7,500)	3,000 (3,000)	1,500	

Remarks: The figures in a parenthesis show reference figures given by EMRD.

Source: PSMP Study Team

(2) Quality of domestic coal

Table 4-7 and Table 4-8 show analytical value of Barapukuria and Khalaspir coal. These mines have more than one coal seam. In the Barapukuria Coal Mine, mining is underway at the sixth coal seam. Table 4-9 shows analysis result of Barapukuria coal by Japanese laboratory. According to these analysis data, Barapukuria coal will be good coal for thermal power plant due to high melting temperature, low sulfur and low ash content.

Table 4-7 Analytical values of Barapukuria coal

Coal seam	Specific gravity	Inherent moisture	Volatile matter content	Ash content	Total sulfur content	Fixed carbon	Fuel ratio [1]	Calorific value CV	Average seam thickness	Depth
	SG	IM(%)	VM(%)	Ash(%)	TS(%)	FC(%)		(kcal/kg)	(m)	(M)
I	1.39	3.5	31.7	19.2	1.33	45.5	1.44	5,859	1.8	130 - 194
II	1.39	3.5	29.6	16.6	0.50	50.6	1.71	6,696	10.9	132 - 253
III	1.57	3.6	29.2	12.6	0.62	54.7	1.87	6,811	1.5	142 -277
IV	1.38	3.0	30.8	16.3	0.52	48.7	1.58	6,833	1.3	159 -306
V	1.46	2.5	28.7	23.7	0.43	44.9	1.56	6,087	8.8	162 - 326
VI	1.37	2.3	31.4	11.8	0.65	53.4	1.70	7,087	36.2	170 -450
VII	1.43	2.7	28.7	15.3	0.77	53.4	1.86	6,960	1.6	204 - 492

Source: GSB

Table 4-8 Analytical values of Khalaspir coal

Coal seam	Inherent moisture	Volatile matter content	Ash content	Total sulfur content	Fixed carbon	Fuel ratio	Calorific value CV	Average seam thickness	Depth
	IM(%)	VM(%)	Ash(%)	TS(%)	FC(%)		(kcal/kg)	(m)	(M)
I	2.6	21.8	18.0	0.84	57.5	2.64	6,529	2.5	162-159
II	2.3	17.4	18.4	0.96	60.5	3.48	6,391	12.0	162-253
III	1.3	40.4	24.9	0.69	51.3	1.27	5,990	1.8	172-277
IV	1.4	24.0	17.5	0.90	57.0	2.38	6,531	1.9	189-306
V	0.8	22.7	26.8	0.74	49.8	2.19	5,958	9.2	198-326
VI	0.6	23.5	27.3	0.65	48.6	2.07	5,797	37.7	170-450
VII	0.5	25.3	19.9	0.87	54.3	2.15	6,433	1.9	204-492
VIII	0.7	23.8	21.6	0.51	54.0	2.27	6,257		

Source: GSB

[1] Fuel ratio: Ratio of fixed carbon/volatile matter content. The ratio is used for a combustion performance assessment index. Ordinary combustion performance range is 1.5< fuel ratio ≤2.5.
A large ratio indicates inferior combustion performance, whereas a small ratio indicates better combustion performance.

Table 4-9 Analytical values of Barapukuria coal by Japanese laboratory

[Proximate analysis] by JIS M.8812		No.1 Barapukuria coal (Seam VI) As Received Base (ar)	No.1 Air Dry Base (ad)	No.1 Dry Base (db)	No.1 Dry Ash Free base (daf)	No.2 Barapukuria coal (1) As Received Base (ar)	No.2 Air Dry Base (ad)	No.2 Dry Base (db)	No.2 Dry Ash Free base (daf)	No.3 Barapukuria coal (2) As Received Base (ar)	No.3 Air Dry Base (ad)	No.3 Dry Base (db)	No.3 Dry Ash Free base (daf)	No.4 Barapukuria coal (3) As Received Base (ar)	No.4 Air Dry Base (ad)	No.4 Dry Base (db)	No.4 Dry Ash Free base (daf)	No.5 Barapukuria coal (4) As Received Base (ar)	No.5 Air Dry Base (ad)	No.5 Dry Base (db)	No.5 Dry Ash Free base (daf)
Moisture	(%)		2.3				11.3				9.5				10.4				9.1		
Ash	(%)		11.9	12.2			11.7	13.2			11.4	12.6			12.3	13.7			11.5	12.6	
Volatile Matter	(%)		31.7	32.5	37.0		29.3	33.0	38.0		29.6	32.7	37.4		29.2	32.6	37.8		31.4	34.5	39.5
Fixed Carbon	(%)		54.0	55.3	63.0		47.7	53.8	62.0		49.5	54.7	62.6		48.1	53.7	62.2		48.1	52.9	60.5
Total	(%)	0.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0

[Ultimate analysis] By JIS M 8813	No.2	No.2	No.3	No.3	No.4	No.4	No.5	No.5
Ash	13.2		12.6		13.7		12.6	
Carbon	73.3	84.4	73.2	83.8	72.9	84.5	73.5	84.1
Hydogen	4.85	5.59	4.84	5.54	4.82	5.59	4.86	5.56
Nitrogen	1.54	1.77	1.54	1.76	1.58	1.83	1.57	1.80
T. Sulphur	(0.61)		(0.68)		(0.57)		(0.57)	
Sulphur in Ash	(0.10)		(0.08)		(0.08)		(0.08)	
Sulphur	0.51	0.59	0.60	0.69	0.49	0.57	0.49	0.56
Chlprine	0.058	0.07	0.057	0.07	0.054	0.06	0.056	0.06
Oxygen	6.51	7.50	7.15	8.18	6.44	7.46	6.91	7.91
Total (%)	100.0	100.0	100.0	100.0	100.0	100	100.0	100

[Ash Analysis Report] By JIS M 8815	No.2	No.3	No.4	No.5
SiO_2	53.1	50.8	59.0	57.4
Fe_2O_3	4.39	4.58	3.96	3.33
Al_2O_3	33.8	36.2	30.4	32.6
CaO	1.45	1.27	1.05	1.25
SO_3	1.06	0.24	0.27	0.26
P_2O_5	0.95	4.04	0.72	0.75
MnO	0.01	0.11	0.01	0.03
TiO_2	2.30	0.37	1.91	1.77
V_2O_5	0.11	0.11	0.06	0.11
Na_2O	0.01	0.21	0.12	0.01
K_2O	0.83	0.68	0.70	0.99
Total (%)	98.01	98.6	98.2	98.5

[Ash Fusibility Report] By JIS M 8801	No.2	No.3	No.4	No.5
Deformation T(Oxidizing)	≧1,600	≧1,600	≧1,600	≧1,600
Hemisphere T(Oxidizing)	≧1,600	≧1,600	≧1,600	≧1,600
Flow Temperature	≧1,600	≧1,600	≧1,600	≧1,600
Deformation T(Reducing)	1,590	≧1,600	≧1,600	≧1,600
Hemisphere T(Reducing)	≧1,600	≧1,600	≧1,600	≧1,600
Flow Temperature	≧1,600	≧1,600	≧1,600	≧1,600

[Heating Value]			No.2	No.3	No.4	No.5
By JIS M 8814		(kJ/kg)	30,160	30,120	29,150	30,070
	(HHV)	(kcal/kg)	7,200	7,190	6,960	7,180

[HGI] By JIS M 8801 7	No.2	No.3	No.4	No.5
HGI	51.2	51.1	50.4	50.7

Source: PSMP Study Team

4.3 Current situations and issues of supply and demand of import coal

4.3.1 Present situations of overseas coal

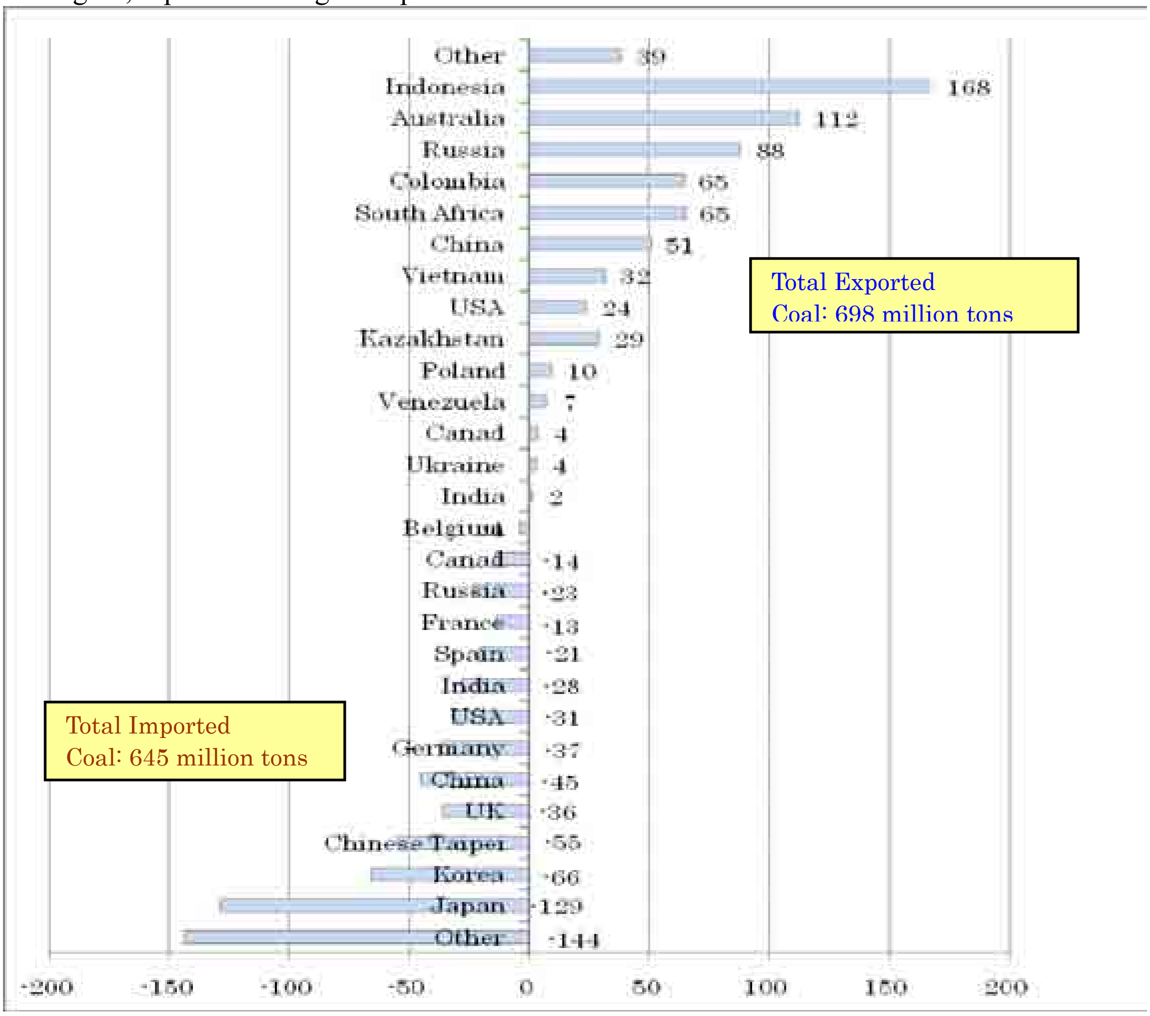
(1) Coal resource

Compared with other fossil fuels, coal possesses an indirect environmental disadvantage in that it produces more CO_2 during combustion. On the other hand, coal has a number of economic advantages. Coal supply is stable owing to low uneven distributions in the world and coal is inexpensive in terms of unit calorific value in Fig. 4-28.

North America and Europe account for more than a half of the minable coal reserves in the world, followed by Asia. A minable period is obtained after the reserve (R) is divided by the production volume (P). According to the calculation formula, oil has 41 to 42 minable years; natural gas, 60 to 67 minable years. On the contrary, coal had 122 minable years (R/P) at the end of 2008.

(2) Present situations of coal supply and demand

Fig. 4-23 shows volumes of thermal coal that are imported and exported in the world. According to the figure, Japan is the largest importer of thermal coal in the world.



Source: IEA Coal Information 2009

Fig. 4-23 2007 Thermal coal imports and exports by nation

(3) Forecast of coal supply and demand

Demand for coal is expected to increase in China, India, and other Asia-Pacific regions in the medium- and long-terms. While natural resources nationalism has been emerging in coal producing countries in recent years, coal prices remain stable at a low level. This trend may discourage new investment in resource exploration and capital investment, limiting the number of entries of new coal suppliers and the expansion of supply capacity potential. This may lead to an unstable balance of coal supply and demand in the future.

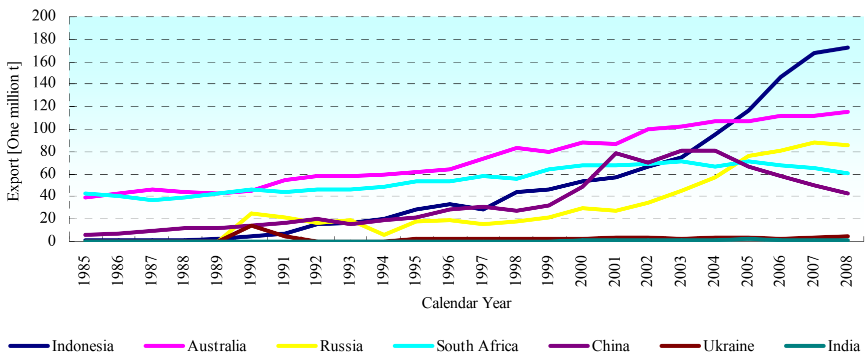
The forecast of coal supply and demand by World Energy Outlook 2009 of IEA. the issue is what situations are likely to occur if Bangladesh is going to import thermal coal from overseas, especially in terms of price and quality. Especially the increase of coal demand of China & India is big and China will be forecasted as a coal imported country.

Above is explaining the difficulty for fresh procurement of high heating value coal which is generally traded between developed countries and contracted by a long term condition, and the possibility of import low heating value coal which is possible to be procured by developing such as Bangladesh is studied below.

(4) Present situation of coal producing countries

Fig. 4-24 illustrates changes in coal exports by the major coal-producing countries that could export to Bangladesh when the transport distance is taken into account. A nation's coal export capacity depends on the reserve volume and the infrastructure including port facilities. This subsection describes the present situations in Indonesia, Australia, China, India, and South Africa. It also refers to the United States only for reference because it possesses the largest coal reserve in the world.

The issue is what import situation will be forecasted when Bangladesh begins to import thermal coal from overseas. Critical issues will be quality and coal prices. These will be discussed in a later section.



Source: IEA Coal Information (2009 Edition)

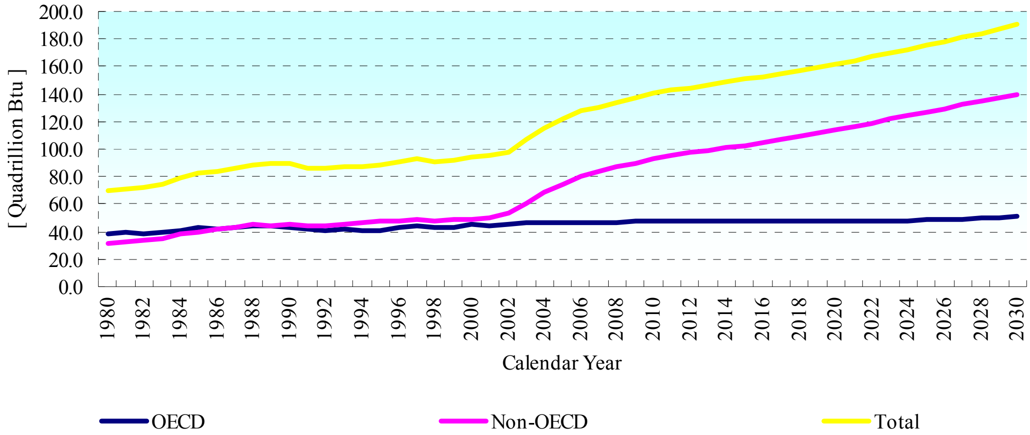
Fig. 4-24 Export volumes of coal from major producing countries that Bangladesh could import

4.3.2 The coal supply and quality of import coal to Bangladesh

(1) Forecasting import coal supply

Fig. 4-25 shows world coal consumption trend as tracked by EIA. From this, it is apparent that coal consumption has been escalating from 2002. Although it will be very difficult to estimate how much coal Bangladesh will be able to import in the future, in terms of the coal quality, coal price and concession issue, it will be possible for Bangladesh to import 20 to 30 million tons of coal in

2030 from the viewpoint of the production capacity in India, Indonesia, Australia and Africa and down-grading the coal specification (heating value) comparing to the present coal specification.



Source: Fig. 42 in International Energy Outlook 2009

Fig. 4-25 World coal consumption by country grouping

(2) Quality of imported coal imported possibly by Bangladesh

(a) Indian coal

Coal import from neighboring India is expected due to geographical conditions. However, from the results of the study, it has become clear that increasing coal imports from 1.5mt - 3.0mt from India at present is generally difficult due to a surge in domestic demand, even if possible at the spot market.

Table 4-10 shows the specifications of the Indian coals which were used at brick factories in Bangladesh. These are supposedly tertiary coals from Meghalaya coal fields in the Eastern part of India because of high sulfur content, and relatively high ash content.

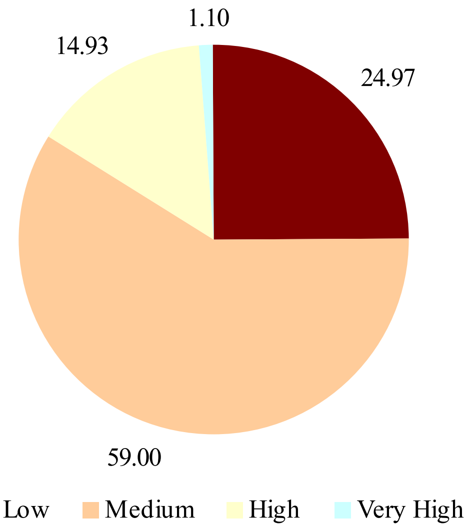
(b) Indonesian coal

At present, it seems difficult that Bangladesh such as a new intended purchaser imports Indonesian coal of high calorific value, like Australian coal. For coal of low calorific value, Adaro coal is known well. In reality, Indonesia has concluded agreements with existing customers to deliver such coal and has no extra capacity to export to new intended purchasers. For example, a new coal mine located in the Province of Jambi in Sumatra produces dry-ash-free coal that ranges 5,800 to 6,000kcal/kg. According to JORK, the measured coal reserve is 200 million tons or more, and the stripping ratio is less than two. The land transportation distance is about 200km. The coal mine could produce a fairly good amount of coal. Hence, to import such coal to Bangladesh is more feasible than to import Australian coal.

Fig. 4-26 shows coal calorific value and 83% of total coal resources is under 6,100kcal/kg and the proven reserve is 4Bt and a probable reserve is 16Bt. As the calorific value of present commercial coal for export is about 5,500kcal/kg, it will be clear that coal having low calorific such as about 5,000kcal/kg is abandon in Indonesia.

There are two kinds of coal referred generally to Low calorific coal and Low rank coal. They are distinguished the coal having high ash and low moisture, called sub bituminous coal and the coal having low ash with high moisture, called lignite coal. The coal quality should be taken care of for using these coals in a coal power plant as the lignite coal is easily to spontaneously combust during stoking at pile or transporting by a ship.

Coal quality as reference shows Table 4-11



Quality	CV	Resources (mt)						Reserves (mt)	
	(kcal/kg)	Hypothetic	Inferred	Indicated	Measured	Total	(%)	Probable	Proven
Low	<5,100	5,057.38	6,579.48	3,651.78	5,750.16	21,038.80	24.97	4,292.15	1,105.40
Medium	5,100-6,100	16,925.13	22,104.38	9,041.44	10,866.96	58,937.91	59.00	8,213.53	2,971.35
High	6.100-7,100	1,560.00	6,031.13	962.56	3,870.47	12,424.16	14.93	670.79	1,275.86
Very High	>7,100	90.11	482.93	5.80	422.81	1,001.65	1.10	73.29	109.18
Total		23,632.62	35,197.92	13,661.58	20,910.40	93,402.52	100.00	13,249.76	5,461.79

Source : Directorate General Mineral, Coal and Geothermal, 2007, Indonesia

Fig. 4-26 Coal resources every calorific value

(c) Australian coal

Both Queensland (QLD) and New South Wales (NSW) mostly trade with fixed customers. At present, among their associated coal mines, no coal mine is going to increase coal of high grade and boost sales. It will be unlikely to sell such high grade coal to new purchasers. However, currently projected new coal mines may sell coal of low Hardgrave Grindability Index (HGI) that has crashing trouble and coal of rather low calorific value. For reference, Table 4-11 list grades of coal.

(3) Forecast of coal quality of import coal

In general it is predicted that planed power stations in Bangladesh will use blended import coals. It is difficult to estimate the blend ratio of many kinds of coals. Based on the specifications of Table 4-9 (Barapukuria Coal), Table 4-10 (Indian Coal), Table 4-11 (Indonesian and Australian Coals), Table 4-12 shows a comparison between Barapukuria Coal and import coals. The colored cells show the problem figures utilized for power generation coal.

Table 4-13 shows specification summary of import coal and Table 4-14 shows average specification of the import coals. It appears that most of the coal will be imported from Indonesia, Africa and Australia. Referential data for the importable coal with high ash content and low heating value to Bangladesh are not much, so here coal mixed with Indonesian and Australian coal forecasted in the near future was used as data to assume coal specifications, using one specification of Australian coal and four specifications of Indonesian coal in Table 4-13. And Table 4-14

Average coal specification based on import coal ratio shows average coal specification based on import coal ratio.

Table 4-10 Specifications of import coal using at brick factories in Bangladesh

[Proximate analysis] by JIS M.8812		No.6 Import coal (1) Sampled at a brick manufacturer (Indian coal)				No.7 Import coal (2) Sampled at a brick manufacturer (Indian coal)				No.8 Import coal (3) Sampled at a brick manufacturer (Indian coal)			
		As Received Base (ar)	Air Dry Base (ad)	Dry Base (db)	Dry Ash Free base (daf)	As Received Base (ar)	Air Dry Base (ad)	Dry Base (db)	Dry Ash Free base (daf)	As Received Base (ar)	Air Dry Base (ad)	Dry Base (db)	Dry Ash Free base (daf)
Moisture	(%)		3.9				4.3				3.8		
Ash	(%)		24.8	25.8			24.1	25.2			25.5	26.5	
Volatile Matter	(%)		35.7	37.1	50.0		35.9	37.5	50.1		39.5	41.1	55.9
Fixed Carbon	(%)		35.7	37.1	50.0		35.7	37.3	49.9		31.2	32.4	44.1
Total	(%)	0.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0

[Ultimate analysis] By JIS M 8813	No.6	(db)	(daf)	No.7	(db)	(daf)	No.8	(db)	(daf)
	Ash	25.8		Ash	25.2		Ash	26.5	
	Carbon	58.7	79.0	Carbon	59.5	79.5	Carbon	47.2	64.2
	Hydogen	4.52	6.1	Hydogen	4.62	6.2	Hydogen	4.18	5.7
	Nitrogen	0.79	1.1	Nitrogen	0.77	1.0	Nitrogen	0.69	0.9
	T. Sulphur	(3.57)		T. Sulphur	(3.84)		T. Sulphur	(6.33)	
	Sulphur in Ash	(0.22)		Sulphur in Ash	(0.24)		Sulphur in Ash	(0.22)	
	Sulphur	3.55	4.8	Sulphur	3.64	4.9	Sulphur	6.11	8.3
	Chlorine	0.006	0.0	Chlorine	0.006	0.0	Chlorine	0.004	0.0
	Oxygen	6.68	9.0	Oxygen	6.23	8.3	Oxygen	15.30	20.8
	Total (%)	100.0	100.0	Total (%)	100.0	100.0	Total (%)	100.0	100.0

[Ash Analysis Report] By JIS M 8815	No.6		No.7		No.8	
	SiO_2	41.6	SiO_2	43.3	SiO_2	30.8
	Fe_2O_3	28.1	Fe_2O_3	22.2	Fe_2O_3	46.3
	Al_2O_3	24.9	Al_2O_3	28.1	Al_2O_3	18.2
	CaO	0.65	CaO	0.67	CaO	0.5
	SO_3	0.74	SO_3	0.73	SO_3	0.51
	P_2O_5	0.01	P_2O_5	0.01	P_2O_5	0.01
	MnO	0.01	MnO	0.01	MnO	0.01
	TiO_2	1.42	TiO_2	1.47	TiO_2	1.06
	V_2O_5	0.04	V_2O_5	0.09	V_2O_5	0.04
	Na_2O	0.41	Na_2O	0.19	Na_2O	0.22
	K_2O	0.36	K_2O	0.34	K_2O	0.27
	Total (%)	98.24	Total (%)	97.1	Total (%)	97.9

[Ash Fusibility Report] By JIS M 8801	No.6		No.7		No.8	
	Deformation T(Oxidizing)	1,475	Deformation T(Oxidizing)	1,465	Deformation T(Oxidizing)	1,445
	Hemisphere T(Oxidizing)	1,535	Hemisphere T(Oxidizing)	1,510	Hemisphere T(Oxidizing)	1,520
	Flow Temperature (Oxidizing)	1,545	Flow Temperature	1,515	Flow Temperature	1,525
	Deformation T(Reducing)	1,415	Deformation T(Reducing)	1,310	Deformation T(Reducing)	1,365
	Hemisphere T(Reducing)	1,470	Hemisphere T(Reducing)	1,375	Hemisphere T(Reducing)	1,435
	Flow Temperature (Reducing)	1,500	Flow Temperature	1,410	Flow Temperature	1,460

[Heating Value]	No.6			No.7			No.8		
	By JIS M 8814	(kJ/kg)	24,210	By JIS M 8814	(kJ/kg)	22,380	By JIS M 8814	(kJ/kg)	18,960
	(HHV)	(kcal/kg)	5,781	(HHV)	(kcal/kg)	5,344	(HHV)	(kcal/kg)	4,528

[HGI] By JIS M 8801 7	No.6	No.7	No.8
	52.9	52.3	52.4

Source: PSMP Study Team

Table 4-11 Specification examples of importable coals from Indonesia and Australia use in Bangladesh

		No.9				No.10				No.11				No.12			
		Import coal				Import coal				Import coal				Import coal			
		Indonesian Coal (1)				Indonesian Coal (2)				Australian Coal (1)				Australian Coal (2)			
[Proximate analysis] by ISO		As Received Base (ar)	Air Dry Base (ad)	Dry Base (db)	Dry Ash Free base (daf)	As Received Base (ar)	Air Dry Base (ad)	Dry Base (db)	Dry Ash Free base (daf)	As Received Base (ar)	Air Dry Base (ad)	Dry Base (db)	Dry Ash Free base (daf)	As Received Base (ar)	Air Dry Base (ad)	Dry Base (db)	Dry Ash Free base (daf)
Moisture	(%)	25.0	18.0			23.5	18.0			14.0	9.0			18.5	9.0		
Ash	(%)	4.1	4.5	5.5		2.8	3.0			9.9	10.5	11.5		7.2	8.0	8.8	
Volatile Matter	(%)	34.8	38.0	46.3	49.0	35.5	38.0			39.2	41.5	45.6	51.5	28.2	31.5	34.6	38.0
Fixed Carbon	(%)	36.1	39.5	48.2	51.0	38.3	41.0			36.9	39.0	42.9	48.4	46.1	51.5	56.6	62.1
Total	(%)	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
[Ultimate analysis] by ISO		Ash		5.5		Ash		3.00		Ash		11.5		Ash		8.8	
		Carbon		70.4	74.5	Carbon		73.33	75.6	Carbon		67.97	76.8	Carbon		73.20	80.20
		Hydrogen		4.19	4.4	Hydrogen		5.24	5.40	Hydrogen		5.13	5.80	Hydrogen		4.50	5.00
		Nitrogen		1.42	1.5	Nitrogen		1.46	1.51	Nitrogen		0.89	1.00	Nitrogen		2.00	2.20
		T. Sulphur		1.13	1.2	T. Sulphu 0.25(adb)				T. Sulphur		0.35	0.40	T. Sulphur		0.70	0.70
		Sulphur in Ash				Sulphur in Ash				Sulphur in Ash				Sulphur in Ash			
		Sulphur				Sulphur		0.19	0.20	Sulphur				Sulphur			
		Chlorine		0.006	0.0	Chlorine 0.01(adb)				Chlorine				Chlorine			
		Oxygen		17.39	18.4	Oxygen		16.78	17.30	Oxygen		14.16	16.00	Oxygen		10.80	11.90
		Total (%)		100.0	100.0	Total (%)		100.0	100.0	Total (%)		100.0	100.0	Total (%)		100.0	100.00
[Ash Analysis Report] by ISO		SiO_2		24.67		SiO_2		36		SiO_2		47.1		SiO_2		54.0	
		Fe_2O_3		11.89		Fe_2O_3		14.8		Fe_2O_3		3.40		Fe_2O_3		13	
		Al_2O_3		14.26		Al_2O_3		13.9		Al_2O_3		27.3		Al_2O_3		22	
		CaO		13.59		CaO		12.7		CaO		7.78		CaO		3.9	
		SO_3		20.34		SO_3		10.6		SO_3		5.37		SO_3		1.4	
		P_2O_5		0.52		P_2O_5		0.2		P_2O_5		0.08		P_2O_5		1.1	
		MnO				MnO				MnO		3.35		MnO			
		MgO		4.89		MgO		8.6		MgO		2.27		MgO		1.8	
		TiO_2		0.72		TiO_2		0.80		TiO_2		1.45		TiO_2		0.9	
		V_2O_5		0.52		V_2O_5				V_2O_5		0.443		V_2O_5			
		Na_2O		7.2		Na_2O				Na_2O		2.25		Na_2O		0.9	
		K_2O		1.76		K_2O		1.7		K_2O		0.66		K_2O		0.60	
		Total (%)		100.36		Total (%)		99.3		Total (%)		101.5		Total (%)		99.6	
[Ash Fusibility Report] by ISO		Initial Deformation (RA)			1,050	Initial Deformation (RA)			1,150	Initial Deformation (RA)			1,260	Initial Deformation (RA)			1,170
		Sphere(Softening Temp)(RA)			1,100	Sphere(Softening Temp)(RA)			1,180	Sphere(Softening Temp)(RA)			1,330	Sphere(Softening Temp)(RA)			1,210
		Hemisphere T(RA)			1,125	Hemisphere T(RA)			1,200	Hemisphere T(RA)			1,340	Hemisphere T(RA)			1,260
		Flow Temperature (RA)			1,150	Flow Temperature (RA)			1,230	Flow Temperature (RA)			1,370	Flow Temperature (RA)			1,300
[Heating Value] by ISO		Gross air dried	(kJ/kg)		23,032	Gross air dried	(kJ/kg)			Gross air dried	(kJ/kg)		25,921	Gross air dried	(kJ/kg)		
			(kcal/kg)		5,500		(kcal/kg)		5,750		(kcal/kg)		6,190		(kcal/kg)		6,400
		Gross as received	(kJ/kg)		20,938	Gross as received	(kJ/kg)			Gross as received	(kJ/kg)		24,497	Gross as received	(kJ/kg)		
			(kcal/kg)		5,000		(kcal/kg)		5,350		(kcal/kg)		5,850		(kcal/kg)		5,760
[HGI] by ASTM					47				42			35-36				53	

Source: PSMP Study Team

Table 4-12 Comparison of Barapukuria coal and import coal

		Barapukuria Coal	Indian Coal (B) (Meghalaya)	Indonesian Coal	Australian Coal
Proximate Analysis	Moisture (%)	9.1～11.3	3.8～3.9	18	9
	Ash(%)	11.4～12.3	24.1～25.5	3.0～4.5	8.0～10.5
	Volatile matter(%)	29.2～31.4	35.7～39.5	38	31.5～41.5
	Fixed Carbon(%)	47.7～49.5	31.2～37.3	39.5～41.0	39.0～51.5
Ultimate Analysis	Nitrogen	1.54～1.58	0.69～0.77	1.42～1.46	0.89～2.00
	Total Sulphur	0.57～0.61	3.57～6.33	1.13	0.35～0.70
Ash Fusibility	Softening point	≧1,600	1,445～1,475	1,050～1,150	1.170～1.260
	Melting point of ash	≧1,600	1,515～1.545	1,100～1,180	1.210～1.330
Calorific Value (HHV)		6,960～7,200	4.528～5.781	5,500～5,750	6.190～6.400
HGI		50.4～51.2	52.3～52.9	42～47	35-36、 53
Fuel ratio (Fixed Carbon / VM)		1.51	0.87～0.94	1.04～1.07	1.23～1.24
Coal		Bituminous Coal	Sub-bituminous coal	Sub-bituminous coal	Bituminous Coal

Source: PSMP Study Team

Table 4-13 Specification Summary of import coal

		Australian Coal (A)	Indonesian Coal (B)	Indonesian Coal (C)	Indonesian Coal (D)	Indonesian Coal (E)	Standard deviation (σ)	Blending
Blending Ratio (%)		15	25	25	25	10		100
Moisture (Ar. %)		18.5	35.0	22.4	15.0	50.0	14.3	25.9
[Proximate analysis]	Moisture	9.0	21.5	14.3	22.0	15.0	5.4	17.3
(%)	Ash	13.0	6.5	10.0	6.5	8.0	2.8	8.5
	Volatile Matter	31.5	38.0	39.5	38.1	45.7	5.1	38.2
	Fixed Carbon	46.5	34.0	36.2	33.4	31.3	6.0	36.0
[Ultimate analysis]	Carbon	76.5	72.3	76.2			2.4	74.8
(%)	Hydrogen	5.8	4.9	5.5			0.5	5.3
	Nitrogen	1.0	1.0	1.2			0.1	1.1
	T. Sulphur	0.8	0.7	1.1	1.2	0.5	0.3	0.9
	Oxygen	16.0	21.1	16.0			2.9	18.0
[Ash Fusibility Report]	Initial Deformation	1260	1190	1,220			35.1	1,218
(Oxidizing,℃)	Sphere(Softening Temp)	1330	1210	1,240			62.4	1,249
	Hemisphere T	1340	1210	1,280			65.1	1,267
	Flow Temperature	1370	1240	1,300	1,100		114.7	1,312
[Heating Value]	Gross air dried(HHV、kcal/kg)	5,300	5,000	5,300	4,800	5,000	216.8	5,070
HGI		44.3	60.0	50.0	50.0	75.0	12.1	54.1
Fuel ratio: Fixed Carbon/Volatile Matter		1.5	0.9	0.9	0.9	0.7	0.3	0.9

Source: PSMP Study Team

Table 4-14 Average coal specification based on import coal ratio

Blending Ratio (%)		(Australian A: Indonesian B: Indonesian C: Indonesian D: Indonesian E =15%:25%:25%:25:10%)	
		Average	Fluctuation
Moisture (Ar. %)		25.9	25.9 ± 14.3
[Proximate analysis]	Moisture	17.3	17.3 ± 5.4
(%)	Ash	8.5	8.4 ± 2.8
	Volatile Matter	38.2	38.2 ± 3.6
	Fixed Carbon	36.0	36.0 ± 6.0
[Ultimate analysis]	Carbon	74.8	74.8 ± 2.4
(%)	Hydrogen	5.3	5.3 ± 0.5
	Nitrogen	1.1	1.1 ± 0.1
	T. Sulphur	0.9	0.9 ± 0.3
	Oxygen	18.0	18 ± 2.9
[Ash Fusibility Report]	Initial Deformation	1,218	1218 ± 35.1
(Oxidizing,℃)	Sphere(Softening Temp)	1,249	1249 ± 62.4
	Hemisphere T	1,267	1,262 ± 65.1
	Flow Temperature	1,312	1,312 ± 114.7
[Heating Value]	Gross air dried(HHV, kcal/kg)	5,070	5,070 ± 216
HGI		54.1	54.1 ±12.1
Fuel ratio: Fixed Carbon/Volatile Matter		0.9	0.9 ± 0.3

Source: PSMP Study Team

4.4 Practicable measures for import coal in Bangladesh

4.4.1 Organizational Structure related to import coal

(1) Economic challenges

Import of coal in Bangladesh has the following challenges:

- Negotiation ability for the purchase price and coal specification
- Understanding the international coal market
- Transition to long-term contracts from spot contracts in order to stabilize the price
- Investment issues for coal mine development to ensure the right to import
- Coordination of domestic infrastructure

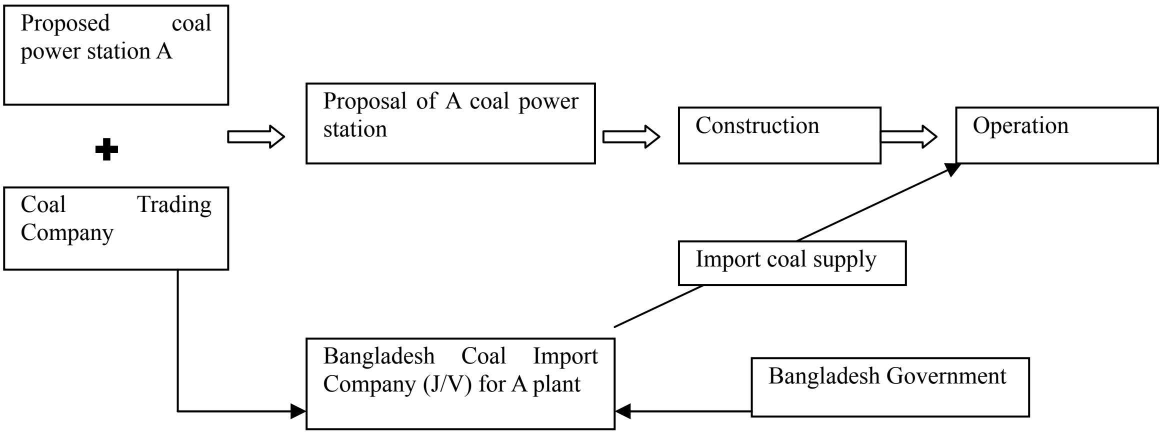
(2) The proposed measures

Bangladesh has no experience with a large amount of import coal used in thermal power plants, so that the following items have been considered for the short, medium and long term in order to assist the situation. Therefore the term of relating to import coal will come up with in the Coal Policy that is announced in future.

(a) Short term

The coal supply system will be changed depending on government operation or private management to a coal power plant and the system is examined as government operation. In the short term, tenders for the construction of coal-fired power plants shall be proposed for the package plan of the stable coal supply corresponding to true consumption. In the result, coal supply security will ensure stable coal power plant operations in Fig. 4-27.

In this case, the foreign coal trading company and local import coal company found a national trading company for importing coal as J / V in Bangladesh, which is responsible for coal supply in each power station. During this period, coal prices will be somewhat expensive, because the foreign coal company's handling cost will be added to the price. On the other hand a long term contract will be prospective since the coal supply to a new power plant will be secured for long time.



Source: JICA PSMP Study Team

Fig. 4-27 The proposed measures for import coal in short term

(b) Medium and long term

According to the situation, coal consumption is assumed to be about more than10 million tons. About this time local companies will acquire experience of import coal and will also get used to practices of import coal, so the company shall handle import coal alone in Bangladesh and shall aim to import coal more economically.

4.4.2 How to import contracts

In Japan, almost 100 percent of the coal depends on steel imports and power industries, because stability is required to avoid risk, so that there are lots of long-term contracts needed to secure coal quantity. When a long-term contract for more than one year and a spot contract is defined as less than 1 year, the power industry in Japan long-term contracts are 70% to 80%, and spot contracts are said to be 20 to 30 percent.

For long-term contracts, such as those by a leading trading company that is investing in coal mine development, it is common to secure the quantities according to proportion.

When developing large-scale coal mines, many mining companies want long-term contracts because of lower accuracy of funding as mainly assuming spot contracts. On the other hand, small scale coal mines tend to prefer spot contract, because they are afraid the risk cannot secure the export volume under some circumstances.

As a recent trend, In order to lower procurement costs, various techniques have been published for either.

(1) Example of the A power company

An energy trading joint venture with a French company was J/V- A company established in December 2007. Since February 2008, J/V- A company has been responsible for procuring and transporting about half of the coal portfolio worth 10 million tons per year and has been responsible for the logistics of the whole 10 million tons for the A power company.

This example seems to be a reference for Bangladesh, so approaches which the A Power Company announced are shown below.

- Power companies deal in large quantities with a small number of suppliers, while J/V- A aspires to deal with as many suppliers as possible.
- Many power companies decide on contracts in March and in October, A J/V- throughout the year makes a purchase.
- Doing business directly with customers - not through the agent.
- By using financial transactions in accordance with customer wishes, a fixed price or even an index price can be accepted.
- The company must not only buy, but make sales. If the A power company has trouble in the power station, the company carried out in accordance with the sales contract, it is possible to avoid oversupply.
- A J/V- has adopted a Decision Support System in order to conduct transactions faster. Thus, trading opportunities which were missed so far can be obtained.
- J/V-A evaluates the business based on market price. The Newcastle FOB price for the benchmark. and Newcastle Index (Global Call) is used.

(2) Example of the B power company

The Company has imported approximately 10 million tons of coal per year from overseas. In procuring coal, there are long-term contracts including the 10-year and yearly contracts on a one year basis. The Company creates a powerful combination of spot contracts based on competitive bidding by the two and takes the balance of supply and economic stability.
On spot contracts, since 2000, the company introduced a system of reverse auctions dealing with the seller who offered the best price on their website. Further, since fiscal 2001, the company has implemented specific procurements that appoint the specifications of the available coal regardless of the brand.

Hong Kong Power and Taiwan Power have also conducted transaction like the above examples. This method remains a risk that suppliers will bid for only those power companies in a strong financial position. Further, new on the international competitive bidding procurement of overseas coal, the company introduced a system of international competitive bidding purchasing coal on the Internet. This is for competitive bidding for overseas business partners and others of which the company's EDI (Electronic Data Interchange) server is intended to use. In overseas coal procurement via international bids, the introduction of its own bidding system is unprecedented in the power industry.

4.4.3 System of transportation of coal

The shipping system for imported coal will be freight by ship using a bulk coal carrier. It is growing in size recently and the pay load (PLD) increases to 300,000 t class. However, when thinking about the coal imports in Bangladesh, the depth of the Bay of Bengal in Bangladesh is overall shallow and the big vessel has difficulty reaching the shore. Bangladesh's commercial port is only Chittagong and Mongla and the draft is about 9m, and about 30,000t will be limited to the ship that can enter the port as the maximum payload now, though it differs and exists by the ship type. Therefore, it will be necessary to require the ship of about 30,000t when considering the import of coal.

4.4.4 Necessity of a coal center

There is the introduction of a coal center as a method of solving the above issue. The coal center is to stock the imported coal and to transport it to necessary second places. There are coal centers in every country in the world. A case example for Japan is shown in the Appendix.

In the case of Bangladesh, the candidate site of a coal power station close to the seashore is too shallow for a big ship to reach there directly. As a result, it is considered best that a coal center with harbor equipment with deep depth far from the power plant is developed and a handling system that supplies import coal to the power plant via the second transportation with the inland vessel is also established.

The development of a large-scale coal center requires the development of a deep harbor. The development of the harbor facilities is indispensable so that Bangladesh will be able to accomplish development mainly in the export processing industry in the future. The Ministry of Shipping is planning to carry out F/S in earnest. Therefore, the development of the coal center should be united with the development of the harbor facilities and the development should proceed with the cooperation between other sections of the government.

4.5 Study of coal price scenario

Regarding domestic coal, the government decides its price in reference to international prices as written in Draft Coal Policy. Regarding international coal trade, the FOB and Cost, Insurance and Freight (CIF) are general for coal prices. When a final domestic consumer receives import coal, coal price becomes CIF plus expenses [port charges, taxes, handling fees and domestic transport fees (ship, rail and truck) and others].

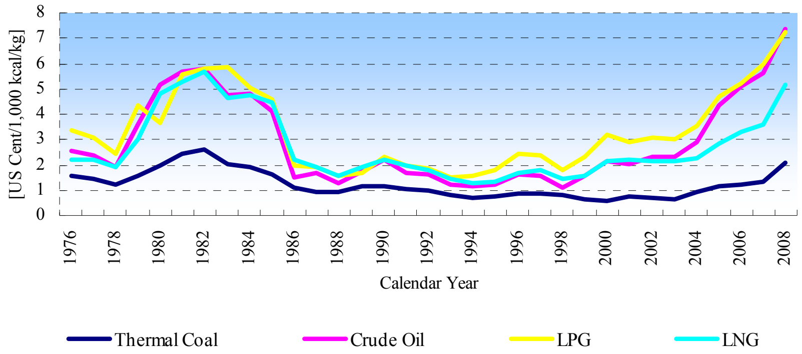
In the event of coal price forecasts, World Energy Outlook by IEA is generally used as reliable data. Table 4-15 is reported on the Table 4 Fossil -fuel price in the Reference Scenario in the Edition 2009 and mentions coal prices by 2030 in OECD. This Scenario is for OECD countries not for developing countries like Bangladesh who are new coal importers for coal power generation. So PSMP Study Team considers that these figures are not related to the import coal prices for Bangladesh. Therefore, in this study the study team originally set up every price as mentioned in APPENDIX - 4 and the forecast of total import coal price for power stations is mentioned as summary in Table 4-16, Table 4-17 and Table 4-18.

Regarding the judgment of import coal price in Bangladesh, prices of other energy resources are studied for reference. Fig. 4-28 shows the change of unit prices for CIF at 1,000 kcal/kg of each energy source which Japan imported.
Comparing to every energy source, all energy unit prices skyrocketed especially in 2008 and slumped in 2009. Including this case coal price, from this table it is clear that coal is a very cheap energy source compared to others and it is obvious that Bangladesh rely on coal as an energy source in the future.

Table 4-15 Fossil-fuel price assumption in the reference scenario

		Unit	2000	2008	2015	2020	2025	2030
Real terms (2008 prices)								
IEA crude oil imports		barrel	34.30	97.19	86.67	100.00	107.50	115.00
Natural gas imports								
	United States	MBtu	4.74	8.25	7.29	8.87	10.40	11.36
	Europe	MBtu	3.46	10.32	10.46	12.10	13.09	14.02
	Japan LNG	MBtu	5.79	12.64	11.91	13.75	14.83	15.87
OECD steam coal imports		tonne	41.22	120.59	91.05	104.16	107.12	109.40
Nominal terms								
IEA crude oil imports		barrel	28.00	97.19	101.62	131.37	158.23	189.65
Natural gas imports								
	United States	MBtu	3.87	8.25	8.55	11.66	14.78	18.73
	Europe	MBtu	2.82	10.32	12.27	15.89	19.27	23.11
	Japan LNG	MBtu	4.73	12.64	13.96	18.07	21.83	26.17
OECD steam coal imports		tonne	33.65	120.59	106.77	136.84	157.67	180.42

Source: IEA World Energy Outlook 2009



Source： JCOAL World Coal Report（quoted from Statistics of Ministry of Finance）

Fig. 4-28 Comparison of the unit price of CIF by energy sources

4.5.1 Forecast of total coal price of import coal

Coal prices at the power plant are the total costs which are FOB＋F&I (Freight and Insurance)＋the transport & handling cost from the port of import to the power plant In APPENDIX 4. Here the total price estimation is calculated using an estimated unit price of FOB (1,000kcal/kg) at New Castle Port by 2030 at AP Fig. 4-7 and AP Table4-11, F&I Estimation at AP Table 4-14 and Domestic Handling cost Estimation at AP Table 4-15.

Table 4-16 shows the grand total price of coal which Bangladesh will be able to get when its average HHV (High Heating Value) is 5,100kcal/kg. For reference and comparison, Table 4-17 shows the grand total price in case of HHV=6,100kcal/kg, Table 4-18 shows the ground total price in the case of imported coal with HHV=7,100kcal/kg such as Barapukuria coal. B) shows those cases where there are no handling costs borne by power plant locations.

Table 4-16 Grand total coal price (HHV=5,100 kcal/kg)

Year	FOB Price (5,100kcal/kg) (US$/t)		Freight & Insurance (US$/t)		Handling Cost (US$/t)	Grand Total of Coal Price at Thermal Power Station (US$/t)	
	High Case	Base case	High Case	Base case		High Case	Base case
2010	64.6	58.8	15.0	15.0	12.0	91.6	85.8
2011	69.5	62.3	15.9	15.8	12.7	98.2	90.8
2012	74.4	65.6	16.9	16.5	13.5	104.8	95.7
2013	79.3	68.9	17.8	17.3	14.3	111.3	100.5
2014	84.1	72.0	18.7	18.0	15.1	117.9	105.2
2015	88.8	75.1	19.6	18.7	16.1	124.5	109.9
2016	93.6	78.1	20.4	19.4	17.0	131.0	114.5
2017	98.2	81.0	21.3	20.1	18.0	137.6	119.1
2018	102.9	83.9	22.2	20.7	19.1	144.2	123.7
2019	107.5	86.7	23.1	21.4	20.3	150.8	128.3
2020	112.1	89.4	23.9	22.0	21.5	157.5	132.9
2021	116.6	92.1	24.8	22.6	22.8	164.2	137.5
2022	121.2	94.7	25.6	23.3	24.1	171.0	142.1
2023	125.7	97.3	26.5	23.9	25.6	177.8	146.8
2024	130.2	99.8	27.3	24.5	27.1	184.6	151.4
2025	134.6	102.3	28.2	25.1	28.8	191.6	156.2
2026	139.1	104.8	29.0	25.7	30.5	198.6	160.9
2027	143.5	107.2	29.8	26.2	32.3	205.7	165.7
2028	147.9	109.6	30.7	26.8	34.3	212.9	170.6
2029	152.3	111.9	31.5	27.4	36.3	220.1	175.6
2030	156.7	114.3	32.3	27.9	38.5	227.5	180.7

Source: PSMP Study Team

Table 4-17 Grand total coal price (HHV=6,100 kcal/kg)

Year	FOB Price (6,100kcal/kg) (US$/t)		Freight & Insurance (US$/t)		Handling Cost (US$/t)	Grand Total of Coal Price at Thermal Power Station (US$/t)	
	High Case	Base case	High Case	Base case		High Case	Base case
2010	76.0	69.1	15.0	15.0	12.0	103.0	96.1
2011	81.8	73.3	15.9	15.8	12.7	110.4	101.8
2012	87.6	77.2	16.9	16.5	13.5	117.9	107.2
2013	93.3	81.0	17.8	17.3	14.3	125.3	112.6
2014	98.9	84.8	18.7	18.0	15.1	132.7	117.9
2015	104.5	88.4	19.6	18.7	16.1	140.1	123.1
2016	110.1	91.9	20.4	19.4	17.0	147.5	128.3
2017	115.6	95.3	21.3	20.1	18.0	154.9	133.4
2018	121.0	98.7	22.2	20.7	19.1	162.4	138.5
2019	126.5	102.0	23.1	21.4	20.3	169.8	143.6
2020	131.9	105.2	23.9	22.0	21.5	177.3	148.7
2021	137.2	108.3	24.8	22.6	22.8	184.8	153.8
2022	142.6	111.4	25.6	23.3	24.1	192.3	158.8
2023	147.9	114.5	26.5	23.9	25.6	200.0	163.9
2024	153.2	117.4	27.3	24.5	27.1	207.6	169.1
2025	158.4	120.4	28.2	25.1	28.8	215.3	174.2
2026	163.6	123.3	29.0	25.7	30.5	223.1	179.4
2027	168.9	126.1	29.8	26.2	32.3	231.0	184.7
2028	174.0	128.9	30.7	26.8	34.3	239.0	190.0
2029	179.2	131.7	31.5	27.4	36.3	247.0	195.4
2030	184.4	134.4	32.3	27.9	38.5	255.2	200.8

Source: PSMP Study Team

Table 4-18 Grand total coal price (HHV=7,100 kcal/kg)

Year	FOB Price (7,100kcal/kg) (US$/t)		Freight & Insurance (US$/t)		Handling Cost (US$/t)	Grand Total of Coal Price at Thermal Power Station (US$/t)	
	High Case	Base case	High Case	Base case		High Case	Base case
2010	89.9	81.8	15.0	15.0	12.0	116.9	108.8
2011	96.8	86.7	15.9	15.8	12.7	125.4	115.2
2012	103.6	91.4	16.9	16.5	13.5	134.0	121.4
2013	110.4	95.9	17.8	17.3	14.3	142.4	127.5
2014	117.1	100.3	18.7	18.0	15.1	150.9	133.4
2015	123.7	104.6	19.6	18.7	16.1	159.3	139.3
2016	130.2	108.7	20.4	19.4	17.0	167.7	145.2
2017	136.8	112.8	21.3	20.1	18.0	176.1	150.9
2018	143.2	116.8	22.2	20.7	19.1	184.6	156.6
2019	149.6	120.7	23.1	21.4	20.3	193.0	162.3
2020	156.0	124.5	23.9	22.0	21.5	201.5	168.0
2021	162.4	128.2	24.8	22.6	22.8	210.0	173.6
2022	168.7	131.8	25.6	23.3	24.1	218.5	179.3
2023	175.0	135.4	26.5	23.9	25.6	227.1	184.9
2024	181.2	139.0	27.3	24.5	27.1	235.7	190.6
2025	187.4	142.5	28.2	25.1	28.8	244.4	196.3
2026	193.6	145.9	29.0	25.7	30.5	253.1	202.0
2027	199.8	149.2	29.8	26.2	32.3	262.0	207.8
2028	206.0	152.6	30.7	26.8	34.3	270.9	213.6
2029	212.1	155.8	31.5	27.4	36.3	279.9	219.5
2030	218.2	159.1	32.3	27.9	38.5	289.0	225.5

Source: PSMP Study Team

4.5.2 Domestic coal price estimation

(1) Setting up domestic coal price

Regarding domestic coal as mentioned in the Draft Coal Policy, the Bureau is to calculate and publish, the export coal price (ECPt) based on the International Coal Price Index. The export coal price (ECPt) per ton is expressed for the US dollar, and it is the average of the international price over the past three months. There is the domestic coal price in the bank for ECPt x 0.7.

In order to estimate the coal price by 2030, actual coal price at present was compared and studied. Table 4-19 shows the selling price of US$71.5 for the Barapukuria power plant in July 2008. It is clear that this is equal to FOB price of 7,100kcal/kg coal in the Base case.

Domestic coal price is cheaper than about 25-30% of the import coal prices received at the power plant.

Table 4-19 Comparison with selling price of Barapukuria coal in results

Actual coal price	FOB 7,100kcal/kg	CIF	G.Total of Coal price at Thermal Power Station	Comparison with FOB	Comparison with CIF	Comparison with actual price
(US$/t)	(US$/t)	(US$/t)	(US$/t)			
71.5	71.5	84.9	95.5	1.00	0.84	0.75

Source: PSMP Study Team

(2) Domestic coal price estimation

FOB Price on Table 4-20 are estimated domestic prices. Here the estimated price is a case of 7,100 kcal/kg coal equal to Barapukuria coal, because the price fluctuates due to the heating value. But this price is the case that the coal is delivered to the power station via belt conveyor like the Barapukuria coal mine. Therefore, the coal price is studied again for delivery methods.

Table 4-20 Selling price of domestic coal

Year	FOB Price (7,100kcal/kg) (US$/t)	
	High Case	Base case
2010	89.9	81.8
2011	96.8	86.7
2012	103.6	91.4
2013	110.4	95.9
2014	117.1	100.3
2015	123.7	104.6
2016	130.2	108.7
2017	136.8	112.8
2018	143.2	116.8
2019	149.6	120.7
2020	156.0	124.5
2021	162.4	128.2
2022	168.7	131.8
2023	175.0	135.4
2024	181.2	139.0
2025	187.4	142.5
2026	193.6	145.9
2027	199.8	149.2
2028	206.0	152.6
2029	212.1	155.8
2030	218.2	159.1

Source: PSMP Study Team

4.6 Risk assessment and recommendation for stable supply of coal to new coal-fired power plant

Overall risk assessment is summarized in Table 4-21. The evaluation point rankings are on a scale from 1 to 5 with 1 being the most inferior and 5 being the most superior.

Table 4-21 Overall risk assessment

	U/G Domestic Coal		O/C Domestic Coal		Import Coal	
	Grade	Assessment articles	Grade	Assessment articles	Grade	Assessment articles
① Coal Supply Stability	2	・Judging from the coal production situation of BCMCL	4	・Precondition : O/P is possible ・Not yet clear relating to the control technology against Upper Dupi Tila formation	5	・Precondition : Playability for international price base. ・Coal is the cheapest in all energy sources.
② Flexibility of production	2	・ The production is limited by facility of coal mine in U/G mining	4	・ The mining facility can be increased and decreased easily.	5	・The quantity is more flexible in market.
③ Coal Price Stability	4	・Production cost mainly depends on natural condition. Here coal price is supposed to maintain 75% of international market price.	4	・Precondition : Above mentioned. ・Precondition :Mentioned at the left but production cost is uncertain.	1	・Coal price depends on international market price. ・More stable after getting long term trading contract.
④ Coal quality Stability	5	・Domestic coal quality is known in advance and the quality is kept.	5	・The same as the left	3	・Coal quality usually fluctuates by coal prices.
⑤Environment	3	・The environment problems like surface subsidence, underground water will occur together with coal production	1	・Comparing to U/G mining, the range of environment impact is large area. ・Water drainage problems are widely influenced by ground water.	5	・No environment impact due to mining in Bangladesh ・There are environment impacts due to port facilities and coal handlings.
⑥The period to realize coal supply	5	・A new coal mine development period will need minimum 5 years after starting exploration boring works.	3	・ There is no permitted example in Bangladesh and there is the big aftereffect about some complications for the Phulbari Project. ・Thinking about the present situation, a new coal mine development period will need more than 10 years	4	・Coal production Countries are distributed throughout world, it depends on completion period of related facilities in Bangladesh.
⑦ Employment creation	5	・2,700 workers/million tons (Direct)	4	・About 1/3 workers against U/G Mine.	2	・Workers relating to domestic coal handling
⑧ Difficulty of training of engineer	3	・Training method for mining, safety technology, Construction of qualification system	4	(Same as left)	5	・Coal quality & coal analysis technology
Comprehensive assessment	◎	・New Coal Mines are planed.	△	・At present stage, development possibility is not clear.	◎	・Import coal is required as well as in the future.

Source: PSMP Study Team

4.7 A road map and an action plan for the master plan embodiment

The issues of supply of domestic and import coal are listed here from the perspective of the short, medium and long term.

4.7.1 Domestic coal

Table 4-22 A road map and an action plan for domestic coal

	Required quantity of coal in the milestone of M/P (1,000t/y)	Issues	Action Plan
Short-term goal	700 ～ 2,000	● Only Barapukuria coal mine produces coal and the mining method for 2nd slice and actual coal production ● The evaluation result of pilot O/C coal mine and decision of mining method of O/C and/or U/G in the future. ● The progress of new coal mine construction.	→Determination of the feasibility by early study and implementation of 2nd slice and after →Early implementation of pilot O/C coal mine and formulation of national strategy →Positive governmental support for realization of a new coal mine.
Medium –term goal	2,850 ～ 12,500	● Completion of two new coal mines and commencement of production ● Continuous production from O/C and commencement of production from a new O/C coal mine	→Department of management of coal mine will be necessary in governmental body →Establishment of system of education & training center for coal mining worker will be necessary →Counter measures when a O/C coal mine failed
Long-term goal	7,000 ～ 26,500	● Stable operation of three new coal mines ● Technical issue of mining method of 2nd slice in U/G	

Source: PSMP Study Team

4.7.2 Import coal

Table 4-23 A road map and an action plan for import coal

	Required quantity of coal in the milestone of M/P (1,000t/y)	Issues	Action Plan
Short-term goal	(Nil)	● Fix of import coal and the contract of import coal are finished before starting construction of the new power station. ● Improvement of domestic infrastructure for handling of import coal	→The bid tender shall include the security of a coal supply contract →Establishment of coal handling system for import coal
Medium –term goal	Max. 18,000	● Stable import coal supply ● Shift the contract of import coal from spot contract to long term contract.	→Construction of a coal center plan →Establishment of national strategy for stable security of import coal supply and long term contract
Long-term goal	Max. 30,000	● The stable security of import coal supply for long term	→Investment for coal mine development in foreign country

Source: PSMP Study Team

Chapter 5 Natural Gas Sector

In this chapter, a present data analysis is conducted about natural gas policy, which is the main source of primary energy in Bangladesh, domestic fuel situation, future development trends, and the demand according to sector. It works on the policy geared towards future stable reservation including LNG imports. A promising point connected to future development is investigated from the viewpoint that domestic resources are utilized to their utmost with regards to the development of natural gas, and the available supplies which are in charge of optimum power development plan decision, which are clarified.

5.1 National development plan

5.1.1 Government policy and plan

The Government's development goals are;[1]

- to provide energy for sustainable economic growth and for maintaining energy security in the country
- to provide energy to all socio-economic groups in the country especially to the less developed areas
- to diversify use of indigenous energy; and
- to contribute towards protection of the environment.

In order to achieve the above goals, the Government is planning to take various measures for the petrochemical fuel sector including natural gas such as to increase the proven gas reserves by hastening survey, exploration, prospect drilling, evaluation and production optimization; to make an adequate assessment before the development; to introduce a method of the legal control of natural resources by the state owned companies; to make a comprehensive control by the state-owned companies, specially commercial applications; to reduce the gas demined by curtailment of system loss and improving the efficiency; to solve the regional development unbalance by extension of the pipeline toward western part of the country; to have strategic stock pile of petroleum fuel for minimum two months; to work privatization of liquefied fuel sector.

In recognition of the importance of natural gas in the socio-economic development of the country to support the poverty reduction strategy paper (PRSP), the Government would implement several measures to the gas sector, including hastening exploration and development of gas fields by the united efforts of government sector and private sector, facilitating foreign capital investments with giving incentives to them through Production Sharing Contract (PSC), privatization of the domestic gas sector, rationalizing the domestic gas price and making link with international gas price, making arrangements for environmental protection from the initial stage of development and evaluation.

5.1.2 Gas reserve estimation report 2003

The latest reserve estimation performed in 2003 by the Hydrocarbon Unit of Energy and Mineral Resources Division (HCU) and related parties, and published as then "Bangladesh Gas Reserve Estimation 2003". The work of the "Bangladesh Gas Reserve Estimation 2003" was started in May 2002 in order to update the existing gas reserve report titled "Bangladesh-Petroleum Potential and Resources Assessment 2001"by forming an expert team comprised of HCU, Petrobangla, Bangladesh Gas Fields Ltd. (BGFCL), Sylhet Gas Field Ltd. (SGFL), Bangladesh Petroleum Exploration & Production Company Limited (BAPEX) and the Norwegian Petroleum Directorate (NPD). In order to update the gas reserve, old reports were examined with the seismic data, well log data, production and other relevant data that was collected. The gas fields operated by the PSC members such as Jalalbad, Sangu, Bibiyana and Moulavi Bazar were not included for this

[1] National Energy Plan (Draft) 2008

re-evaluation work and the figures of the reserves of these fields provided by Petrobangla were kept unaltered and applied to this report.

The gas fields in the Bangladesh were divided into Developed Gas Fields and Undeveloped Gas Fields. And for the purpose of re-estimation, developed gas fields were divided into Producing Gas Fields and Suspended Gas Fields. Out of 22 discovered gas fields, 16 gas fields were included for re-assessment by volumetric method. The producing sand of 5 gas fields were analyzed by Material Balance method using Shut In and Flowing Well Head Pressure since enough Shut in Bottom Hole Pressure data required for this method were not available for the most producing wells. Therefore, the results of re-assessment by the Material Balance were not considered to be correct.

All of the previous reports relating to the gas reserves were described based on this "Bangladesh Gas Reserve Estimation 2003." In this MP, the latest preliminary reserve estimation which currently assessed by HCU is used. Since the latest estimation report has not published yet, the details are not clear at this stage, however, the accuracy of the estimation is expected to be improved by reflecting new material balance method and 3D seismic survey result.

GoB formulated the National Strategy for Accelerated Poverty Reduction II (revised) (NAARP-II(revised)) in which it emphasizes essential infrastructure development in the 3rd block out of the 5 strategic blocks, especially focusing on the power and energy sector as a priority matter. It requires that the National Energy Policy be updated to provide the guidelines for achieving the nation’s energy security.

5.1.3 Gas Sector Master Plan 2006

At present, the latest Gas Master Plan for the Bangladesh Government is Gas Sector Master Plan (GSMP 2006) published by Petrobangla/World Bank (Consultant: Wood Mackenzie) in 2006. The following issues are presented in the GSMP 2006;

(1) Current status in the Bangladesh gas sector

The GSMP 2006 indicated that the Gas Sector in the Bangladesh faces a very financially weak sector, as a result of low gas prices and recognized that insufficient funds were therefore available to undertake the level of investment required in both supply and transmission to meet demand growth, which continues to be strong.

The Bangladesh has only proved gas reserves to fully meet demand until 2011, although taking into account probable reserves this extent to 2015. For this reason, the GSMP 2006 suggested that there is an urgent need for radical reform measures to enable that gas demand can be met.

(2) Gas demand forecast up to 2025

Based on GDP growth assumptions, the gas demand forecast was made for the three cases.

- Case A: Essentially a continuation of the recent GDP growth trend in 2006.
- Case B: Consistent with the Bangladesh Government PRSP and MDG aspirations.
- Case C: 9% GDP growth until 2015, then decrease to 7% by 2025.

In comparison with actual gas demand (1,791mmcfd) at the end of fiscal year in 2009, it is nearly same as Case C (1,785mmcfd at the end of 2009) and the actual gas demand shows higher growth than Base Case (Case B) assumed by the GSMP2006. In Case C, the total demand as of 2025 is estimated 7,441mmcfd. In this case, there will be causing shortage of gas supply against gas demand in 2013 if the gas supply is only proved reserves (P1) plus probable reserves (P2).

(3) Gas network issue

Substantial expansion and modification of gas network system in the Bangladesh is inevitable to satisfy with increasing gas demand. Significant investment is essential to improve the infrastructure, and then of addition of compressor. In total an investment requirement of US$1.3 billon was identified in the transmission sector over period to 2025.

(4) Strategy and investment for the Bangladesh gas sector

The expected total addition of gas needed from new gas fields will be 16 to33 Tcf, or which will require an investment of about US$5 billion to 10 billion.

5.1.4 Gas Sector Reform Road Map (2009-2012)

The Bangladeshi Government dialogued with ADB to revise the Gas Sector Reform Road Map (GSRR) to address the various issues held in the Gas Sector. The GSRR forms the action plans to set concrete countermeasures, time frames, monitoring instruments etc, classified into following seven categories. By implementing these action plans, the GSRR aims to improve operational performance in the gas sector and reform the inadequate investment, uneconomic tariffs, inadequate investment resources, inefficient use of gas and inadequate capacity in the state-owned gas companies and government agents.

(1) Policy Framework

To update the road map on gas sector reforms covering 3 years, and outline the latest government's vision on the gas sector.

(2) Regulatory Instruments

To develop rules and regulations for private sector participation and to establish competitive and effective markets in terms of gas purchases, sales, and transmissions.

(3) Sector Planning

To update the gas master plan and disseminate investment options for the private sector.

(4) Increased Access to Natural Gas

To develop a strategy for the exploration and utilization of undiscovered reserves.

(5) Corporate Governance

To reduce the accounts receivables from public and private customers and minimize system losses in distribution and transmission in order to improve financial management.

(6) Gas Sector Restructuring

To establish TGTDCL as three separate companies and BGSL into two separate companies in order to improve management performance.

(7) Private Environment

To allow private financing in the gas sector in order to reduce dependence on government funds.

5.1.5 Natural Gas Access Improvement Project (2010)

In the face of impending gas shortage as well as the continued growth of Bangladesh's energy and natural gas requirements in recent years due to economic growth, the Bangladeshi Government has requested ADB financing for several priority projects in the sector that would help implement its Poverty Reduction Strategy (PRSP). In response to a request from the Government, the ADB in January 2008 engaged with Technoconsult International Limited (TCIL) who is a local technical consultant firm based in Bangladesh to undertake the Technical Assistant study for preparing a clean fuel sector development program (the Program). TCIL commenced its study for the Program from February 2008 and submitted a final report with its proposal after compiling investigation results to ADB on March 2009. Following the proposal by TCIL, ADB worked out a proposal for the Natural Gas Access Improvement Project (the Project) mainly to provide a loan to the People's Republic of Bangladesh, and the Board of ADB approved the Project on 26 March 2010. The outlines of this Project are as follows.

(1) Project cost and financial plan

The project is estimated to cost US$542 million equivalent, including tax and duties of US$ 101 million. ADB loan will be US$261 million equivalent from ordinary capital resources (OCR) and US$5 million equivalent from the Asian Development Fund (ADF). Korea Eximbank will provide US$45 million equivalent for construction of Ashuganj-Bakhrabad Gas transmission loop-line and installing interface metering as shown in Table 5-1. The Bangladesh Government will provide US$231 million equivalent through loan and equity contributions.

(2) Explanation of the program

The gas sector has been affected by inadequate investment, compounded by uneconomic tariffs, inadequate investment resources, inefficient gas usage, and a large number of system losses, so that it has not performed at its potential gas production capability yet. The project is to support the country's gross domestic product (GDP) growth and promote broad-based development across the country through improving the sector. This will be accomplished by improving the efficiency and expanding the gas transmission and distribution network in the targeted areas at the same time ensuring a sustainable gas production, and maximizing the utilization of natural gas.

(3) Impact and outcome

The impact of the project will be increased and more reliable access to natural gas for sustained economic growth, achieved by reinforcing and augmenting natural gas supply and addressing policy and institutional constraints. The main outcome of the project will be expanded capacity and improved efficiency in natural gas production, transmission, and distribution systems.

(4) Outline of the Project

Table 5-1 Project cost summary for Natural Gas Access Improvement Program

Cost by Project Component	(Million US$)
A. Base Cost 1. GTCL(Gas Transmission Company Ltd)- Transmission Capacity Expansion A-1: Ashuganj-Bakhrabad gas transmission loop-line. ➢ Construction of gas loop line: 30" OD 61km 400 mmcfd ➢ Installation of major transmission –distribution interface metering and regulating stations at Manohardi, Dewanbhog, Kutumbpur, Feni and Barabkund A-2: Gas Compressor installation at Ashuganj and Elenga ➢ Ashuganj maximum throughput: 1,500mmcfd ➢ Elenga maximum throughput: 500mmcfd	81 173
2. Safety and supply efficiency improving in Titas gas field B-1: To improve safety at existing problematic wells in Titas field B-2: To improve supply efficiency through four additional appraisal-cum-development wells and install processing plants in Titas field to increase gas production by 120 mmcfd	9 103
3. Access improvement in southwestern region Construct 2" to 20" gas distribution pipeline of 845 km to provide gas to the districts of Kushtia, Jhenidah, Jessore, Khulna, and Bagerhat (including Mongla.)	73

Cost by Project Component	(Million US$)
4. Supply and demand management Establish gas metering at consumer connection of Titas Gas Transmission and Distribution Company Limited (TGTDCL) include installing prepaid Meter for domestic consumers and for industrial consumers replacing existing meters with remote sensing meters on a pilot basis.	8
2. Contingencies	54
3. Financing charge during implementation	41
Total (1 + 2 + 3)	542

Source: ADB, Natural Gas Access Improvement Project

(5) Estimated project completion date

31 March 2015

(6) Project benefits

The government's ongoing reform program based on the GSRR will strengthen the financial position of sector entities, enhance public–private partnership, and improve sector and corporate governance. The project will create efficient and viable gas infrastructure to address priority supply and network constraints. These interventions will ensure sustained growth in the gas sector, which is critical to the country's economic development.

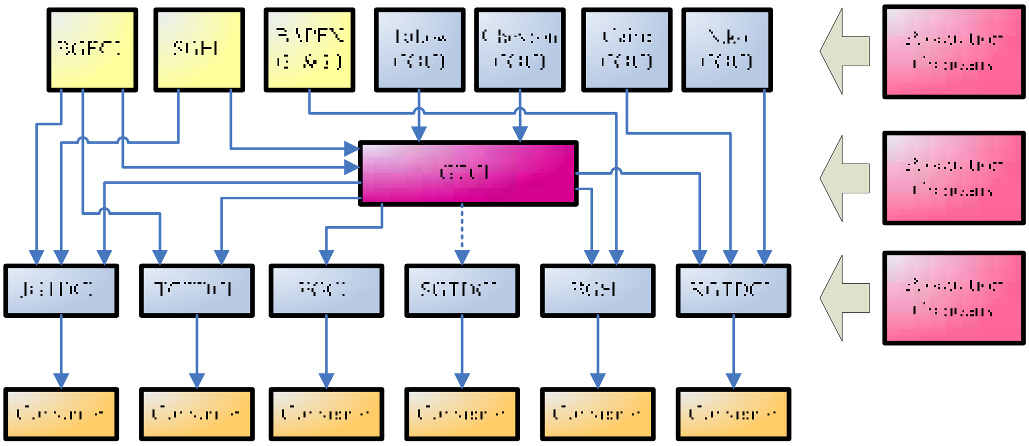
An estimated 200,000 households will gain access to gas through the new distribution network. The project will have a positive impact on environment and health, particularly of women and the poor, who are the most vulnerable to indoor air pollution from the use of biomass and fuel wood, which will be replaced with natural gas. An additional 1,400 industrial and commercial establishments and 35 compressed natural gas filling stations will have access to gas in the southwest. Industries such as jute mills, textile weaving factories, small cottage industries, and textile mills, and commercial entities such as restaurants and bakeries, will benefit, generating significant employment in the region and thus reducing poverty. The project will directly create 3,000 persons per month of job opportunities during implementation.

The perspective of gas demand-supply projection forecast is presented by TCIL in the Program and projections indicate that the gas demand will exceed the supply at the year of 2010. Gas supply will increase year by year up to 2017, however, the supply may not catch up the growth of demand. Therefore, the gap between gas demand and supply will be magnified increasingly since production supply will decrease gradually after 2017. Thereafter, production will decline if no new reserves have been found. This would be addressed by requiring the Government to encourage and accelerate exploration activities both in the public and the private sectors to ensure timely gas availability. The Program addresses these concerns by appropriate policy reforms to promote upstream investment.

5.1.6 Organizational structure

(1) Natural gas sector overview

The gas sector in Bangladesh is organized into distinct segments for exploration and production, gas transmission and gas distribution under Petrobangla. All of the installation and supervision of the pipelines are under control of Gas Transmission Co. Ltd. (GTCL).



Source: EMRD (2011)

Fig. 5-1 Organization structure of gas sector

(2) Formation of companies under Petrobangla

Since the gas was found for the first time in 1955, the gas-based petroleum industry in Bangladesh has grown active gradually. In 1974 after the independence, the national company Bangladesh Oil, Gas and Mineral Corporation (Petrobangla) for carrying out the exploration, the production, transportation, and the sales of natural gas and petroleum and the excavation of coal and granite was established under the Energy and Mineral Resources Division (EMRD) based on the petroleum law of Bangladesh. In 1976, the national company BPC for carrying out the petroleum refinery and the sales of petroleum products was established.

The activities of the Petrobangla group encompass the entire spectrum of the gas sector. The companies under Petrobangla are involved in each of the stages from the drill bit to burner tips. Petrobangla, through its companies, conducts geological and geophysical exploration by its own crew, drills exploration and development wells by its own rig, processes the raw gas, transports the processed gas through the network of high-pressure transmission lines and distributes gas to the consumers.

Bangladesh constitutes one of the largest deltas in the world and has proved its hydrocarbons potentiality through the discovery of 23 gas fields including one oil field during the course of drilling only 76 exploration wells over a period of the last 50 years of exploration. In spite of a slow exploration pace, the success ratio is 3:1. However, when offshore drilling is concerned a total of 17 gas fields have been drilled with only one commercial discovery i.e. Sangu Gas Field. Before emerging as an independent country in 1971, exploration was conducted under license by foreign companies and also by the state exploration wing. 1974 marked the year when the opportunity for the international petroleum industry to explore, develop and produce oil and gas under PSC in the offshore areas only arose

Currently, Petrobangla controls eleven companies divided in five departments

(3) Organization for production/exploitation

(a) Bangladesh Petroleum Exploration and Production Company (BAPEX)

BAPEX was separated from Petrobangla in 1989 to be established as a development company. It has the exploration development capability only in Petrobangla-owned companies and assumes geology department, physical exploration department, and excavation and renovation department. The production department has three gas fields; Salda, Fenchuganj, and Shahbazpur and currently, these gas fields produce approximately 2% of whole gas quantity produced in

Bangladesh. BAPEX has 10% right of mine sites in blocks 5, 7, 9, and 10 and 100% right of mine sites in blocks 8 and 11. BAPEX also has a joint venture with Niko to develop two marginal gas fields Feni & Chattak. Currently, it operates two drilling rigs and one workover rig and orders new drilling rig to replace present one in order to replenish inefficient operation. Additionally, it has one seismic survey equipment, trained personnel and the analytical capability. The total number of employees is 1989. (As of June 2009)

(b) Bangladesh Gas Field Company Limited (BGFCL)

BGFCL is the largest gas production company in three Petrobangla-owned companies. It produces approximately 39 % of whole gas quantity produced in Bangladesh from four gas fields; Titas, Bakhrabad, Habiganj, and Narshingdi. The predecessor of BGFCL is Pakistan Shell Oil Company established in 1965 and it was acquired by the government in 1974 after the independence of Bangladesh, and the name was changed to BGFCL in 1975. Titas gas field produces the second largest gas production volume; 395mmcfd of gas after 527mmcfd of natural gas production volume of Chevron Bangladesh (Chevron), and it is planned to excavate two evaluation wells based on the result of recent seismic survey. It is also planned to excavate four production wells additionally depending on this result. The reserves are re-evaluated and it is expected that the production volume will increase dramatically. The number of employees is 1975. (As of June 2009)

(c) Sylhet Gas Field Limited (SGFL)

SGFL's predecessor is Burma Oil Company (BOC) established in the 1950s and after the nation's independence, it fell under the control of the Bangladeshi government. It produces 9 % of all of the gas produced in Bangladesh from four gas fields; Sylhet, Kailashtila, Rashidpur, and Beanibazar. It is planning to carry out the 3D seismic survey including Sylhet, Kailashtila, and Rashidpur gas fields from 2010 and re-evaluate the structure of each gas field and excavate five evaluation wells. The gas field of SGFL, especially Kailashtila gas field has a higher production ratio of condensate than that of other gas fields. The construction of the Petrochemical plant in the future is planned. The number of employees is 1982. (As of June 2009)

(d) International oil companies (IOC's)

Currently, five foreign companies; Chevron, Cairn Energy Plc. (Cairn), Tullow Oil Plc. (Tullow), Niko, Total E & P are evolved in exploration, development and production of natural gas and petroleum onshore and offshore under PSC with Bangladesh and the companies other than Total E & P are producing the gas at PSC gas field. The gas field activity of each PSC company and current activity are listed shown below based on the data of Petrobangla.

Table 5-2 Activity for each block of IOC companies

Operator	Block	Activities (Jun. 2009)
Cairn Energy Exploration (Bangladesh) Limited	5	So far conducted 69 LKM (line kilo meter) seismic surveys beyond the buffer zone of Sundarban forest. Not drilled any wells yet.
Chevron Bangladesh Block Seven limited	7	Has conducted 1,047 LKM seismic survey. Not drilled any wells yet.
Tullow Bangladesh Limited	9	Discovered Bangora-Lalmai gas field in 2004. Now producing from Bangora field at the rate of 87 mmcfd.
Cairn Energy Exploration (Bangladesh) Limited	10	Has conducted 1233 LKM seismic survey. Not drilled Any wells yet.
Chevron Bangladesh Block Twelve Limited	12	Discovered Bibiyana gas field in1998. Bibiyana has started production from 2007.Current production rate is about527 mmcfd as of June 2009.
Chevron Bangladesh Block Thirteen & Fourteen Limited	13 &14	Discovered Moulavibazar gas field in 1997. Currently producing 74 mmcfd. Chevron is also producing gas from previously discovered Jalalabad gas field at the rate of about 158 mmcfd as of June 2009.
Cairn Energy Sangu Field Limited	16	Discovered Sangu gas field in 1996. This is the first and only producing offshore gas field in the country. Now Producing 50 mmcfd as of June 2009.
Total E & P	17&18	An amendment agreement was signed on 2007 to Extend the exploration period up to 2010. But, they subsequently withdrew.

Source : Petrobangla

(4) Gas transmission organization

(a) Gas Transmission Company Limited (GTCL)

GTCL was established in 1993 and is eligible as a National Gas Transmission Company in Bangladesh. Since then GTCL is at present extending gas transmission network to the South-Western districts of the country.

It is responsible for transforming the produced gas and condensate via its owned transmission line from each gas field to the distribution line owned by a franchised gas distribution company. The total length of the pipeline is 930 km and the piping diameter is 20 to 30 inch and the Supervisory Control And Data Acquisition (SCADA) system is facilitated to monitor gas transportation conditions.

In recent years the development plans of the gas transportation capability has been studied with World Bank (WB) and ADB, where Ashuganj is marked as a hub station and some bypass lines to the south-western area and/or the western area next to Dhaka is under study by Gas distribution organization.

(5) Gas distribution organization

(a) Titas Gas Transmission and Distribution Company Limited (TGTDCL)

TGTDCL has been jointly founded by the former Pakistan Government and Pakistan Shell Oil in 1964 and has transformed natural gas in Dhaka and the surrounding areas. After the independence of Bangladesh, as a 100% government-owned corporation, it became a subsidiary company of Petrobangla under control of EMRD in 1975. It has the largest number of customers in Dhaka and its neighbor in Bangladesh.

The annual sales amount of gas is around 12,239 MMCM and the number or customer counts on 1,350 thousands including 28 power plants. As for the transportation ability, it has its own 613km transmission line and a 10,277km distribution line.[1].

[1] Source: annual report of TGTDCL, 2008

(b) Bakhrabad Gas Systems Limited (BGSL)

BGSL was established in 1980 and has transformed natural gas for the benefit of the customers concentrated mainly in the Chittagong area as a subsidiary company of Petrobangla under control of EMRD. In 1985 onwards the connection line to TGTDCL was settled between Bakhrabad and Demra to meet the Dhaka area's large demand.

The annual sales amount of gas is around 2,811 MMCM and the number of customers is in around the 430 thousands including five power plants. As for the transportation ability, it has its own 67km transmission line, a 246km lateral line, and a 5760km distribution line.[1].

(c) Jalalabad Gas Transmission & Distribution System limited (JGTDSL)

JGTDSL has been established in 1977 and has transformed natural gas to the customers mainly in Sylhet area (north-eastern area) as a subsidiary company of Petrobangla under control of EMRD. In the north-eastern area there exists a plenty of gas field like Sylhet, Bibiyana, and Kailashtila, so the stable gas supply can be achieved when compared to other franchised gas companies.

The annual sales amount of gas is around 885 MMCM and the number of customers is around 120 thousands including 4 power plants. As for the transportation ability, it owns transmission line of 2,831km in length[2].

(d) Pashchimanchal Gas Company Limited (PGCL)

PGCL has been established in 1999 and has transformed natural gas to the customers mainly in Rajshahi area (north-western area) as a subsidiary company of Petrobangla under control of EMRD.

The annual sales amount of gas is around 614 MMCM and the number of customers is around 40 thousands including 4 power plants. As for the transportation ability, it owns distribution line of 878km in length[3].

5.2 Gas reserves

Bangladesh has discovered so far twenty three gas fields with a total GIIP (Proven + Probable) of 28.8 Tcf of which 20.4 Tcf is recoverable. As of June 2009, seventeen gas fields are producing from 79 wells. The capacity of daily gas production is about 2000 mmcfd and cumulative production for 49 years from 1960 to June 2009 has reached to 8.4 Tcf. According to the Petrobangla , remaining recoverable reserves as of end of June 2009 is estimated to be 12.1 Tcf of which 6.7 Tcf is proven reserves (P1) and 5.4 Tcf is probable reserves (P2), and possible recoverable reserves (P3) is 7.9 Tcf. The amount of deposit announced is based on the works made by HCU in 2003, by establishing an evaluation team with experts of petroleum in Norway.

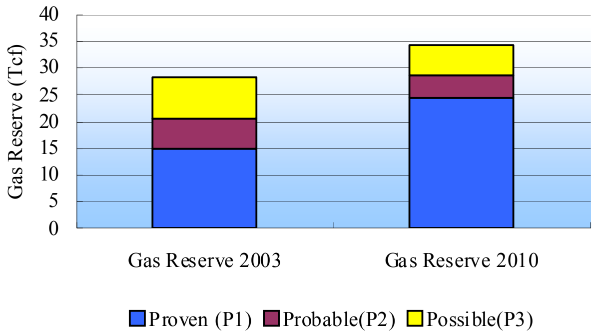
Meanwhile, HCU is re-evaluating the gas reserve by retaining Gustavson Associates as a consultant. The re-evaluation has still been under way as of October 2010. According to the interview with HCU, it is estimated that the overall remaining reserve will be increased. The gas reserves in 2003 and preliminary evaluation as of October 2010 is shown in Table 6-3. This MP uses the preliminary data as the latest information.

[1] Source: annual report of BGSL, 2008
[2] Source: annual report of JGTDSL, 2008, The annual gas sales amount was reviewed by PSMP Study Team
[3] Source: annual report of PGCL, 2008

Table 5-3 Gas reserve scenario

Category	Gas Reserve 2003	Gas Reserve 2010	difference
	(Tcf)	(Tcf)	(Tcf)
Proven Recoverable Reserve (P1)	15.0 (53%)	24.3 (71%)	9.3
Probable Recoverable Reserve (P2)	5.4 (19%)	4.5 (13%)	▲0.9
Possible Recoverable Reserve (P3)	7.9 (28%)	5.4 (16%)	▲2.4
Recoverable Reserve (P1+P2+P3)	28.3 (100%)	34.2 (100%)	5.9
Cumulative Production (Up to June 2009)	8.4	8.4	—
Net Recoverable (Proven +Probable) (Up to June 2009)	12.1	20.4	8.3

Source : Gas Reserve Estimation Report 2003, 2010 modified by PSMP Study Team (2010 data is preliminary basis)



Source: HCU Gas Reserve Estimation Report (2003, 2010 preliminary)

Fig. 5-2 Gas reserve comparison

The gas reserve estimate in 2010 is on a preliminary basis so that the details are not clear yet. However, it is estimated that the production from major gas fields such as Bibiyana, Rashidpur, Titas has increased up to 2.8Tcf, 1.9Tcf, 1.7Tcf respectively, while that from Habiganj has decreased to 1.1Tcf. It is supposed that the reasons for the increase are due to the accuracy of the evaluation by using 3D seismic survey improved and the recovery factor improved via renovated drilling technology, as a result the probable and possible reserves were upgraded to a proven one. The PSMP Study Team recognized this reserve estimation is as reasonable.

5.3 Current status and the future forecast of gas demand

5.3.1 The present situation of gas demand

(1) Area wise and sector wise demand in the present and future

This study is implemented with reference to the operating data from the annual report of Petrobangla and four major distribution and marketing companies. Sectors such as Power, Fertilizer, Industry, CNG, Captive Power, Commercial, Domestic, and Tea Estate are examined in this study.

The data of Petrobangla report are those from 1981 onward, in which the gas for the power is both for power stations and captive powers, and the gas for CNG is combined with that for Tea Estate.

As the purpose of this report is to clarify the future fuel source of power stations, it is needed to extract the real gas demand for power stations. CNG should also be analyzed independently from that for Tea Estate with different market. The data of four major distributors are those from 2004 onward and their demand groupings are same as Petrobangla's. Their total sale meets the Petrobangla wholesale to them. The following table shows the wholesales of Petrobangla from 1981 to 2003 and sales of four distributors from 2004 onward. The data is used as the base data to forecast the future gas demand.

Table 5-4 Present situation of gas demand

(Unit: mmcfd)

F.Year	Power/Captive Power		Fertilizer	Industry	Commercial	Domestic	CNG/Tea		Brick Field	Total	Gas Production	System Loss	Loss Ratio
	Power	Captive P.					CNG	Tea					
1981	36		49	22	4	9	0	0	0	121	137	16	12
1982	49		73	25	5	12	0	0	0	163	178	14	8
1983	60		71	27	5	14	0	0	0	177	198	20	10
1984	63		81	28	6	16	0	0	0	193	228	35	15
1985	105		75	35	6	17	0	0	0	237	259	22	8
1986	109		92	45	7	19	0	0	0	272	288	16	5
1987	142		96	51	9	19	0	0	0	317	331	14	4
1988	170		140	46	10	21	0	0	0	386	404	17	4
1989	179		146	41	9	25	0	0	0	401	444	43	10
1990	207		153	39	8	28	0	0	0	436	459	23	5
1991	226		148	36	8	29	0	2	0	450	473	24	5
1992	241		169	37	8	32	0	2	1	489	516	27	5
1993	256		190	42	7	37	0	2	1	533	578	45	8
1994	267		204	56	8	42	0	2	3	581	613	32	5
1995	294		221	66	8	52	0	2	3	645	677	32	5
1996	304		249	75	8	57	0	2	3	698	728	30	4
1997	304		213	78	12	63	0	2	1	673	715	41	6
1998	338		219	89	13	68	0	2	1	730	772	42	5
1999	386		227	98	13	74	0	2	1	800	844	43	5
2000	404		228	114	11	81	0	2	1	841	911	70	8
2001	480		242	131	11	87	0	2	1	955	1,023	68	7
2002	521		216	147	12	101	0	2	1	999	1,073	74	7
2003	522		263	175	12	123	0	2	1	1,098	1,154	56	5
2004	549	85	254	127	13	135	5	2	0	1,172	1,240	69	6
2005	578	105	257	143	13	144	10	2	0	1,254	1,333	79	6
2006	615	133	244	173	14	155	19	2	0	1,356	1,460	104	7
2007	606	172	256	212	15	173	33	2	0	1,469	1,542	73	5
2008	642	220	216	253	18	189	63	2	0	1,601	1,646	45	3
2009	704	260	205	287	21	207	85	2	0	1,770	1,791	21	1

Source : Annual report in 2008 of Petrobangla and four major distribution and marketing companies

(a) Power and captive power

The gas demand ratio of the Power sector to all sectors was slightly over than 45% in 2004, but after that it has been decreased yearly to its present 40%. This trend is shown below.

Table 5-5 Gas demand ratio of the power sector for all sectors

F. Year	Power/Total Gas (%)
2004	46.8
2005	46.1
2006	45.3
2007	41.3
2008	40.1
2009	39.8

Source: PSMP Study Team

(b) Fertilizer

In general, the gas demands of fertilizer plant are met to the extent possible during the peak season of production by adjustment with supplies to power stations.
PSMP Study Team interviewed to KAFCO Japan which is a parent company of KAFCO of a major Fertilizer company. Chittagong where KAFCO located is in the supply franchise area of distribution gas company BGSL. In 2009, there is in chronic gas shortage, while demand for the gas within the supply area is about 400 mmcfd on an average, actual supply was at about 300 mmcfd, with shortage about 100 mmcfd, though KAFCO as a foreign company is generally given priority in terms of gas supply over government owned other fertilizer plants. As for the fertilizer sector, while demand is about 120 mmcfd, gas supplies are only about 70 mmcfd with the shortage about 50 mmcfd.

For this reason, CUFL, another major Fertilizer company in Chittagong is obliged to suspended operation temporarily. Although the government guaranteed KAFCO to enough gas supply for operation. KAFCO reduced production by 20 to 30% from the scheduled quantity of production due to the shortage of gas supply, which appears big influence in revenue.

The cause of the gas shortage is the decrease in production of a Sangu gas field. Installation of the line compressor in April, 2009 does not help the situation completely. For the time being, although the production increase from Bakhrabad gas field, Semutang gas field and Feni gas field is expected, it is projected that restrictions of gas will continue until about 2013.

As a national energy policy, gas supply to Fertilizer sector has been restricted until 2013 and then will be expected to be increased due to the update of the facility according to the gas task team meeting on Feb.4, 2010. This view will be applied for the network analysis described later.

(c) Industry

The gas demand for Industry has increased steadily after 1981 and the share has reached to 16% of the total gas demand in 2009.

(d) Commercial

The gas for commercial use is only 1% of the total gas demand in 2009. However, it has been increasing steadily after 1981, the earliest year the data are available.

(e) Domestic

The gas for domestic use is slightly below12% of the total gas demand in 2009. It has also been increasing steadily after 1981.

(f) CNG

The gas demand for CNG suddenly appeared in 2004 and is increasing rapidly.

(g) Tea estate

The gas demand for Tea Estate appeared in 1991. The demand is stagnant and little.

(h) System loss

The system loss was more than 10% in 1980s, but has been improved to 1 % dramatically after 2009.

(2) Current status of area wise and sector wise gas demand

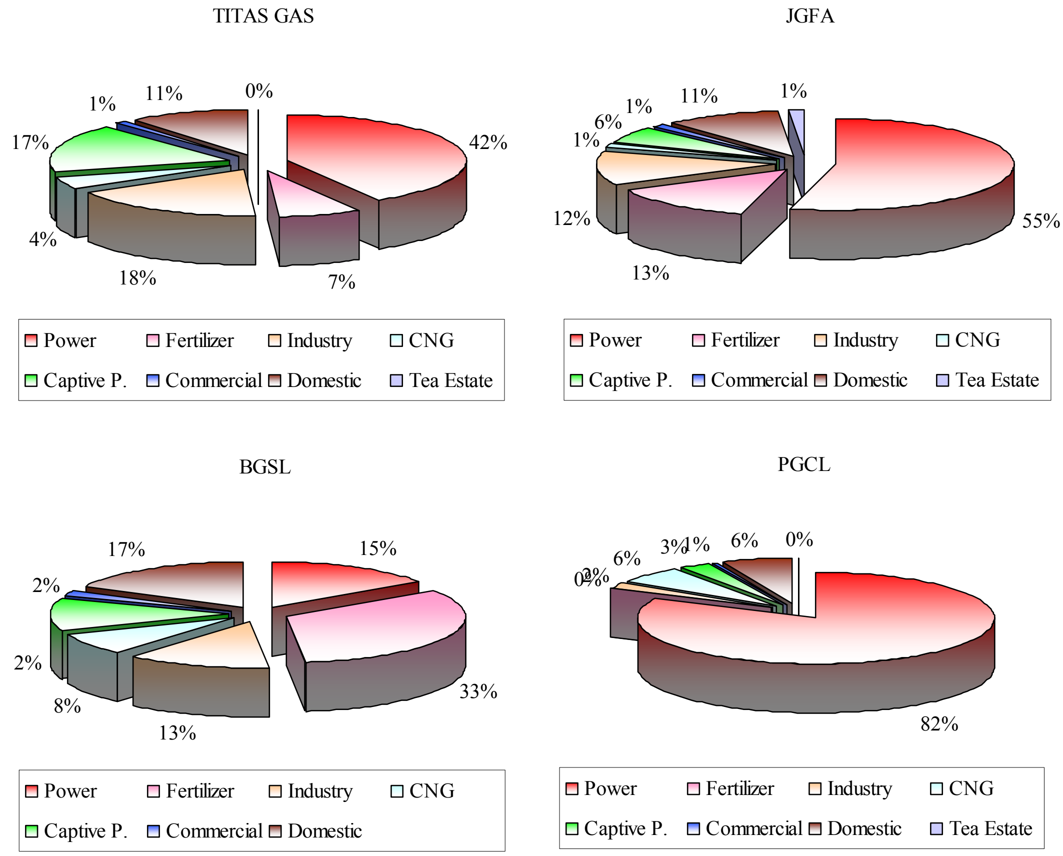
Four distribution and marketing companies are responsible for gas retail in Bangladesh. The amount of gas sales from 2004 to 2009 was calculated utilizing each annual report and local interview. The results are shown below.

Table 5-6 Gas sales amount by sector

(Unit : mmcfd)

	Fiscal Year	Power	Captive P.	Fertilizer	Industry	Commercial	Domestic	CNG	Tea Estate	Total
TGTDCL	2004	400	73	135	103	8	95	5	0	820
	2005	417	88	140	119	8	101	9	0	882
	2006	460	111	133	146	9	109	15	0	983
	2007	469	146	139	176	10	121	25	0	1084
	2008	495	186	107	211	12	130	44	0	1184
	2009	537	219	97	234	13	142	58	0	1301
BGSL	2004	64	12	103	20	4	31	0	0	234
	2005	71	14	101	20	4	34	1	0	245
	2006	77	18	95	23	4	36	3	0	256
	2007	68	21	102	29	4	39	7	0	270
	2008	56	28	93	32	5	44	13	0	272
	2009	42	32	92	37	6	48	21	0	278
JGFA	2004	32	0	16	4	1	8	0	2	63
	2005	32	3	16	4	1	9	0	2	67
	2006	32	3	16	4	1	10	0	2	68
	2007	26	4	16	7	1	10	1	2	68
	2008	40	5	15	8	1	11	3	2	86
	2009	62	7	15	14	1	12	1	2	115
PGCL	2004	53	0	0	1	0	0	0	0	54
	2005	58	0	0	1	0	1	0	0	60
	2006	46	0	0	1	0	1	0	0	49
	2007	43	1	0	1	0	3	0	0	48
	2008	50	1	0	1	0	4	2	0	59
	2009	62	2	0	2	0	5	5	0	76
Total	2004	549	85	254	128	13	134	5	2	1171
	2005	578	105	257	144	13	145	10	2	1254
	2006	615	132	244	174	14	156	18	2	1356
	2007	606	172	257	213	15	173	33	2	1470
	2008	641	220	215	252	18	189	62	2	1601
	2009	703	260	204	287	20	207	85	2	1770

Source : Annual Report, Titas Gas、Annual Report, BGSL、Annual Report, JGFA、Annual Report, PGCL



Source : PSMP Study Team

Fig. 5-3 Sector wise gas sales amount of 4 retailers (FY 2009)

(3) Gas demand-supply management

Petrobangla and the EMRD have involved taking some policy decisions on allocating and sharing the available gas among the power and fertilizer sectors to obtain maximum socio-benefit. For better gas management, especially for the power sector, a committee jointly headed by the Director (Operation) of Petrobangla and the Member (Generation) of BPDB is working since 2006 for gas allocation to different power stations considering the availability of gas. Gas allocations and sharing among the fertilizer and power sectors were carried out by Petrobangla, BPDB and BCIC. In Bangladesh, February to April being the irrigation season of the agricultural sector for which it is essential to supply more electricity for irrigation purposes, and each time, for the last couple of years, more gas is supplied to power sector even reducing gas supply to fertilizer plants.

5.3.2 Gas demand forecast

(1) Methodology

The annual gas demand up to 2030 can be forecasted by using the actual demand data in 2009 as foundational data. Generally speaking, the gas demand and the real GDP are correlated. However it is not universal. Some sectors never depend on real GDP and the newly generated sector has not had enough data for this statistic analysis. Therefore in a strongly correlated sector with a real GDP, a regression analysis can be conducted and for the other sectors, the demand can be forecasted utilizing the materials and local interviews.

(2) Analysis of the correlation between GDP and gas sales by each sector

Demand function is expressed with this equation. D=a*(GDP) ^b

This equation is developed. Log (D) =b*Log (GDP) +Log (a)

And Log (a) and b are found. The magnitude of correlation is checked by R^2.
Where y is log (mmcfd) and x is log (GDP).
Sensibility analyses were also done in forecasting gas demand by GDP correlation.

Table 5-7 Analysis of the correlation and data selection

Group	Sector	Correlation	Principle of demand forecast
Bulk	Power	y=0.9331x-3.2508 R^2=0.9387	The gas demand has a strong correlation with GDP. But it is strongly influenced by government policy, so the statistic analysis will not be appropriate for demand forecast. As the lead time for constructing new plant is long, the forecast will be conducted by investigating the mid-to-long term power plant development program.
	Fertilizer	y=-0.1361+3.2491 R^2=0.0736	The demand has no correlation with GDP. The market itself has not been activated and has gradually shrunken. There are only seven fertilizer plants and no new construction plan in Bangladesh. The demand forecast will be conducted through the interview with the task team of the gas sector.
Non-bulk	Industry	y=1.5649x-7.8163 R^2＝0.8083	The gas demand has a considerable correlation, but not sufficient. The demand forecast will be conducted through the interview with Petrobangla and calculated using the market growth rate in each area reported in Gas Evacuation Plan (2010-2015).
	Captive Power	y=3.6887x-21.681 R^2=0.9961	The gas demand has a strong correlation with GDP. But it is easily influenced by the national policy and it has a trade off relation with the stability of electricity supply, so a statistic analysis is not appropriate in this sector. The demand forecast will be conducted in accordance with the diesel shift scenario obtained from Petrobangla.
	Domestic	y=1.7953x-9.3976 R^2=0.9892	As the gas demand has a strong correlation with GDP and the customer’s number is statistically meaningful, the demand forecast will be conducted by regression analysis. As SGCL is a new area, the demand forecast will be conducted in accordance with the Gas Evacuation Plan.
	Commercial	y=0.9321x-4.8255 R^2=0.8537	As the gas demand has a strong correlation with GDP and the customer’s number is statistically meaningful, the demand forecast will be conducted by regression analysis.
	CNG	y=9.1048x-57.515 R^2=0.9892	The gas demand has a strong correlation with GDP. But the task team of gas sector indicated that the demand might be different by area. So, the demand forecast will be conducted through the interview with Petrobangla and calculated using the market growth rate in each area reported in Gas Evacuation Plan.
	Tea Estate	y=0.0703x-0.1521 R^2=0.0122	The gas demand has no correlation with GDP. The market remains stagnant. The demand will continue the same level of 2009 up to 2030.

Source: PSMP Study Team

(3) Gas demand forecast by each sector

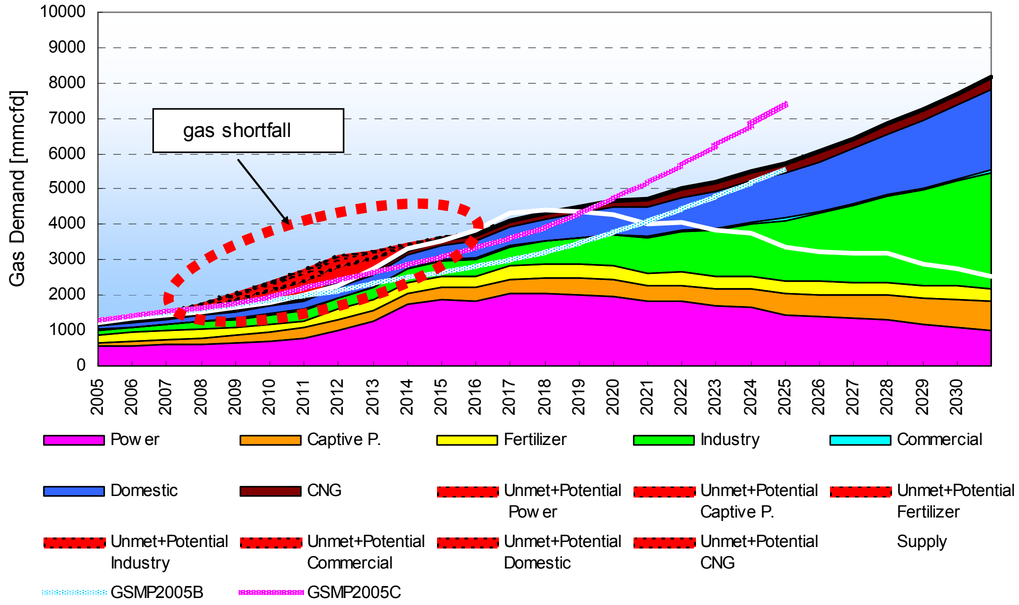
Gas demand forecast by each sector is shown in below table and figure.

Table 5-8 Gas demand forecast by each sector

(Unit : mmcfd)

Fiscal Year	Power	Captive P.	Fertilizer	Industry	Commercial	Domestic	CNG	Tea Estate	unmet + Potential	Total
2004	549	85	254	127	13	135	5	2		1,170
2005	578	105	257	143	13	144	10	2	0	1,252
2006	615	133	244	173	14	155	19	2	160	1,515
2007	606	172	256	212	15	173	33	2	320	1,789
2008	642	220	216	253	18	189	63	2	480	2,083
2009	704	260	205	287	21	207	85	2	640	2,411
2010	776	309	177	326	22	220	102	2	800	2,733
2011	1,023	284	290	320	21	289	109	2	800	3,138
2012	1,265	303	290	356	22	326	125	2	600	3,289
2013	1,734	324	290	396	24	367	142	2	200	3,477
2014	1,863	347	320	440	25	414	158	2	100	3,669
2015	1,841	372	320	489	27	467	174	2	100	3,792
2016	2,050	400	370	562	29	527	183	2	0	4,122
2017	2,068	431	370	647	31	593	192	2		4,334
2018	2,030	465	370	744	33	669	202	2		4,514
2019	1,962	503	370	855	35	755	212	2		4,693
2020	1,819	441	370	983	37	851	222	2		4,726
2021	1,820	465	370	1,131	39	943	234	2		5,004
2022	1,692	490	370	1,301	41	1,046	245	2		5,188
2023	1,641	532	370	1,496	44	1,160	257	2		5,501
2024	1,460	576	370	1,720	46	1,286	270	2		5,731
2025	1,386	625	370	1,926	49	1,427	284	2		6,068
2026	1,352	650	370	2,158	51	1,569	290	2		6,441
2027	1,322	675	370	2,417	54	1,725	295	2		6,860
2028	1,177	722	370	2,707	56	1,898	301	2		7,233
2029	1,113	773	370	2,977	59	2,087	307	2		7,689
2030	1,007	827	370	3,275	62	2,296	313	2		8,152

Source: Gas Evacuation Plan (2010-15) modified by PSMP Study Team



Source: Petrobangla, GSMP2006, Gas Evacuation Plan, modified by PSMP Study Team

Fig. 5-4 Gas demand forecast

As of June 2010, there exists a gas shortfall, breakdown of which is shown in the below table. The total gas shortfall was about 800 mmcfd, in which about 500 mmcfd was unmet demand, i.e. the amount was not delivered to the existing gas customer, and about 300 mmcfd was potential demand, i.e. the amount was wanted from the potential customer who had already applied for a gas contract but it was not executed yet. This gas shortfall arose continuously from around 2005. In order to project the gas demand forecast, the shortfall amount as of June 2010 was incorporated into the forecast as unmet/potential demand, then extrapolated to 2005. The gas shortfall will be alleviated due to the Gas Evacuation Plan (2010-2015) including the introduction of LNG, and the Government incentive plan for switching from gas to other fuels to gas potential customers. Via these measures, the gas shortfall is expected to be dissolved by 2016.

Table 5-9 Breakdown of unmet demand and potential demand as of June 2010 (mmcfd)

Category	Demand	Supply	Balance
Power	1076	760	316
Captive	370	330	40
Fertilizer	289	170	119
Industry	415	375	40
Domestic	245	235	10
CNG	115	100	15
Others	35	30	5
Sub Total	2545	2000	545
Potential	300	0	300
Grand Total	2845	2000	845

Source: Petrobangla

5.4 Current status of natural gas development and production

5.4.1 Current status of natural gas production

Since the development of Chattak gas field, 23 gas fields have been discovered until now and currently (June 2009), 17 gas field are producing the gas. The gas fields are operated by three National companies and four IOC companies. The gas fields of Titas, Bakhrabad, Habiganj, Narsingdi, and Meghna are possessed by BGFCL, the gas fields of Sylhet, Kailastila, Rashidpur, and Beanibazar are possessed by SGFL Company, and the gas fields of Salda, Fenchuganj, and Shahbazpur are possessed by BAPEX. The gas fields of Jalalabad, Moulavi Bazar, Bibiyana (Chevron), Sangu (Cairn), Bangura (Tullow) and Feni (Niko) are operated by IOCs with PSC. The average gas production volume is 1,791 mmcfd (2008/09) in all, and the production volume of IOC makes up 50%. The production capability for each gas field is shown in the following tables. Natural gas chemical properties are tabled in Appendix.

Table 5-10 Production capacity of each gas field

(Bcf)

	Company	Sl. No	Gas field	Discovery	Number of gas well		Production Capacity (mmcfd) (as of June 2009)			Recoverable (Proven+Probable) 2003 basis	Recoverable (Proven+Probable) 2010prelim.	Cumulative (June 2009)	Remaining Reserve (2003 basis)	Remaining Reserve（2010 prelim.）
National	BGFCL	1	Titas	1962	14	30	395	697	41%	5,128	7,582	2,996	2,132	4,586
		2	Bakhrabad	1969	4		33			1,049	1,322	692	357	630
		3	Habiganj	1963	9		236			3,852	2,787	1,617	2,235	1,170
		4	Narsingdi	1990	2		33			215	217	99	116	118
		5	Meghna	1990	1		0			120	49	36	84	13
		6	Begumganj	1977			0			33	33	0	33	33
		7	Kamta	1981			0			50	50	21	29	29
	SGFL	8	Sylhet	1955	1	14	2	157	9%	479	372	189	290	183
		9	Kailastila	1962	6		91			1,904	2,654	466	1,438	2,188
		10	Rashidpur	1960	5		50			1,402	3,149	448	954	2,701
		11	Beanibazar	1981	2		15			170	137	57	113	80
	BAPEX	12	Saldanadi	1996	2	4	10	38	2%	116	267	59	57	208
		13	Fenchuganj	1988	1		27			283	281	60	223	221
		14	Shahbazpur	1995	1		0			466	269	0	466	269
		15	Semutang	1995			0			150	318	0	150	318
IOC	Chevron	16	Jalalabad	1989	4	31	158	811	48%	837	1,245	509	328	736
		17	Moulavi Bazar	1997	4		74			360	889	140	220	749
		18	Bibiyana	1998	12		527			2,401	5,199	361	2,040	4,838
	Cairn	19	Sangu	1996	6		50			500	695	458	42	237
	Tullow	20	Bangura	2004	2		0			309	0	0	309	0
	Niko	21	Feni	1981	3		3			129	130	62	67	68
		22	Chattack	1959			0			474	474	26	448	448
		23	Kutubdia	1977						--	--	--	--	--
Total					79	79	1,70	1,70	100	20,427	36,761	8,376	12,130	19,822

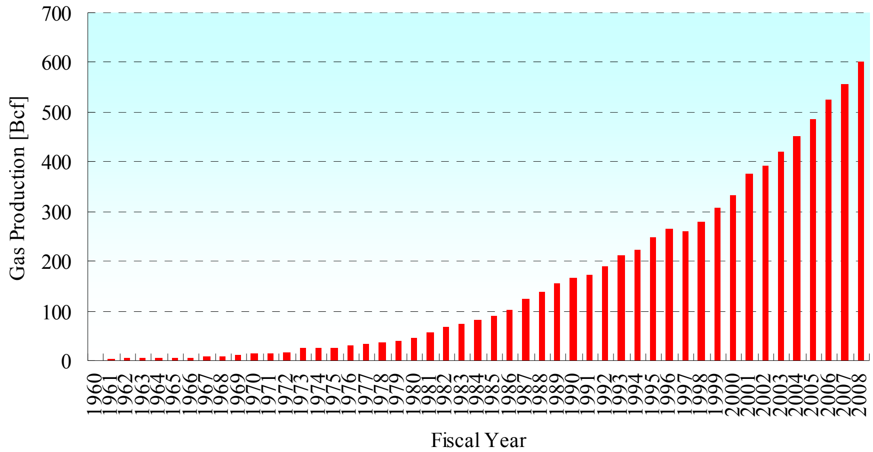
Source: Petrobangla Annual Report 2008 modified by PSMP Study Team

5.4.2 History of gas production

Production history of the country dates back to 1959 when Chattak Gas Field started commercial production and supplying gas to the then Assam Bengal Cement Factory. In 1960 Sylhet Gas Field started commercial production and the only consumer was Fenchuganj Natural Gas Fertilizer Factory. Titas Gas Field which started production in 1968 and in the following year Habiganj Gas Field went into production. Till 1983 these four fields supplied gas to the consumers. Average daily production during 1982-83 was 197 mmcfd. In 1984 Kailastila was added to the list of producing fields. Next year Bakhrabad and Kamta went into production. During the year 1991-92 Feni started production. During 1992-93 daily average production was 577 mmcfd.

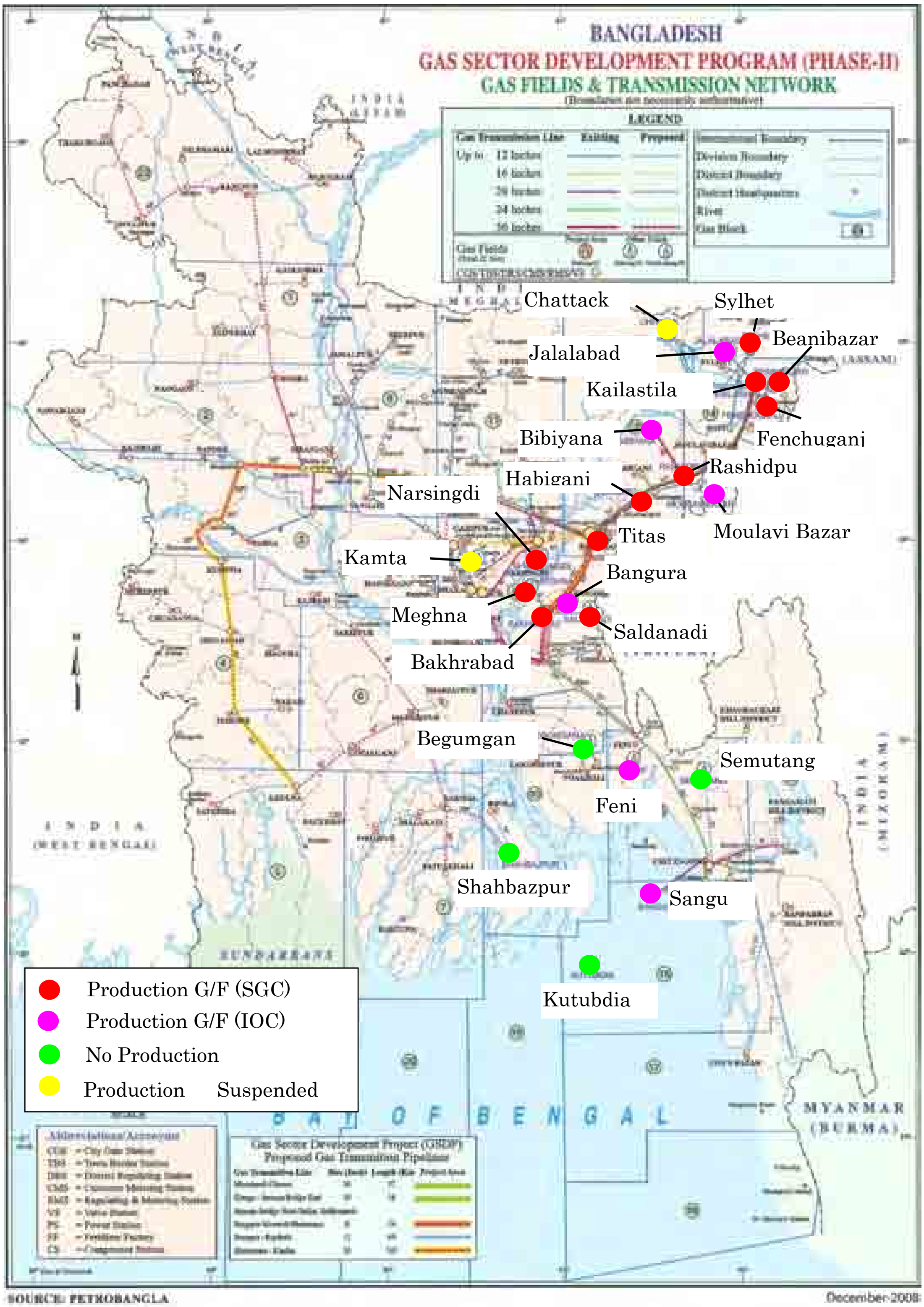
Currently, out of 23 gas fields so far discovered, seventeen are producing. Production from two fields i.e. Chattak and Kamta were suspended in 1985 and 1998 respectively due to excessive water production from different wells. First offshore gas production of the country started in June, 1998 from Sangu Gas Field operated by Cairn Energy Bangladesh Ltd.

At present gas is being produced from 17 fields and operated by three national and four international companies under PSC & JVA. The cumulative production of natural gas in Bangladesh for last 49 years is 8.4 Tcf. The volume of gas production has been increasing substantially from 2000 and onwards. The average annual gas production since inception is given as below:



Source: Clean Fuel Development Program, TCIL (2009)

Fig. 5-5 History of gas production in Bangladesh



Source: Petrobangla

Fig. 5-6 Location map of gas fields

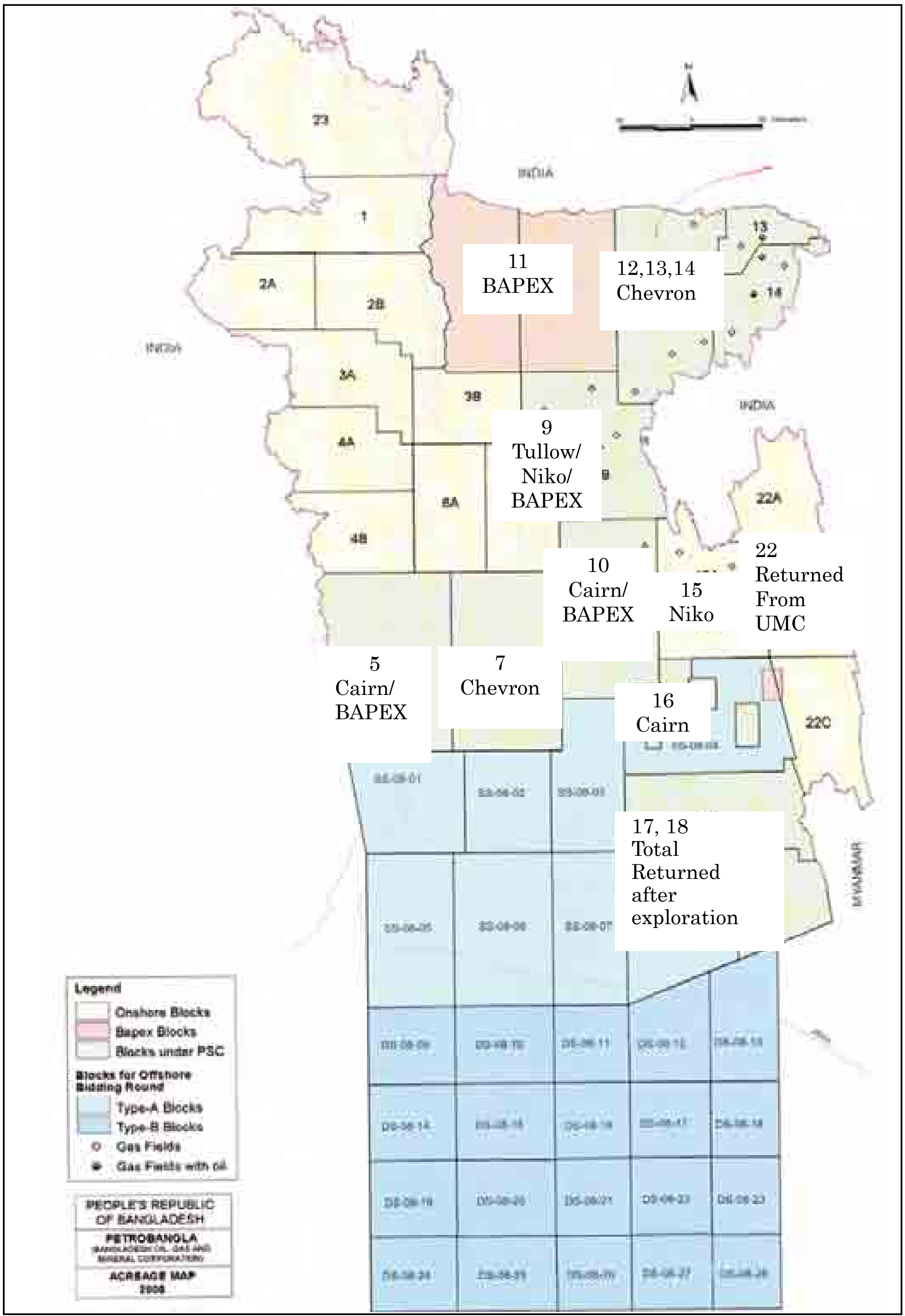
5.4.3 International bidding for newly opened offshore blocks

Before the independence in 1971, the exploration activities were mainly carried out by foreign companies, however, since the effect of petroleum law in 1974, the PSC (Production Sharing Contract) was introduced to exploration, development and production of petroleum and the international bidding of mine site were carried out. In 1993/1994, the first bidding was carried out and eight blocks were awarded a contract. The block 11 was given to BAPEX preferentially. Occidental carried out total five exploratory excavations in three blocks; 12, 13, and 14 under the PSC agreement and confirmed the gas at two places. However, a blast was generated in a well and the accident occurred that destroyed the gas field structure itself and the facility on land surface. On the other hand, for Jalalabad gas field that had been discovered, the production was started in 1998 and it was finally sold to Chevron via Unocal. In blocks 15 and 16, Cairn Energy carried out six exploratory excavations and discovered Sangu gas field at ocean location. The production was started in 1998, however, the gas production volume comes down currently and only 30 to 40 mmcfd of gas is produced. In 2000, Shell/Cairn discovered a new gas field South Sangu 1, however, the production is not carried out until now. In blocks 17 and 18, the exploratory excavation was also carried out, however, the commercial gas was not discovered. The block 22 is not practically investigated yet. Almost all of three blocks; 17, 18, and 22 were returned to Bangladesh following the PSC agreement.

At the second bidding carried out in 1998/1999, four blocks were awarded a contract. With this bidding, BAPEX ensured 10% right of each block. The block 7 and blocks 5 and 10 were awarded a contract by Unocal (Chevron) and JV of Shell/Cairn, respectively. The block 9 was awarded a contract by Tullow Oil and Chevron Texaco. In August and September 2003, ChevronTexaco and Shell made the sellout of mine sites known to public. The reason is that the export of gas was not allowed and the domestic market had a limitation. In 2004, Niko Resources purchased the area possessed by Chevron Texaco (60%) in the block 9. In the block 9, the drastic seismic survey including 3D was carried out and after five test wells were excavated, a large-scale gas field was discovered in Bangora-Lalmai. The production was started in August 2006 and the production volume of 60mmcfd at first increased to 120 mmcfd currently. On the other hand, in the block 12, Chevron finished the development of the first phase in Bibiyana gas field and the gas production accomplished 290 mmcfd, and after the development of the second phase was terminated, the production volume accomplished 500 mmcfd. Bibiyana gas field currently produces 600 mmcfd or more of gas and it seems to have a capability of 700 mmcfd. It is said that the capability can reach 1,000 mmcfd in the future.

Bangladesh divided the offshore mine site into 28 blocks in February 2008 and carried out PSC Offshore Bidding Round- 2008. The recent news report said that seven IOC companies bid for 15 blocks and after the review, ConocoPhillips won a bid for deep sea block (water depth 200m or more) and Tullow won a bid for shallow sea (water depth 200m or less) block. However, the agreements have been suspended and the gas production prospect is not yet clear due to an international border dispute with Myanmar and India.

A new acreage map has been prepared for Bangladesh Offshore Bidding Round -2008 in Fig. 5-7.



Source : Petrobangla

Fig. 5-7 Bangladesh PSC Blocks Status-2008

Box 5.1 What is Production Sharing Contract（PSC）?

PSC is an exploration development contract, a type of service contract which became common in Indonesia from early 1960s, and was adopted by other oil-producing countries. Indonesian president issued a decree to nationalize oil industry in 1960. However, as a result of search for a contract to adopt fund and technology from foreign companies, a series of development contract and PSC were adopted the 1960s.

Different from traditional profit sharing exploration development contract, PSC allows oil-producing countries and foreign oil companies to share products. Foreign oil companies act as contractors for oil-producing countries or crown companies of oil-producing countries, and also provide necessary funds and technology. If commercial-scale product is discovered by exploration, the cost is recovered in kind. The contract allows to recover actual cost in advance as a production cost and to share crude oil after collecting cost between oil-producing countries and oil-producing companies.

Generally, there is a "limit for cost recovery," and only cost for certain percentage of annual production volume is recovered （Unrecovered part is rolled over from year to year）. Since adaptation of the PSC in Egypt in 1970, many countries had adopted PSC. It is now the most common system in developing oil-producing countries. This is because the system allows oil companies to have (1) advantage in terms of cash flow by preferential recovery of funds, and increased possibility for development of smaller oil mines and (2) relatively large profit by minimizing cost. (3) In the meantime, oil-producing countries can benefit from a control over oil resources and exclusive mining rights to nation for nation or crown oil company to operate oil mines and the business, and maintain direct control over crude oil.

5.4.4 Gas Evacuation Plan

A production plan has been drawn up to meet the demand by augmenting supply from national gas companies and increasing gas purchases from the IOCs, There would be about 15 new exploration and development drilling and the five workover together with the necessary process capacity in the public sector supported by necessary process plants which will be installed. The upcoming drilling and workover programme of Petrobangla under the short, mid and long term are furnished below (GEP: Gas Evacuation Plan 2010-15). According to the GEP, the production rate as of 2015 will be double of current one, including 500 mmcfd LNG import. This production plan is indicative/development wells drilling results and reservoir conditions, therefore it could be achievable from technical view points. As it is based on high success rate of exploration and depending on IOC's development more than half, PSMP Study Team assumes the production plan will be ambitious/opportunistic or high case scenario.

Table 5-11 Short/Mid/Long term development and workover

I. Short Term Program (Up to December 2010)					
SL No.	Name of Well	Type of Program Well	Owner of Field/ Structure	Expected Completion Time	Expected Production Augmentation (mmcfd)
1	Sylhet # 7	Workover	SGFL	Jan'10	8
2	Meghna #1	Workover	BGFCL	Jun'10	15
3	Habiganj # 11	Workover	BGFCL	Jun'10	20
4	Titas # 12	Workover	BGFCL	Jun'10	20
5	Semtang # 1, 5	Workover	BAPEX	Dec'10	15
6	Sundalpur # 1	Exploration	BAPEX	Oct'10	15
7	Fenchuganj # 4	Appraisal	BAPEX	Oct'10	20
8	Saldanadi # 3	Appraisal	BAPEX	Jul'10	15
9	Sangu (South)	Exp/Dev	Cairn	Dec'10	30
	Sub Total				158

II. Mid Term Program (Up to Dec 2013)					
SL No.	Name of Well	Type of Program Well	Owner of Field/ Structure	Expected Completion Time	Expected Production Augmentation (mmcfd)
A. Petrobangla Companies					
1	Kapasia # 1	Exploration	BAPEX	Mar'11	15
2	Srikail # 2	Exploration	BAPEX	Fev'11	15
3	Mubarakpur # 1	Exploration	BAPEX	Jun'11	15
4	Saldanadi # 4	Appr/Dev	BAPEX	Mar'11	15
5	Fenchuganj # 5	Appr/Dev	BAPEX	Aug'11	20
6	Titas # 17	Appr/Dev	BGFCL	Jun'11	25
7	Titas # 18	Appr/Dev	BGFCL	Nov'11	25
8	Bakhrabad # 9	Development	BGFCL	Apr'12	20
9	Titas # 19, 20, 21, 22	Development	BGFCL	Jun'12	100
10	Rashidpur # 5	Development	SGFL	Jun'12	15
11	Rashidpur # 8	Development	SGFL	Jun'12	20
12	LNG	Import		Dec'12	500
	Total (I)				785
B. IOC's					
1	Moulavibazar	Development	Chevron	Jun'12	100
2	Kajol	Exploration	Chevron	-	-
3	Bibiyana	Development	Chevron	Dec '13	200
4	Manama	Exploration	Cairn	-	-
	Sub Total				300
	Total (II)				1085

III. Long Term Program (Up to 2015)					
SL No.	Name of Well	Type of Program Well	Owner of Field/ Structure	Expected Completion Time	Expected Production Augmentation (mmcfd)
A. Petrobangla Companies					
1	Titas #23,24,25,26	Appraisal	BGFCL	2015	100
2	Sylhet, Kailashtila & Rashidpur	Appraisal	SGFL	2015	80
	Sub Total				180
B. IOC's					
1	Magnama	Development	Cairn	2015	-
2	Kajol	Development	Chevron	2015	-
3	Moulavibazar	Development	Chevron	2015	200
4	Bibiyana	Development	Chevron	2015	250
5	Jalalabad	Development	Chevron	2015	250
6	Offshore bidding round 2008	Exploration		2015	200
	Sub Total				900
	Total (III)				1080
	Grand total (I +II + III)				2323

Source: Gas Evacuation Plan (2010-2015)

5.5 Examination for marginal production capacity of natural gas

5.5.1 Possibility of increasing production at existing gas fields

As of November 2009, Bangladesh produces gas equivalent to approx. 1,950 mmcfd at 79 gas wells in 17 gas fields. Among them, 11 wells have been suspended of production due to a certain reason. Except for 2 or 3 wells that stopped production due to mechanical reasons, most of the suspension in production is attributable to gas layer itself. When a well cannot produce gas due to inclusion of formation water, a refurbishment work is necessary by filling the lower layer and newly completion the upper layer. How to refurbish varies well by well. Even a tentative blocking of formation water inflow can secure production volume of 5 to 10 mmcfd per well. However, if stereoscopic structure of gas layers, distribution of gas and formation water using a 3D seismic survey can be identified, more effective refurbishment plan can be formed. It is necessary to shape methods of increasing gas production by introducing a latest completion technology. It is also essential to pay efforts to reduce cost for refurbishment works as well as to enhance speed of the works by using a coil tubing unit. Among the existing gas fields, Begumganj, Shahbazpur and Semutang Gas Fields have been left unattended after confirmation of gas layers exist. Past data should be reviewed and re-development works should be examined by referring to the latest seismic survey data. Besides them, Chattack Gas Field and Kamta Gas Field have hefty amount of deposit still now but production hasn't been resumed yet. These gas fields must be surveyed so that production can be resumed as soon as possible. As broad seismic surveys have been conducted to existing gas fields, depending on the outcome, there is still room of drilling fair number of wells additionally. Like Titas Gas Field, a half of the structure on the southern part of it is left underdeveloped. It seems that there is still room of developing gas fields in the country.

5.5.2 Possibility of increasing production from new gas field development

In Bangladesh, total 75 trial wells have been drilled so far during the history of about 50 years. Speaking of 2001 and thereafter, the number of trial wells drilled remains 5 on the land and 4 under the sea. This level is quite low from the world standard. So far, 23 inland gas fields and 2 sea gas fields have been discovered including two petroleum layers. The ratio of successful trial drilling is about 30%. In this sense the ratio of discovery is quite high suggesting that the country is blessed with abundant natural gas reserves. BAPEX conducted a series of geological survey from 2007 to 2008 for 183 km extended from the eastern end of the Julji Structure to the western end of the Banderban Basin. 77 rock specimens as well as gas specimens from two locations were collected for analysis as to whether they contain hydrocarbon or not. Additionally, gas specimens were collected and analyzed from 14 gas leakage sites. The locations include Sylhet, Chittagong, Khulna and Moulavibazar. In addition to the geological surveys, seismic surveys were also conducted. A 3D seismic survey will be conducted by BAPEX covering the area of 1,250km^2 where Titas Gas Field and Bakhrabad Gas Field controlled by BGFCL and Sylhet Gas Field, Kailashtila Gas Field and Rashidpur Gas Field controlled by SGFL exist. In addition, similar seismic surveys will be conducted in Mubarakupur, Kapasia and Sundalpur as candidates for trial drilling. As to IOC, the Block-7 Chevron is being focused. It is reported that at Chevron, a seismic survey was conducted in 2006 extending to 1,000 km that as a result, hydrocarbon structures were found at three places and that detailed survey of the structure is ongoing now. Cairn Energy discovered the Magnama Structure in the vicinity of Sangu Gas Field in Block-16 Mine Area and it is said that a 3D seismic survey is being conducted. There are many underdeveloped areas both inland and sea areas According to a joint survey conducted in 2001 by United States Geological Survey (USGS) and Petrobangla, gas equivalent to 32 Tcf exists with the probability of 50%. It is highly likely that new structures will be discovered.

5.6 Possibility of importing natural gas by pipeline

In Bangladesh, where there is a growing and urgent demand of natural gas, there seems to various arguments on import of natural gas. In the past, there was a plan to supply gas from Bibiyana Gas Field to the gas market in northern India but was suspended due to the assertion of the Government of Bangladesh that it would not export gas unless strategic volume of reserves enough to support domestic demand of gas for at least 50 years be secured. After then, there was a sudden change in conditions and people in Bangladesh argued against the possibility that supply of natural gas doesn't meet its demand and importing natural gas was on the table of argument. The possible importing route via pipeline is from India or Myanmar. In India, Reliance, a conglomerate discovered a large-sized gas field, Dhirubhai, at KG-DWN-98/3 (D6) mining area located at the KG sedimentation basin in the east of the Bay of Bengal in 2002. The success of discovering the gas field stimulated investment to the upstream function of the area, which led to discovery of other large-sized gas fields. Consuming the period of 7 years, the gas field started production in April 2009. It is expected that this will further lead to uplifting Indian economy and securing energy. Under such circumstances, Bangladesh seems to have had several times of meetings with India over importing natural gas from the country, but the result of the meeting is unknown. On the other hand, in Myanmar, Daewoo in South Korea discovered Shwe Gas Field at A-1/3 mining area off the western coast of the country in 2004. According to Daewoo, available gas reserve combining 3 gas fields in the vicinity amounting to 4.8 to 8.6 Tcf. Bangladesh seems to have had a negotiation with Myanmar in February 2002 to import natural gas from the country via pipelines, but Myanmar seems to have announced that it would prioritize export of natural gas to China and India, first. The Myanmar side disclosed that it would examine export of natural gas to Bangladesh provided that there is room of doing so after exporting to China and India. The trend surrounding importation of natural gas seems to be a very complex and sensitive issue with a mixture of speculations of related countries.

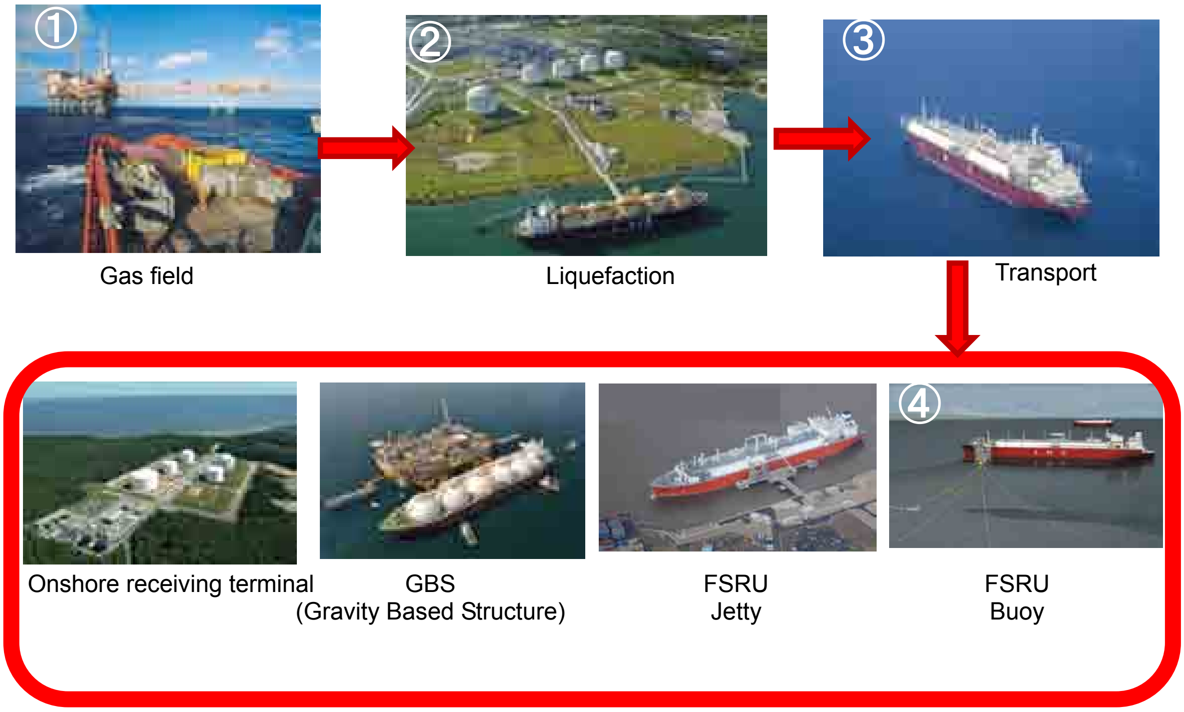
5.7 Feasibility of LNG imports

In consideration of the excess demand versus the supply of natural gas in Bangladesh, the shortage should be resolved by LNG imports.
Taking into account of the above situation, a feasibility study of the offshore regasification system should be taken up in view of availability of a new technology in the LNG world.

5.7.1 LNG chain

The LNG chain from production in the gas field up to consumption at the user level is described below.

(1) Production in gas field
(2) Liquefaction.
(3) Natural gas is liquefied with its volume approximately 1/600, temperature -162 degree C.
(4) Transportation from the liquefaction plant to a user by a special cargo ship. Regasified at the regasification system, then supply natural gas to the user.



Source: NIKKISO CO., LTD. study data (2010)

Fig. 5-8 LNG chain and receiving terminal

5.7.2 Offshore regasification system outline

Floating Storage Regasification Unit (FSRU) is one of the technologies developed as an offshore LNG regasification system.
The advantage of FSRU is that LNG storage, transportation and regasification are available with low costs and short delivery instead of a huge and complicated plant onshore.
All regasification processes which encompass storage, transportation and regasification can be completed by the FSRU itself.
RV (regasification vessel) developed by the Excelerate as well belongs to category of FSRU.
Currently, following the two types of mooring systems have been established as shown below.

Jetty

-Enough depth of water for voyage is required
-Convenient of human access
-All types of FSRU are available

Buoy

-Anchored in the offing. Hence no special attention is required regarding to the depth of water.
-Type of FSRU which can be connected to buoy is restricted.

Source: NIKKISO CO., LTD. study data (2010)

Fig. 5-9 Type of mooring system

5.7.3 Comparison of LNG receiving terminal

GBS (Gravity Based Structure) and FSRU have been categorized as offshore receiving terminals. Furthermore, 2 types of LNG loading systems which are the Jetty mooring and the Buoy mooring systems have been developed as FSRU.

The onshore receiving terminal and the GBS have an advantage in supplying bigger gas capacity, however, the construction lead time is long and the cost is high compared with FSRU as shown in the below table.

Table 5-12 Comparison of LNG receiving terminal[6]

	Onshore Receiving Terminal	Offshore Receiving Terminal		
		GBS	FSRU	
			Jetty mooring	Buoy mooring
Operating history since development	50 years	2 years	3 years	5 years
Construction Cost Note-1	US$500M to 1000M	US$ 1500M	Pipe line US$80M FSRU US$100M-250M	Buoy US$80M FSRU US$100M-250M
Lead time	4 years	4 years	0.5 years 1.5 years	1.5 years 1.5 years
Capacity	>1000 mmcfd	775mmcfd	500 mmcfd	500 mmcfd
Miscellaneous	Expansion is possible	Expansion is impossible	Both shuttle/fix operation is possible Enough water depth for voyage is required	Both shuttle/fix operation is possible
Evaluation	△	△	○	◎

Source: NIKKISO CO., LTD. study data (2010)

[6]Costs shown on the table is a reference value, because it depends on the location, design etc.

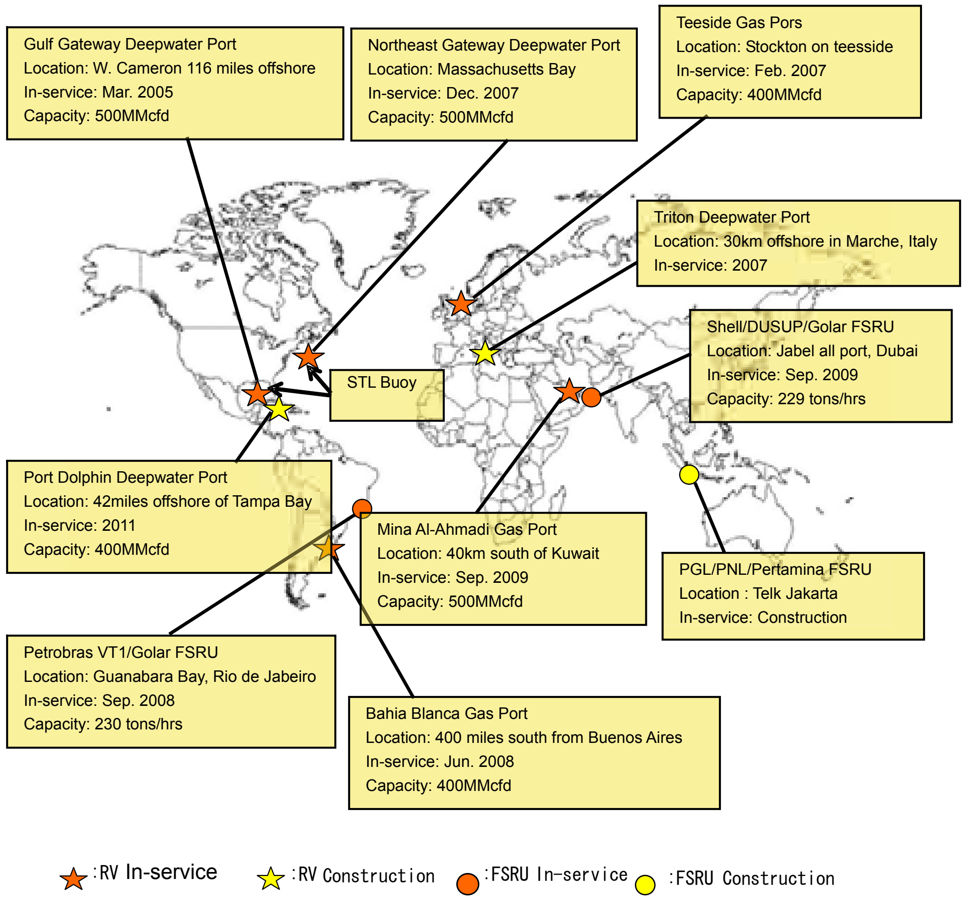
5.7.4 FSRU/RV installation list

Number of FSRU in Table 5-13 are now working in the world.

Table 5-13 FSRU/RV in the world

Project	Energy Bridge	Suez Neptune	Petrobras Guanabara Brazil	Shell DUSUP Dubai	Livorno offshore Italy
Ship owner	Exmar Excelerate energy	Hoegh LNG	Golar LNG	Golar LNG	OLT Offshore LNG
RV/FSRU	RV	RV	FSRU/RV	FSRU	FSRU
Nos.	8	2	2	1	1
Ship name	Excelsior Excellence Excelerate Explorer Express Exquisite Expedient Exemplar	GDF Suez Neptune GDF Suez CAPE ANN	Golar Spirit (FSRU) Golar Winter (RV)	Golar Freeze	Golar Frost
Operation start at	3 ships 2005～2006 5 ships 2008～2010	2009	Golar Spirit 2008 Golar Winter 2009	2010	2010
Storage capacity	3 ships 138,000 m3 (4.87Mcf) 5 ships 150,900 m3 (5.33Mcf)	145,000 m3 (5.12Mcf)	Golar Spirit 129,000 m3 (4.56 Mcf) Golar Winter 138,000 m3 (4.87 Mcf)	125,000 m3 (4.41 Mcf)	137,000 m3 (4.84 Mcf)
Sendout capacity	500 mmcfd	500 mmcfd	Golar Spirit 250 mmcfd Golar Winter 500 mmcfd	400 mmcfd	500 mmcfd
Voyage	Possible	Possible	Possible	Impossible	Impossible
Jetty/Buoy	Both available	Both available	Jetty	Jetty	Buoy

Source: NIKKISO CO., LTD. study data (2010)



Source: NIKKISO CO., LTD. study data (2010)

Fig. 5-10 Location of FSRU/RV

5.7.5 Subjects to be considered for offshore regasification unit

List of expected problems and an evaluation is described as below.

Table 5-14 List of expected problem and evaluation

	Subject	Evaluation
1	Access of FSRU/LNG Cargo	Generally, the necessity of the water depth under 100% LNG loading condition is approximately 20m. It is possible to adopt the FSRU system in case the water depth around the receiving system is deeper than 20m.
2	Evaluation for rolling and pitching	1) Mechanical strength of LNG tank Mechanical strength of LNG tank in FSRU must be considered in order to withstand the hydraulic force due to movement of LNG during voyage. (sloshing) Old cargo ships were designed based on only 2 typical cases such as LNG fully loaded or completely emptied in the tank during voyage. 2) Limitation of wave height in operation STL (Submerged Turret Loading) system is designed up to 11m of wave height, corresponding to a 100 year storm. It was confirmed that the operation was performed without any problems at the Hurricane Katrina attack (category 5) in 2005 at Mexico bay.

	Subject	Evaluation
		*Wave height at "category 5" is categorized as 5.8m or greater. 3) Restriction while the LNG is loaded to FSRU from the cargo ship Loading is possible under the wave height below 2.5m. It can be concluded that LNG loading within "category 2" is possible.
3	Influence to environment	Influence to the environment of FSRU is lower than the onshore regasification system. 1) Consideration to NIMBY (Not In My Back Yard) campaign Influence to the environment can be minimized by the establishment of the FSRU in the offing. 2) Consideration of the cooled water used after vaporizing Influence to the marine ecological system around the FSRU due to draining the cold water used after the LNG vaporizing is concerned. This problem can be solved by using the Vaporizer except for the Open-Rack type. Although the running cost is higher than the Open-Rack vaporizer.

Source: NIKKISO CO., LTD. study data (2010)

5.8 Underground coal gasification

Recently, each country conducts experimental test of underground coal gasification (UCG) technology. It seems that the UCG technology is being developed for the purpose of effective utilization of coal resources located deep under the ground or in complex geological structure. It is pointed out that the merit of gasification of coal under the ground includes there is no need of constructing a gasification furnace above ground and cost can be curtailed. It is reported that Bangladesh has five coal fields in the northwestern area. Among them, however, Barapukuria Coal Field is only the one that is in operation now, and for others coal mining hasn't been started yet. Among them, Jamalganj Coal Field has a coal layer at 640m to 1,000m under the ground and hence, normal method of mining cannot be applied. In order to effectively use the coal reserves and due to the shortage in gas supply, it seems necessary for the country to examine whether the UCG technology can be applied to Jammalganj Coal Field or not. The coal reserve at Jammalganj Coal Field is said to be approx., 1 billion ton. The UCG technology has been among the topic for a long time and each country seems to be involved in the study of it. However, a new and more effective technology may be discovered that is environmentally friendly at the same time, by merging new technologies to UCG technology. Russia is advanced in terms of UCG and it is said that a practical plant has been in operation after the World War II. There is also a report that India and Vietnam are involved in an experimental development project. Bangladesh should start examination of the possibility by requesting experts for investigation of it and establish pilot test for it as far as possible.

5.9 Long and mid term production forecast of natural gas

5.9.1 Long-term production forecast scenario setting

Long-term production forecast was investigated by setting with three scenario cases; Government Plan (high), PSMP Study Team Plan-1 (base), and PSMP Study Team Plan-2 (low). The element of each case is shown in Table 5-15 for natural gas supply scenario basic chart.

Table 5-15 Natural gas supply scenario basic chart

Case	Government	Study Team 1	Study Team 2
(National Company)			
Existing gas field (Petrobangla) Proven reserve(P1)	●	●	●
Existing gas field (Petrobangla) Probable reserve (P2)	●	●	●
Existing gas field (Petrobangla) Possible reserve (P3)			
Kamta gas field re-development	●	●	●
Chattack gas field re-development (East)			
New discovery 1 （Petrobangla） Srikail, Sundalpur, Kapasia, Mubarakpur	●	●	●
Block 11 (Netrokona)	●		
(IOC)			
Existing gas field (IOC 1) Proven reserve (P1)	●	●	●
Existing gas field (IOC 1) Probable reserve (P2)	●	●	●
Existing gas field (IOC 1) Possible reserve (P3)			
Chattack gas field re-development (West)	●		
New discovery (IOC 2)			
Block 7 (Kajal)	●	●	●
Block 16 (Magnama, Hatia, Manpura)	●	●	●
Block 17 & 18			
New discovery (IOC 3)			
Offshore Bidding 2008 #1	●	●	
Offshore Bidding 2008 #2	●		
(Imported Natural Gas)			
LNG	●	●	●

Source: PSMP Study Team

5.9.2 Concept for each case

The gas production forecast is composed of development and work-over from existing gas fields as well as development from new gas fields. According to the expectation level of success, the PSMP Study Team with Petrobangla and the member of the Task Team investigated three cases; Government Plan (high case), PSMP Study Team Case 1 (middle case) and PSMP Study Team Case 2 (low case).

In the long-term forecast, the PSMP Study Team reviewed the “Clean Fuel Sector Development Program (consultant: Technoconsult International Limited) which ADB carried out in March, 2009” (ADB program) as base and modified it according to the results of an investigation, the field survey and discussion with Task Team. The long-term forecast is based on the sum total of the proved reserves (P1) of the existing gas field (the gas production company affiliated with Petrobangla plus the existing IOC) and probable reserves (P2).

As for field survey, it was conducted from the end of October, 2009 to early in November during a visit to Petrobangla, three subsidiary gas production companies (BAPEX, BGFCL, SGFL) and an interviews with two companies (Chevron, Cairn) of IOC were held. Further, a field survey in the Titas gas field of BGFCL, the Kailashtila gas field of SGFL, and the Bibiyana gas field of Chevron was conducted.

According to the information acquired from Titas gas field, the southern part of the area which occupies a space of 30 percent or more of the gas field is underdeveloped. However, it seems to be promising based on the 3D survey with the financial support of ADB. Such a situation has been taken into consideration and the Titas Prediction of the ADB investigation which has set the maximum production size of the gas field to 565 mmcfd by 2020 is revised upward to 678 mmcfd.

The production of the Kailashtila gas field was interrupted due to the decreased pressure of the No.5 well which began production as a new layer in 2006 with the permeation of the stratum water. Since the upper part had thick unproduced sand layers according to SGFL, it was scheduled to be finished with this repair work. Concerning the production of this gas field, it gradually increased from 115 mmcfd in 2010 via an ADB investigation. Then the production was increased as predicted to 325 mmcfd in 2020. Based on the production increase plans of SGFL, the production history of this gas field, it was judged that there is more potential so that production forecast may go up to 500 mmcfd in 2023 in the Government case.

At the field survey of the Bibiyana gas field, the amount of gas production during the investigation period exceeded original expectations of 640 mmcfd. According to Chevron’s explanation, the potential production capacity of the gas field was able to reach more than 1,000 mmcfd if the results of the 3D prospecting were taken into consideration. Since the maximum production size was predicted to be 500 mmcfd in the ADB investigation. However, the current production rate is already exceeding the ADB’ prediction. The forecast was revised upwards to 1166 mmcfd in the Government case.

In addition to the aforementioned results of the investigation, the production increase prospects from the new offshore sites were considered and a prediction evaluation was conducted.

Reflecting the aforementioned site survey and the prospects form the new discovery, a natural gas prediction was conducted.

Government case (high case):
The gas reserve is derived from the HCU preliminary reserve report 2010, including proven and probable reserves. In terms of the new discovery, New discovery 1 (Srikail, Sundalpur, Kapasia, Mubarakpur), New discovery 2 (Block 7 (Kajal), Block 16 (Magnama, Hatia, Manpura), Block 11 (Netrokona) and New offshore bidding site (200mmcfd) have been taken into account as gas production. The Government case fully reflects the “Gas Evacuation Plan (2010-15)” up to 2015 as the fast track augmentation program where Petrobangla, GTCL et al formulated. In the Government case, the gas production will reach to plateau around the year 2018, at a 4,000mmcfd production rate, and then decrease gradually thereafter.

PSMP Study Team Case 1 (middle case):
The gas reserve is derived from the HCU preliminary reserve report as well. New discovery 1 (Srikail, Sundalpur, Kapasia, Mubarakpur), New discovery 2 (Block 7 (Kajal), Block 16 (Magnama, Hatia, Manpura) and New offshore bidding site (100mmcfd) are taken into account, however, Block 11 (Netrokona) is not taken.

PSMP Study Team Case 2 (low case):
The gas reserve is derived from the HCU preliminary reserve report as well. Only New discovery 1 (Srikail, Sundalpur, Kapasia, Mubarakpur), New discovery 2 (Block 7 (Kajal), Block 16 (Magnama, Hatia, Manpura) have been taken into account.

Chattack East re-development, New Discovery 2 (Block 5, 10, 17, 18) are not included in any cases, as it is judged difficult to commence production by 2030 in consideration of the current development situation.

In addition, the Bangladeshi Government has set forward the introduction of LNG by 2013 for the measures of serious gas shortfall. As mentioned previously, the PSMP Study Team independently researched the feasibility of LNG facilities, there already exists several offshore LNG terminals to be practically used. Therefore, the PSMP Study Team believes the offshore LNG terminal is technically possible as a provisional case until the permanent terminal is constructed. In this MP, LNG is included as a complement to domestic gas production.

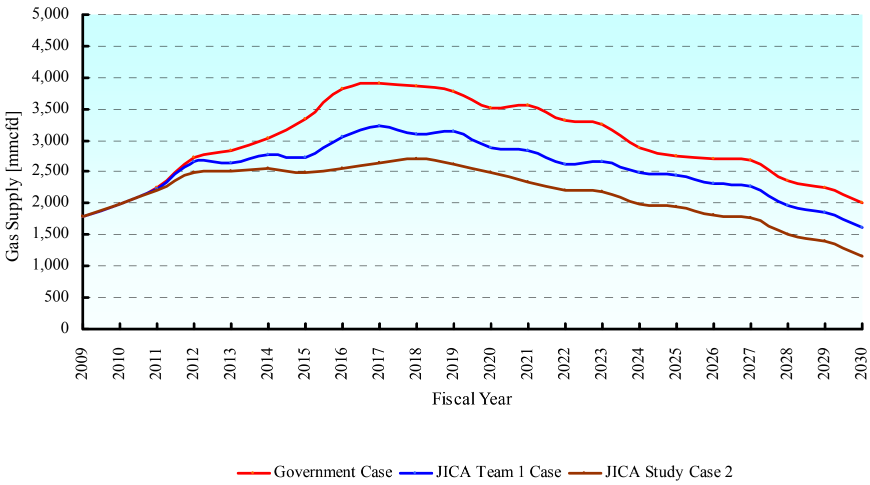
5.9.3 Results of long-term production forecast

Estimated resuls of long term production forecast is shown I Table 5-16 and its graphical view is shown in.Fig. 5-11

Table 5-16 Long term production forecast (without LNG)

Cases	Government Case		PSMP Study Case 1		PSMP Study Case 2	
	(mmcfd)	(Bcf)	(mmcfd)	(Bcf)	(mmcfd)	(Bcf)
2008 – 2009	1,791	654	1,791	654	1,791	654
2009 – 2010	1,995	728	1,995	728	1,995	728
2010 - 2011	2,253	822	2,225	812	2,208	806
2011 - 2012	2,738	999	2,673	976	2,479	905
2012 - 2013	2,838	1,036	2,636	962	2,512	917
2013 - 2014	3,038	1,109	2,765	1,009	2,563	935
2014 - 2015	3,348	1,222	2,730	996	2,498	912
2015 – 2016	3,818	1,394	3,062	1,118	2,554	932
2016 – 2017	3,907	1,426	3,230	1,179	2,647	966
2017 – 2018	3,874	1,414	3,108	1,134	2,698	985
2018 – 2019	3,778	1,379	3,148	1,149	2,618	956
2019 – 2020	3,513	1,282	2,888	1,054	2,488	908
2020 – 2021	3,563	1,300	2,838	1,036	2,328	850
2021 – 2022	3,323	1,213	2,623	957	2,203	804
2022 – 2023	3,253	1,187	2,653	968	2,173	793
2023 – 2024	2,879	1,051	2,479	905	1,979	722
2024 – 2025	2,749	1,003	2,449	894	1,949	711
2025 – 2026	2,709	989	2,309	843	1,809	660
2026 – 2027	2,679	978	2,279	832	1,779	649
2027 – 2028	2,367	864	1,967	718	1,517	554
2028 – 2029	2,247	820	1,847	674	1,397	510
2029 – 2030	2,017	736	1,617	590	1,167	426

Source: Petrobangla modified by PSMP Study Team



Source: Petrobangla modified by PSMP Study Team

Fig. 5-11 Long term production forecast (without LNG)

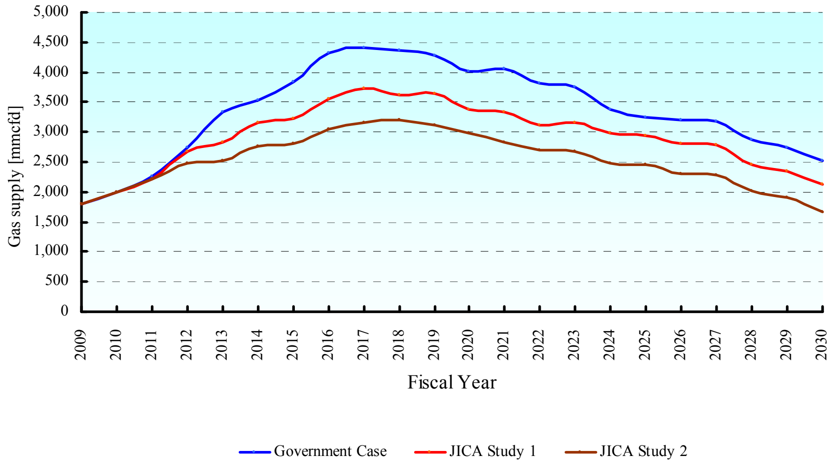
In each case, in addition to the production from the existing gas fields, the increased production is expected from a new gas field via the discovery of a new structure in the future and the production amount will be increased till 2017. In case of the PSMP Study Case 1, the production amount will peak out at 3,320 mmcfd in 2017 and gradually decline thereafter. Even in the Government Case, the production amount will peak out at 3,907 mmcfd in 2017 and begin its decline thereafter and the PSMP Study Case 1 also indicates the same trend. In case of the PSMP Study Case 2, it also indicates the same trend but the peak production amount is steady at 2,698mmcfd.

As a measure of gas shortage, the Bangladeshi Government plans to introduce LNG by 2013. The table and figure shows the total gas supply with LNG below.

Table 5-17 Long term gas production forecast (with LNG)

Cases	Government Case		PSMP Study Case 1		PSMP Study Case 2	
	(mmcfd)	(Bcf)	(mmcfd)	(Bcf)	(mmcfd)	(Bcf)
2008 – 2009	1,791	654	1,791	654	1,791	654
2009 – 2010	1,995	728	1,995	728	1,995	728
2010 - 2011	2,253	822	2,225	812	2,208	806
2011 - 2012	2,738	999	2,673	976	2,479	905
2012 - 2013	3,338	1,218	2,836	1,035	2,512	917
2013 - 2014	3,538	1,291	3,165	1,155	2,763	1,008
2014 - 2015	3,848	1,405	3,230	1,179	2,798	1,021
2015 – 2016	4,318	1,576	3,562	1,300	3,054	1,115
2016 – 2017	4,407	1,609	3,730	1,361	3,147	1,149
2017 – 2018	4,374	1,597	3,608	1,317	3,198	1,167
2018 – 2019	4,278	1,561	3,648	1,332	3,118	1,138
2019 – 2020	4,013	1,465	3,388	1,237	2,988	1,091
2020 – 2021	4,063	1,483	3,338	1,218	2,828	1,032
2021 – 2022	3,823	1,395	3,123	1,140	2,703	987
2022 – 2023	3,753	1,370	3,153	1,151	2,673	976
2023 – 2024	3,379	1,233	2,979	1,087	2,479	905
2024 – 2025	3,249	1,186	2,949	1,076	2,449	894
2025 – 2026	3,209	1,171	2,809	1,025	2,309	843
2026 – 2027	3,179	1,160	2,779	1,014	2,279	832
2027 – 2028	2,867	1,046	2,467	900	2,017	736
2028 – 2029	2,747	1,003	2,347	857	1,897	692
2029 – 2030	2,517	919	2,117	773	1,667	608

Source: Petrobangla modified by PSMP Study Team



Source: Petrobangla modified by PSMP Study Team

Fig. 5-12 Long term production forecast (with LNG)

In the table below, it indicates the comparison with the predicted gas supply assumed in this MP and the previous Gas Sector Master Plan 2006 (GSMP2006).

Comparison with GSMP2006 and this master plan is shown in following table.

Table 5-18 Comparison with GSMP2006

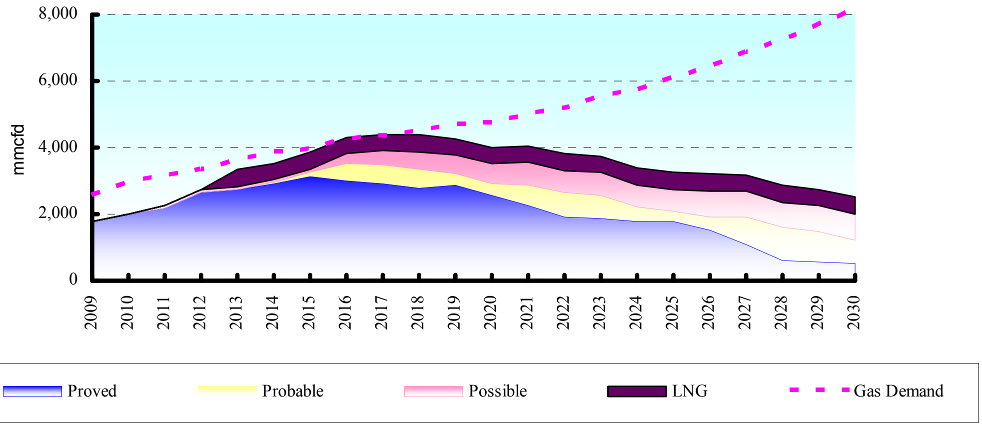
	Gas Sector Master Plan 2006	PSMP2010	
	PSMP Study Case1	Case B	difference
	(mmcfd)	(mmcfd)	(mmcfd)
2009 – 2010	1,896	1,995	99
2010 – 2011	2,022	2,225	203
2011 – 2012	2,158	2,673	515
2012 – 2013	2,340	2,636	296
2013 – 2014	2,518	2,765	247
2014 – 2015	2,669	2,730	61
2015 – 2016	2,852	3,062	210
2016 – 2017	3,030	3,230	200
2017 – 2018	3,240	3,108	-132
2018 – 2019	3,509	3,148	-361
2019 – 2020	3,818	2,888	-930
2020 – 2021	4,112	2,838	-1,274
2021 – 2022	4,439	2,623	-1,816
2022 – 2023	3,992	2,653	-1,339
2023 – 2024	3,636	2,479	-1,157
2024 – 2025	3,324	2,449	-875

Source: GSMP2006, PSMP Study Team

When comparing case B of GSMP2006 with the PSMP Study Case 1 of this MP, the production amount of the MP is greater than that of GSMP2006 until 2017, while the production amount of GSMP 2006 is greater than that of the MP after 2018. The reason for this difference is derived from the GSMP2006 which assumes 1600mmcfd a large amount of YTF (Yet to Find) in the later years. The production of GSMP 2006 without YTF is max 3424 mmcfd in 2010, which is almost the same as max production 3230 mmcfd in 2007 of this MP. In any case, unless a large scale gas field is discovered soon, it will be difficult for domestic gas to maintain a stable supply over the long term.

5.9.4 Government Target Case

In the Government Target Case, the gas production is derived from the "Gas Evacuation Plan (2010-15)" and expected gas production from each gas field extrapolated up to 2030. The gas demand supply balance of the Government case is shown in the below figure.



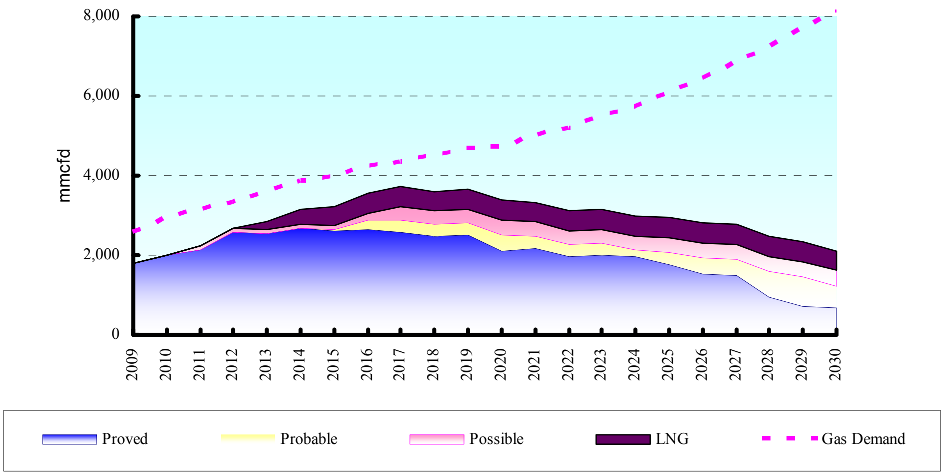
Source: Petrobangla and modified by PSMP Study Team

Fig. 5-13 Gas demand supply balance (Government Target Case)

The amount of gas production all included Proven (P1), Probable (P2), possible reserve (P3) and LNG will be increased until 2017, then gradually decreased thereafter. In 2016 and 2017, the production will be greater than the demand and the demand supply gap will be dissolved for a short period of time. However, the gap will be split again after 2019. The gap would reach 6,000 mmcfd as of 2030, if the demand supply forecast drastically changes.

5.9.5 PSMP Study Case 1

The gas demand supply balance of the PSMP Study Case 1 is shown in the below figure.



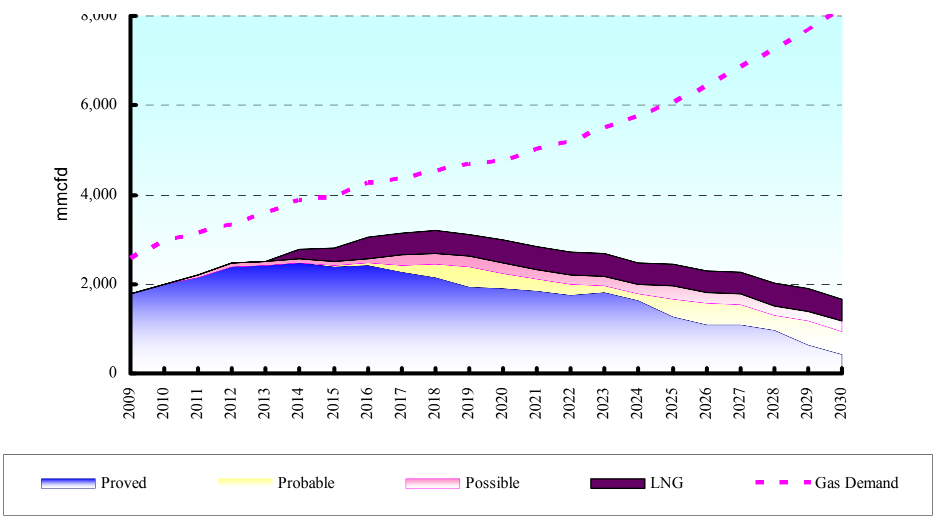
Source: Petrobangla and modified by PSMP Study Team

Fig. 5-14 Gas demand supply balance (PSMP Study Case 1)

In the case of the PSMP Study Case 1, the gas demand and supply will not be balanced and the gap will not be dissolved. The gas production will be increased up to 2019. However, without meeting the demand and supply gap, the gap will be expanded after 2019. The gap is 955mmcfd in 2010, and will be expanded to 722 mmcfd and 1,338 mmcfd in 2015 and 2020 respectively.

5.9.6 PSMP Study Case 2

The figure below indicates the PSMP Study Case 2 Gas Supply-Demand Balance.



Source: Petrobangla and modified by PSMP Study Team

Fig. 5-15 Gas Supply-demand Balance（PSMP Study Case 2）

It is obvious that the PSMP Study Case 2 will not balance and follows the same trend as PSMP Study Case 1. The production amount will be increased until 2017 when it begins to declining thereafter. The Supply-Demand Gap in 2010, 2015 and 2020 will be expanded to 955mmcfd, 1154 mmcfd, and 1,738 mmcfd respectively.

5.10 Gas pipeline network analysis

The demand side issues regarding gas in Bangladesh have been discussed in the foregoing sections.

The supply side issues include the development of new gas fields in the upstream, improvement of gas transmission capacity of the GTCL-owned pipeline network as well as the feeding networks of the retail companies.

In this section, the PSMP Study Team conduct a network analysis based on the on-site data to evaluate the transport capacity of the pipeline network at present and in the future.

5.10.1 Calculation results and considerations

Transportation ability of a network can be judged by checking if required pressures are secured at each gas consumption node. In case gas is supplied to a gas turbine without a fuel gas compressor, the supply pressure should be higher than 1.7MPa (250psi).

(1) Calibration

As mentioned previously, the efficiency factor of each pipeline was adjusted so as to match the measured flow and pressure to the calculated results. The measured data are shown in Fig. 5-16. It should be noted that the total supply to the network is not consistent with the total consumption from the network. It is due to the unsteady local behavior. Whatever the reason is, it contradicts the law of conservation of mass. Therefore, complete conformance between the measured and the calculated is impossible.

In this study, a node of gas supply from a gas field was identified as a pressure designated point, at which the calculated gas supply differs from the measured data. Fig. 5-16 shows measured /calculated gas pressures at major nodes and measured /calculated gas supplies at supply nodes.

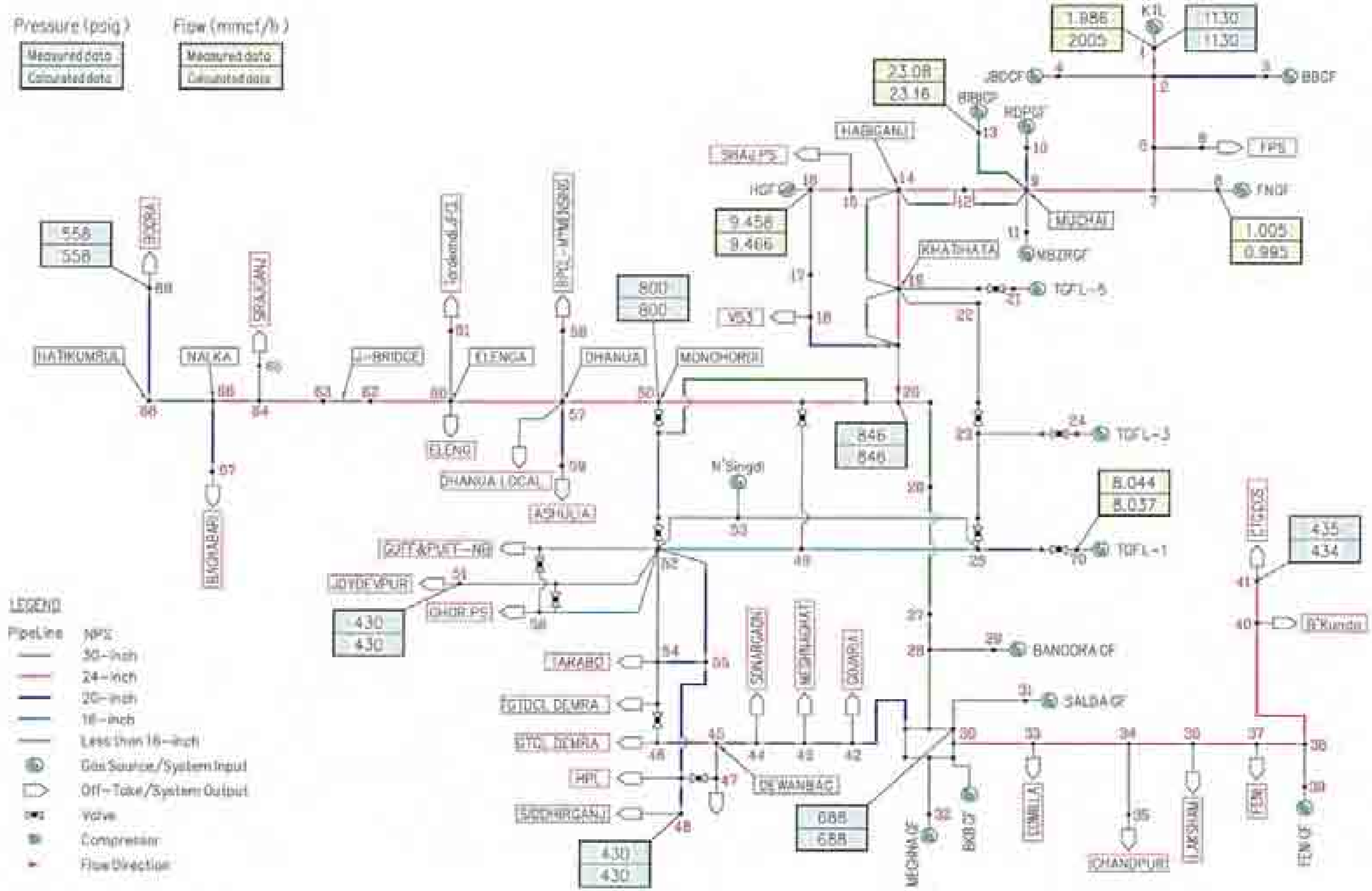
Generally speaking, the efficiency factor of a pipeline in Japan is about 0.93. However, many factors are below 0.8 in this study. There is a possibility that the pipelines are acting up. Sediment deposits may have accumulated inside.

(2) The study results on fiscal year 2009

In the case of average load, the transport capabilities are enough. When the load is increased to 1.2 times of the average load, troubles in the transport appear at around node40 and node41 (Chittagong), at node51, and in the region of node 61 and its downstream in the east-west line. Even if the pressure of node30 is changed from the current 688psi to 960psi (maximum operation pressure) the situation does not change. To circumvent this supply shortage, the gas supply from Feni (node of 39) should be increased to meet the total demand at No.40 and No.41 or additional pipelines parallel to the lines between No.30 and No.40 should be installed. However, there is no problem in the case of a conventional load. Generally speaking, a big pressure drop occurs in the branch lines from the east-west trunk line and lines around Dhaka. It implies the lack of transport margin in those areas; careful maintenances including pigging are desirable.

At other nodes, the gas supply pressures are more than 250 psi, where the supplies are secured. The flow velocities are not shown in the tables, but they are less than the 15 m/sec, reasonable value.

The tendency of locations where the transport trouble appears conforms to the real tendency. Although the actual peak load is bigger than 1.2 times average, the actual flow is unsteady and the holder effect of the pipelines can be expected. The aforementioned result supports the rationality of using the value of the 1.2 in the analysis. In the study on 2015 and 2030 hereafter, the PSMP Study Team used 1.2 times of the average loads to analyze the transport ability.



Source: PSMP Study Team

Fig. 5-16 Gas pressure at measure nodes and supply from gas fields (Calibration)

(3) The study results on fiscal year 2015

It is assumed that the line from Hatikumrul (Node68) to Bola (Node85) through Khulna (Node 83) and the line from Bakhrabad (Node30) to Siddhirganj (Node73) are completed and the new gas demands appear before 2015. It is also assumed that new gas supply sources like LNG (connected to Node41, Chittagong), Semutang (Connected to Node41), New Discovery (connected to 38) appear.

(a) Case study: Existing network.

In this case study, reinforcements like the installment of compressor stations (Node12.Node20, and Node60), in addition of loop lines (from Node20 to Node41, from Node50 to Node66 from Node12 to Node20, and from Node9 to Node11), and bypass line from Node50 to Node51 are not applied. The calculation used the gas load of1.2 times of the average. The results are shown in Fig. 5-17. As already explained, the 'Unable' in the pressure columns means 'unable to calculate the flow', i.e. inability in supplying gas through the pipeline there. The red figure means low pressure (＜250psi).

The transport troubles appear in the circular line from Bakhrabad (Node30) to Monohordi (Node50) through Demra (Node46), which surrounds Dhaka. They also appear in the down stream trunk/branch line of Dhanua in the east-west trunk line. Despite their location far from the northern gas fields, many new power stations are planning to get gas from those nodes. The pressure at Bahkrabad (Node30) is 688psi; the outlet pressure of Bahkrabad gas fields is controlled at the value. If the capacity is not enough and the pressure decreases below 688psi, the situation will be worse. The transport troubles do not appear in the lines between Bakhrabad and Chittagong. This is because LNG is introduced to Chittagong.

(b) Case study: Effect of compressors and additional loop lines

The effect of the aforementioned compressors as well as the loop lines is analyzed.

The outlet pressure of the compressors is set at 1,000psi. As enough pressure is secured in the area from the northern gas fields to Ashuganj, the compressor at Node12 has been eliminated. However, if the outlet pressures of the gas fields are not secured or the compressor at Node20 requires a lower pressure ratio, a re-examination would be necessary. Pressure designations to Bahkrabad (Node30), Salda (Node31), and Narsingdi (Node53) are changed to Supply designations. It is because reverse flow occurs if set pressures in preceding calculations are used, which means the gas fields can not feed gas to a high pressure network. 1.2 times of production rates are used for setting the above supply rate. At those nodes, calculated results will be pressures, which must be secured to feed the set value of supply.

The pressures at the major nodes in the pipeline are shown in Fig. 5-18. 1.2 times of the average gas load is used in the calculation. Fig. 5-18 shows that gas transport is secured except Node61.The supply problem to Node61 can be overcome by one of following countermeasures.

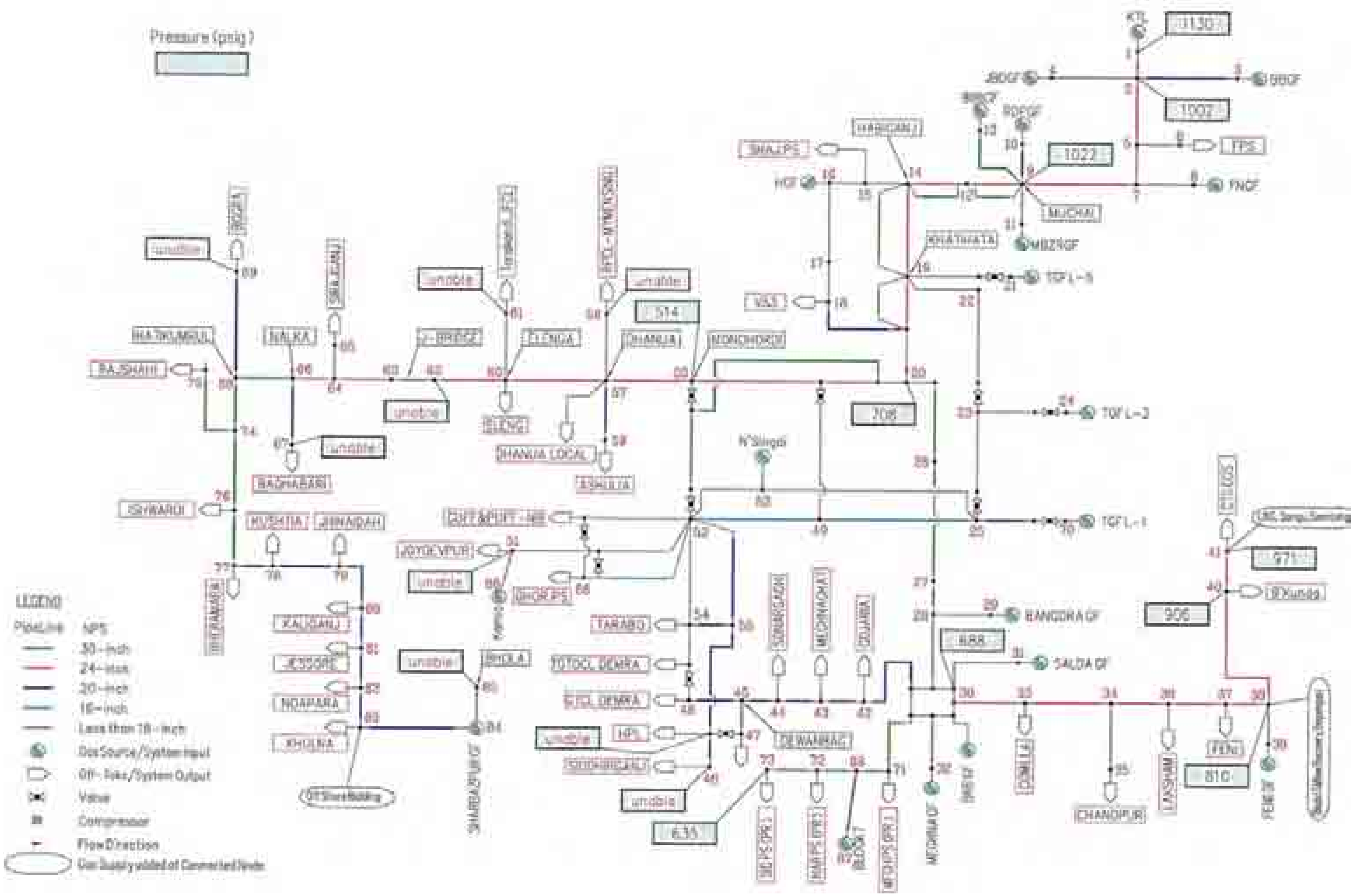
- Introduction of new gas fields like Block11 to this area
- Installation of bypass line from Node13 to Node57 (described later)
- Change of the connecting point of the branch line to the discharge of the compressor

(c) Case study: Effect of bypass line

The effect of the bypass line between Node13 and Node57 is analyzed. The pressure distribution in the area between the two compressors (Node20 and Node60) is shown in Fig. 5-19. This bypass line has been proposed in the Gas Evacuation Plan (2010-15) and the primary purpose is to reduce the flow duty on the compressor (Node20). However this bypass line improves the transport around Node61. It also contributes to reducing the compression related running cost as well as the plant cost. However, the following problems may appear.

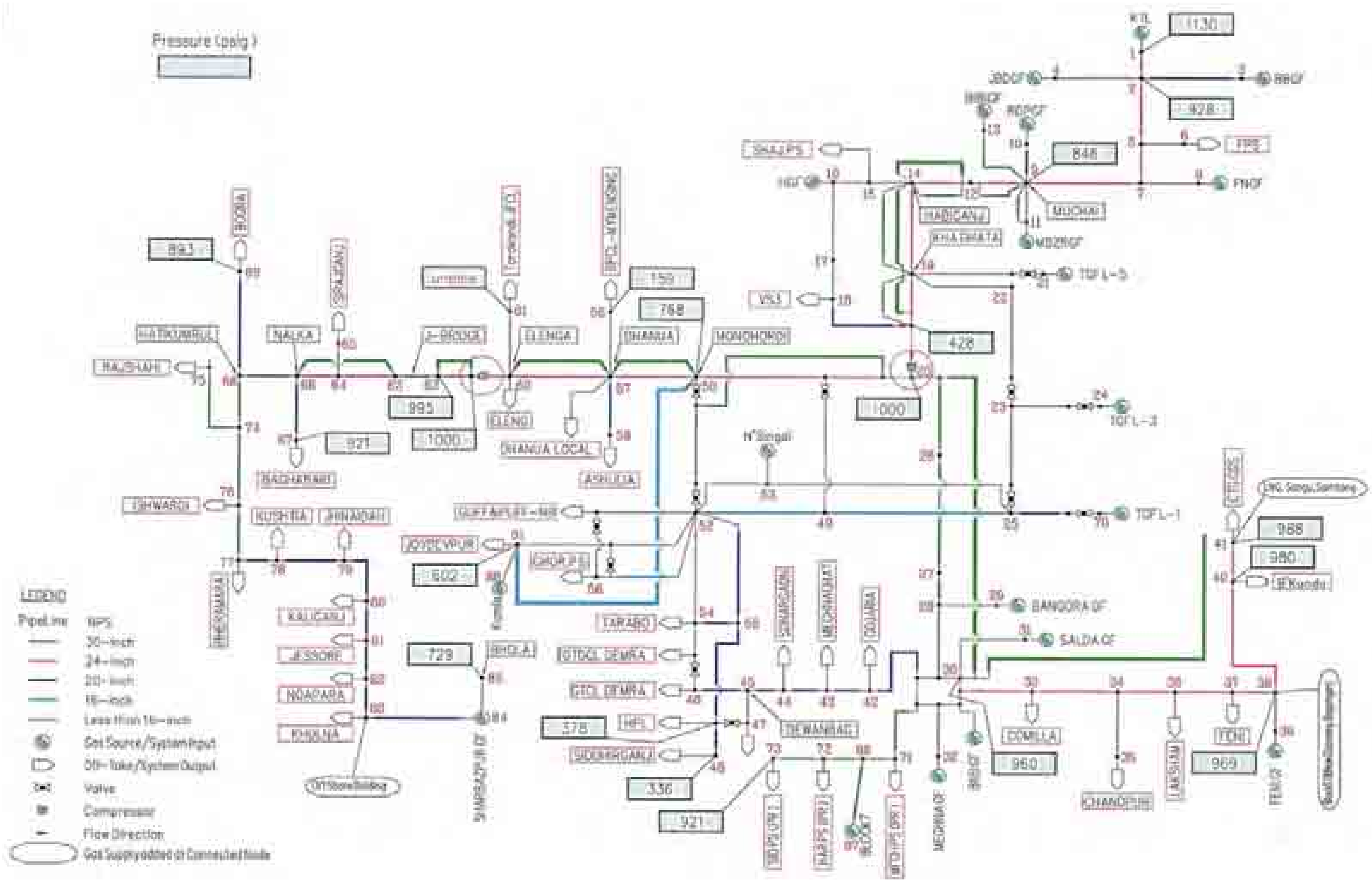
- The network becomes complex as a whole. So does the control.
- Pressures upstream from Node57 also increase. Difficulty in feeding from some gas fields may occur.

Careful and detailed analysis is required before start of the installation.



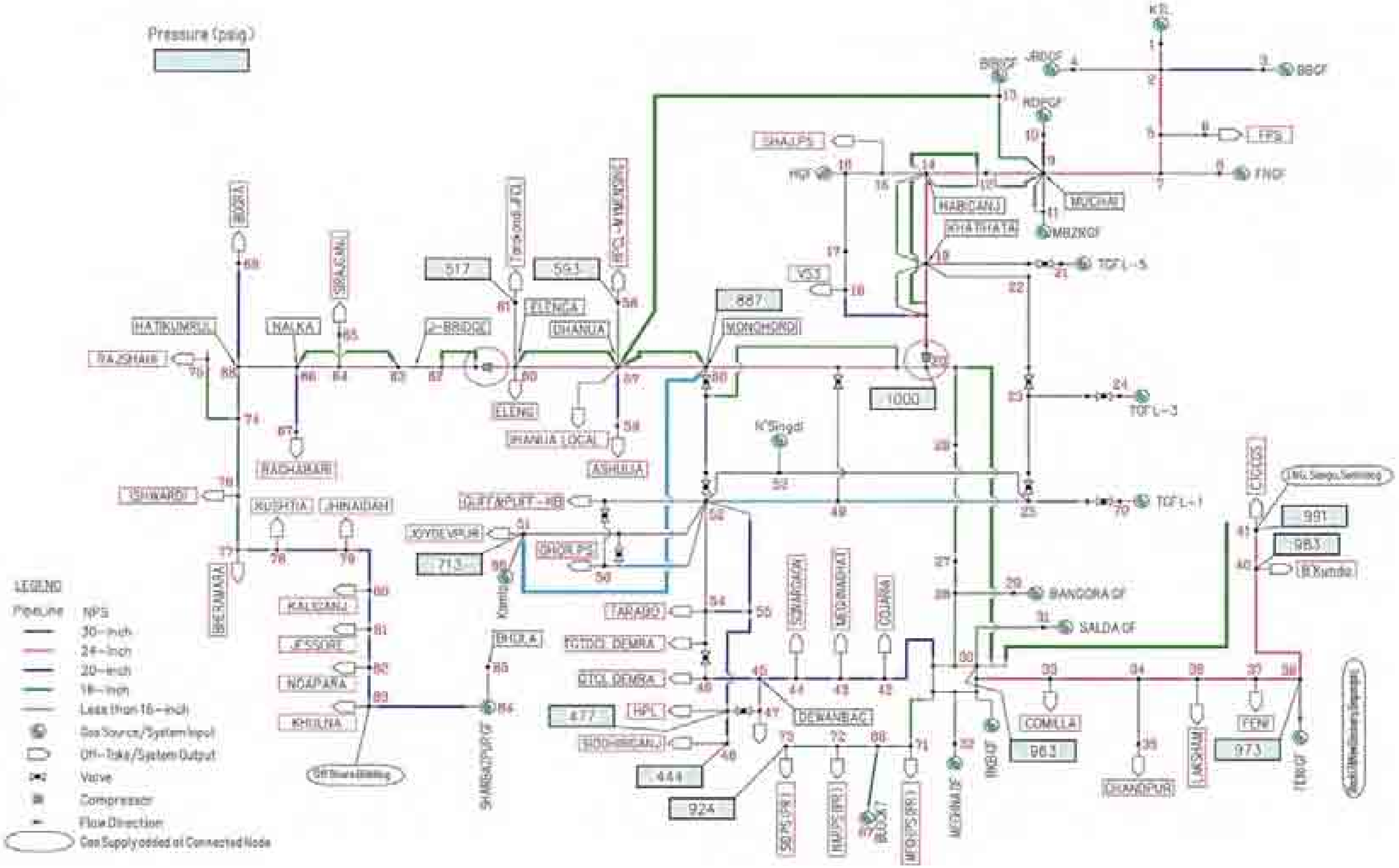
Source: PSMP Study Team

Fig. 5-17 Pressures at measure nodes (2015, Ave. Gas Demand × 1.2)



Source: PSMP Study Team

Fig. 5-18 Pressures at measure nodes (2015, Ave. Gas Demand × 1.2, Network Reinforced)



Source: PSMP Study Team

Fig. 5-19 Pressures at measure nodes (2015, Ave. Gas Demand×1.2, Bypass btwn.Node13 and Node57 Added)

(4) The study results on fiscal year 2030

1.2 times of the average load in fiscal year 2030 is used in the calculation. The network is the same as that mentioned in (3) except additional new gas fields. It has compressor stations at Ashuganj (Node20) and Elenga (Node60). The new gas fields are Off Shore Bidding (connected to Node83), Block7 (connected to Node88), and Kamta (connected to Node51).

The necessary pressure is secured in the PGCL area and the SGCL area (downstream of Elenga Compressor Station, Node60) except at Bogra (Node69). However, almost all nodes in the TGTDCL area and the BGSL area (up-stream of Elenga Compressor Station, Node60) fall into 'Unable'. As the flow through, Node20 can not be gained, pressure in JGTDSL (upstream of Node20) can not be calculated.

In the year 2030, the total gas demand is 7,909mmcfd and the total gas supply is 2,117mmcfd. There is a big discrepancy between demand and supply, which means the flow calculation, is intrinsically impossible. As all new gas fields are dealt as the supply designated node, most of the gas demand must be supplied from old gas fields in calculation. This fact may have brought many 'Unable' throughout the TGTDCL area and the BGSL area. To check this possibility, the PSMP Study Team made additional calculations by setting pressure to all nodes representing gas fields. The result is shown in Table 5-19.

According to Table 5-19, pressure is secured in the BGSL area, the PGCL area, and the SGCL area except Node35 and Node69. As these two nodes are in the branch lines, it can be overcome easily by adding a parallel line. Many nodes in the TGTDCL area still have trouble. It means the capacity of the pipelines is not enough.

Under such circumstances, it is difficult to overcome the trouble without sweeping measures.

Such measures include

(a) Reinforcement of pipeline by construction of loop lines with a focus on Padma Bridge

Padma Bridge, multipurpose bridge of 6km length to connect Maowa on the east bank of the Padma river (35km from Dhaka) to Zajira on the west bank, is being considered. Pipe lines on the bridge to connect Khulna, Shariapurin, etc. in the SGCL gas distribution area to Munshiganj, Narayangonj, etc. in the TGTDCl gas distribution area, bridge attribute to exchange gas between two areas. Additional loop lines around Dhaka such as lines parallel to the East-west & North-South trunk line, line from Bakhrabad to Monohordi would be necessary to secure pressure at the peripheral of the network.

(b) Pressure boost by turbo-compressors

The pressure boost by compressors is effective. They should be installed just before or somewhat upstream by a margin from the line where a big pressure drop takes place.

(c) Acceleration in exploiting domestic gas fields, introduction of foreign gas/LNG

The discrepancy between supply and demand would be filled by exploiting new gas field, by purchases from Myanmar, and by the introduction of LNG. Those gases should be injected from the southern part of the Dhaka area .to smooth out the pressure distribution.

(d) Promotion of energy saving and/or direct demand cut

In the rapidly growing industry sector, the promotion of energy conservation will curtail gas consumption. It includes the introduction of efficient equipment, the effective use of exhaust heat, and the use of unharnessed energy. Government measures such as various incentives are desirable.

In the domestic sector of the second largest gas demand, adding to the dissemination of efficient appliances, awareness campaigns toward the people through, for example, the development of charging methods or the introduction of prepaid cards are desirable.

In the power sector, the levelizing of demand is important. As the peak duration time is very short during the day and the remnant demand shape is flat, the use of prime movers like an oil-fired diesel engine during peak hours will cut down the peak load considerably.

(e) Introduction of SCADA

The introduction of the SCADA system is desirable in order to operate the network soundly. It can control pressures and flows throughout the network. With the help of SCADA, the staffs can create an improvement plan in a timely manner for the areas suffering from transport difficulty. They can adjust the gas flow by controlling valves so that power plants or other important facilities can secure a sufficient gas supply.

(f) Reduction of flow resistance in the network through maintenances like pigging

Many pipelines around Dhaka are old. The resistance of those pipelines tends to increase due to scales. It is possible to keep the transport capacity high by keeping the inner wall smooth.

Table 5-19 Gas demand/supply and pressure distribution (2030, Ave.x1.2, pressure designated)

	Node	Demand	P/S	Supply	Pressure		Node	Demand	P/S	Supply	Pressure
		mmcf/h		mmcf/h	psi			mmcf/h		mmcf/h	psi
TGTDCL	20		C	214.754	1,000	BGSL	33	12.368			848
	23				845		34	0.603			896
	24		P	8.486	900		35	1.865			Unable
	25				398		36	0.829			938
	26				890		37	4.678			983
	27				889		38		P	47.804	1,000
	28				889		40	9.458			990
	29				889		41		P		990
	30				837	PGCL	62				998
	31				837		63	2.701			980
	32				837		64				978
	42	6.486			Unable		65	1.626			911
	43	1.359			Unable		66				979
	44	1.733			Unable		67				979
	45				Unable		68				979
	46	28.723			Unable		69	4.647			Unable
	47				Unable	SGCL	74				981
	48	50.377			Unable		75				981
	49				Unable		76				983
	50				Unable		77	1.489			983
	51	46.389			Unable		78				986
	52	5.624			Unable		79				990
	53				Unable		80				991
	54	27.331			Unable		81				994
	55	5.733			Unable		82				996
	56	1.362			Unable		83		P	6.361	1,000
	57	32.741			Unable		84				981
	58	17.300			Unable		85	1.483			906
	59	43.496			Unable						
	60	16.250	C		* Unable						
	61	4.289			Unable						
	70		P	27.225	900						
	71	8.957			842						
	72	1.489			904						
	73	3.227			903						
	86		P	20.078	1,000						
	87		P	19.905	1,000						
	88				912						

P/S:P=Pressure set point S=Supply rate set point
C=compressor
* Pressure at compressor inlet

Source: PSMP Study Team

5.10.2 Conclusions

(1) Analysis on present network

Network analysis was done for Year 2009, Year 2015, and Year 2030.

It has confirmed that the numerical simulation results in Year 2009 conforms well with actual state.

In Year 2015, transport trouble takes place in PGCL, SGCL, and the southern part of TGTDCL.

In Year 2030, transport trouble takes place in almost all areas.

(2) Analysis on reinforced network for Year 2015

If reinforcements in accordance with 'GSMP/PB/2006 (Wood Mackenzie) are applied to the network, almost all transport troubles will disappear except Node61, located in the branch line from the compressor inlet. The trouble at Node61 is overcome by additional reinforcements presented in the 'Gas Evacuation Plan'. The reinforcement is useful.

(3) Analysis on reinforced network for Year 2030

With increased demand in 2030, the reinforced network mentioned above (GSMP/PB/2006, Gas Evacuation Plan) can not avoid trouble.

(4) Recommendations for Year 2030

Bulk gas demand for power stations stays almost constant; it changes from 704 mmcfd in 2009 (40% of total demand) to 742 mmcfd in 2030 (less than 10% of the total demand). That for fertilizers also stays constant. The lack of supply is mainly due to the rapid increase of Non-bulk gas demand.

The gas demand is quite large especially in the area of TGTDCL, which comprises 78 % of the total nationwide demand. It is why most transport trouble manifests itself in this distribution area. The transport reinforcement plan should be focused on the area of capital Dhaka.

On the other hand, according to the forecast, gas production in 2030 is supposed to be 1,617mmcfd. Even with the addition of 500mmcfd LNG, the total supply will be 2,117mmcfd. By contrast, the total gas demand will be 7,909mmcfd. The discrepancy is 5,792mmcfd. Adding to the exploitation of new gas fields, measures such as the import of gas from Myanmar and the import of LNG should be considered.

As the demand in the capital area is huge, LNG stations should be located as near as possible to Dhaka and the gas should be introduced into the circular lines surrounding Dhaka.

5.11 Price scenario

For a reliable information or data to predict a natural gas price, World Energy Outlook (WEO) by IEA. is utilized. According to WEO2009, the prospect of gas market in North America and other regions has been changing due to the rapid development of unconventional natural gas in the US and Canada during recent years. Because shale gas, remained untouched for its development due to the high cost, can particularly become possible to be produced with low cost by technological innovation, the oversupply is predicted in the future and there is a possibility to influence on the pricing system in Asia-Pacific region.

On the other hand, the natural gas price in Bangladesh is suppressed largely as lower price by the government subsidy, compared to the international price. Because the demand cannot be fulfilled only by the domestic natural gas, the LNG import and the import through interconnected international pipelines are predicted and it is considered that the natural gas price could be linked with the international price soon or later. In addition, for supplying natural gas stably and continuously, the dependency of spot market has a high risk of price fluctuation and is inappropriate; therefore, it is considered that it is necessary to conclude the long-term contract with gas suppliers for 10 years or more.

It is assumed in this study that the natural gas price scenario will be raised in incremental steps after 2010 and linked with the international price by 2020. In addition, for the linked international price, the long-term contract for natural gas (Japan price for JCC link) described in WEO2009 is adopted as a reference value. However, as discussed previously, the LNG import price can be largely changed depending on the negotiation between Bangladesh and gas suppliers in consideration with the production trend of unconventional gas and the gas price scenario might need to be re-examined with rolling base every year. The detail of the natural gas scenario is described in Chapter 8.

5.12 Assessment of risks

5.12.1 Risk for existing gas field production

Summary of risk associated with the production of gas from existing gas field is provided below.

Table 5-20 Summary of production impediments in existing gas fields

Risk Factor		Cause of Impediment	Phenomenon during production	Occurrence of the Risk	Related Problems	Significance of the Risk		Measures	
						Frequency %	Damages	Hard	Soft
(1)	Formation Water	Inappropriate gas well control	Early increase of formation water level	Generation of formation water	- Decrease in production - Suspension of production - refurbishment works	30	Serious	- Periodical check of pressure at the bottom of wells - 3D earthquake survey - Collect gas at the place farther from the boundary of gas and water as much as possible	Establishing an optimum production model
(2)	Sand	Fragile sandstone layers	- Inflow of sand into a well - Occurrence of erosion	Damages to gas collection pipe due to erosion (perforation)	- Decrease in production - Suspension of production - Refurbishment works	10	Serious	- Use of a gravel packing (filled with sands and gravels) for completion - Fixing sand by injecting plastic materials	Analysis of sand grain size
(3)	Scale generation	Deposition of salts in formation water into a well	Deposition of scales inside of pipes in a well Clogging of gas pathway	- Closure and clogging of gas collection pipe - Creation of cracks at the upper parts of open holes	- Reduced production - Suspension of production - Leakage of as to above ground and fire due to cracks	10	Serious	- Periodical measurement of inner diameter of gas collection pipes - Periodical removal of scales - Removal of scales using a coil tubing unit	Identification of inhibitors appropriately by water quality analysis
(4)	Clogging of gas layers Clogging of drilled holes	- Clogging of gas layers due to clay minerals and other solid substances - Insufficient drilling	Failure of gas passing through gas layers	Production impediment	Reduced production volume	20	Large	- Reducing difference in pressure between oil/gas layers and mud column pressure in completion - Drilling using a through tubing - Re-drilling	- Understand production impediment factors quantitatively using the results of periodical high-low pressure measurements
(5)	Freezing	Generation of gas hydrates near the well mouth or in flow lines	Under a certain temperature and pressure condition, gas and water reacts chemically to generate gas hydrates causing a freeze.	Generation and freezing of hydrates	- Clogging of the well mouth and flow line pipes - Temporary suspension of production	5	Small	- Heating - Use of an agent that inhibit generation of hydrates (methanol/glycol)	Reducing gas pressure within pipes

Source: PSMP Study Team

5.12.2 Risks involved in developing new gas fields

(1) Risks associated with drilling of abnormally high pressure layers

Bangladesh has experienced several times of gas explosion accidents in the history of gas field development projects. All of them are associated with unexpected blowout of gas in trial drilling. This is not limited to Bangladesh only, but is observed every corner of the world. By using the recent advancement of well drilling technology, existence of gas under a shallow layer can be detected beforehand. Blowout accidents haven't been eliminated, however.

More recently gas leaked out from the Titas-3 well, which is an offending issue in the country. The leakage started from the well mouth in March 2003 and stopped in January 2008. However, due to cracks generated in the well, gas is leaking out at various locations around the well. In order to stop the leakage, BGFCL, operator of the well plans to invite an expert team through a bidding process to eliminate the gas leakage. The gas leakage from gas production fields greatly impedes gas production. Causal analysis and thorough measures to prevent occurrence of it are wanted.

(2) Risks associated with developing new gas fields at marine mining areas

Demand for natural gas is ever increasing year by year in Bangladesh. In order to fill the demand-supply gap, development of new gas fields is urgently required. The country recently conducted 2D and 3D seismic surveys to review the volume of gas reserves in existing gas fields and to examine whether or not new gas deposits should be explored. In response to the gas field discovery works in the Bay of Bengal by India, Myanmar and other neighboring countries, in 2008, the GoB chose 28 new marine mining areas to invite a tender by overseas corporations to take part in development of these marine gas fields. Even if a new and potential gas deposits be found in a seismic survey under the sea at the depth of more than several hundred meters, huge amount of cost will be required for drilling test and delineation wells, completion of the sea bottom, laying pipelines under the sea and construction of above-ground production and treatment facilities. Moreover, 6 to 7 years will be required from exploration to start of production, from the example of Dhirubhai Gas Field in India.

5.12.3 Risks related to the policy

Although the necessity of domestic gas exploration development business and pipeline maintenance is described in the national policy and project, it is hard to say that the plan has been preceded as scheduled in the existing circumstances. Because the natural gas development has been exposed to various risks for a long time, it is necessary for the government to lead or precede the development. If the change of power happens or the political situation become fluid, the implementation of the national development plan, such as LNG import or pipeline project, may be significantly changed and/or delayed.

(1) Risk related to changes in political administration

Since Bangladesh became independent in 1971, several severe changes in political administration have occurred between ruling and opposition parties in the country. The general election (every five years) had not been held as scheduled. The general election in January, 2007 was delayed for two years due to struggles between the ruling and opposition parties, so it was held in December, 2008, and the current administration was inaugurated in January, 2009. In the meantime, the interim government ruled the country. At the PSC international bidding of offshore area in 2008, Petrobangla and EMRD recommended Conoco Phillips and Tullow to the interim government as successful bidders of PSC. As for IOC's, the former made a bid for Block 10, 11, 12, 15, 16, 17, 20 and 21, and the latter for Block 5. Nevertheless, the administration postponed the decision by regarding it as a matter for the next government. Petrobangla and EMRD asked the current administration to consent the bidding result, but the government considered that it would not be wise to give the nine blocks of PSC to the two companies. Thus, the government decided to allocate Block 10 and 11 to Conoco Phillips and Block 5 to Tullow, respectively. Petrobangla and EMRD have had the contract negotiation with Conoco Phillips and Tullow, but it is still unsettled at present. The delay in political decisions by changes in administration has become a big obstacle to invite investment for Bangladesh and had a tremendous impact on the promising project on gas mining development in the Bay of Bengal.

Furthermore, it is required to have a political solution regarding oceanic boundary issue with Myanmar and India so that the offshore new gas fields are developed by IOCs. Otherwise, the international oceanic boundary issue takes very long time to solve, then the offshore bidding could not be succeed within the expected time line.

(2) Risk of delay in the project due to slow bidding process

In Bangladesh, it takes quite a long time to start and implement a project after preparing a draft plan. According to the BAPEX's Annual Report (FY 2007-2008), for example, there was an project on procurement of drilling rigs (5,000m+) to strengthen the operation capability of oil/gas exploration. The aim was to improve efficiency of the exploration work by replacing the old rigs with new ones (the old rigs need extra time for maintenance and repair) and to cut down on drilling expenses. This project – its budget amount was 815.8 million taka - was authorized by the Executive Committee of the National Economic Council (ECNEC) on June 8, 2003. The first bidding ran over the budget by 31%, and the best bid at the second bidding also exceeded the budget by 90%. Thus, it was modified to 1.42 billion taka. Likewise, Development Project Proposal (DPP) was revised in that the project completion would be June, 2008. The third and fourth bidding were also not successful, but there were six bids in March, 2006. Two of them satisfied the bidding requirements. The winning bid has been approved by the board of directors in BAPEX, and the PSMP Study Team is told that the prescribed process is now under way. DDP was modified according to a result of the winning bid, so the cost is now 2.565 billion taka and the date of acceptance/receiving inspection has been changed to December, 2011. After the approval of ECNEC, this project will take eight and half years to finish the receiving inspection. In addition, the cost is three times higher than the predicted cost, which was approved by ECNEC in 2003. On afterthought, something seems to have been wrong with the bidding system. The delay in the main bid had a tremendous impact on the gas field development. As countermeasures against gas shortage, the short-term, medium-term and long-term plans on increased production have been considered, but there is some possibility that the gas production will not implemented in a timely manner if these plans will not work out as scheduled.

5.12.4 Risks related to finance

The requirements or conditions surrounding the natural gas exploration/development are becoming more difficult and the maintaining of economic efficiency is also becoming more difficult with an increase of necessary investment amount. In addition to the national conditions in the exploited regions targeted for deeper and complicated stratification, the costs for infrastructure maintenance such as roads could be increased. Furthermore, because of the increased interest for environment, a requirement of environment assessment becomes general by severely being asked for environmental attention.

The depletion of domestic natural gas would be timing issue, therefore, importing natural gas by LNG and/or pipeline will be inevitable. As gas price is exposed to international gas demand-supply situation, in order to secure the stable natural gas supply, the government should revised the current gas tariff, which is currently regulated significantly low price from the political reason, to link to international market price. It is desired to make the gas price system more appropriate for collecting those increased costs.

Chapter 6 Other Primary Energy

6.1 Petroleum sector

In this chapter, a present data analysis is conducted of oil regarding policy, domestic reserve situation, future development, import trends, etc. as sources of primary energy other than coal and natural gas. The basic information was collected for the optimum power development plan. To establish domestic transportation and storage system is a matter of urgent for the recent fast track project of oil fired power stations.

6.1.1 Petroleum policy

(1) Basic policy and plan

From 1997 to 2007, the demand for oil is increasing by 2.6% as an annual average. Under the present circumstances, the demand of oil refinery productions and around one third of the petroleum products was refined by the Eastern Refinery Limited (ERL: subsidiary of BPC), with the remains imported outside the country. In order to correspond to the demand growth of petroleum products, the procurement of energy security and storage for 60 days, the basic plan for the petroleum sector is as follows;[1]

- To undertake by ERL to increase its present processing capability from 1.5 million metric tons to 4.5 million metric tons per annum,
- To construct deep sea unloading facilities with sub sea pipe line linkage to ERL for crude oil and refined petroleum products to facilitate a quick and safe discharge,
- To construct pipe lines including the ancillary facilities for the transportation of petroleum products from Chittagong to Dhaka to ensure the safe and smooth transportation of petroleum products. The pipe line may be gradually extended to the northern region of the country.
- To increase storage facilities at ERL, Oil Marketing Companies main installation and other different strategic points especially the Southern and Northern regions to maintain the inventory of petroleum products in accordance with the 60 days requirement.
- To establish 2nd Main Installations (MI) at the Mongla port for discharging imported petroleum products as an alternative arrangement to meet emergency requirements.
- To modernize river transportation and the custody transfer system of petroleum products from MI to secondary and territory depots to minimize the transit loss & pilferage during transportation.
- To develop railways facilities for the transportation of petroleum products via tanker.

As for liquefied petroleum gas (LPG), priority has been placed on marketing LPG for domestic use. After meeting the domestic requirements, the surplus may be used as commercial fuel. To meet the demand for cooking fuel in non-gas areas, the establishment of an LPG bottling plant in the west zone may be encouraged. So far, there are no existing power generation plans that utilize LPG or a mixture of LPG with other natural gases.

For environmental prevention in the urban areas, utilizing diesel as fuel for transportation is restricted, and the promotion of CNG utilization is underway.
The promotion of CNG utilization will be extended to the western area and the eastern part of the county.

[1] National Energy Policy (Draft), MPEMR (2008)

6.1.2 Current status and subject concerning supply and demand

The demand for whole petroleum in Bangladesh is 3.8 million tons per annum, in which 1.2 million tons of crude oil was refined in ERL and 2.6 million tons of petroleum products were imported in the fiscal year 2006/07.

The oil-refining equipment in Bangladesh is located only in ERL in Chittagong. The design installed capacity of ERL is 1.5 million tons per annum, while the 1.2-1.4 million tons per annum was actually refined crude-oil, on average annual 330 day operation.

Imported crude oil is comprised of mainly two kinds, the Murban crude oil of Abu Dhabi, and the Arabian light (ALC) of Saudi Arabia. In ERL, 15 kinds of oil-refining products, such as HSD (High Speed Diesel), FO (Furnace Oil), and LPG (Liquefied Petroleum Gas), are manufactured.

In 2009, HSD 139,000 ton/year, and FO 116,000 ton/year were refined for the electric power supply, which was 7.7% of the total amount refined in ERL. In the near future, ERL will supply HSD 310,000 ton/year and FO 810,000 ton/year for Rental power (eight sites) and Small oil fired power stations (ten sites) in the year 2011. The supply from ERL will be assumed to be HSD 440,000 ton/year and FO1,500,000 ton/year with the addition of 3 IPPs in 2013, which will be 8 times larger than the current capacity. In response to these rapid demand increases, BPC is prepared to reinforce capacity in ERL, which includes the construction of deep sea unloading facilities in Matarbari Island from the mother ship via a single point mooring (SPM) with a sub sea pipe line linkage to ERL. After the construction of SPM, which forecasts that the operation will start in the year 2012 and the capacity will be increased to a total of 4.5 million tons/year.

The supply into these electric power sectors is called fast-track projects. Urgent installation for fulfilling electricity demand will result in a temporary 30 percent of the total oil supply. It is assumed that it will eventually settles down to about 5% of the total supply.

From May 13, 2010, in responding to the aggravating electric power shortage, BPDB announced plans to urgently install power generation plants.

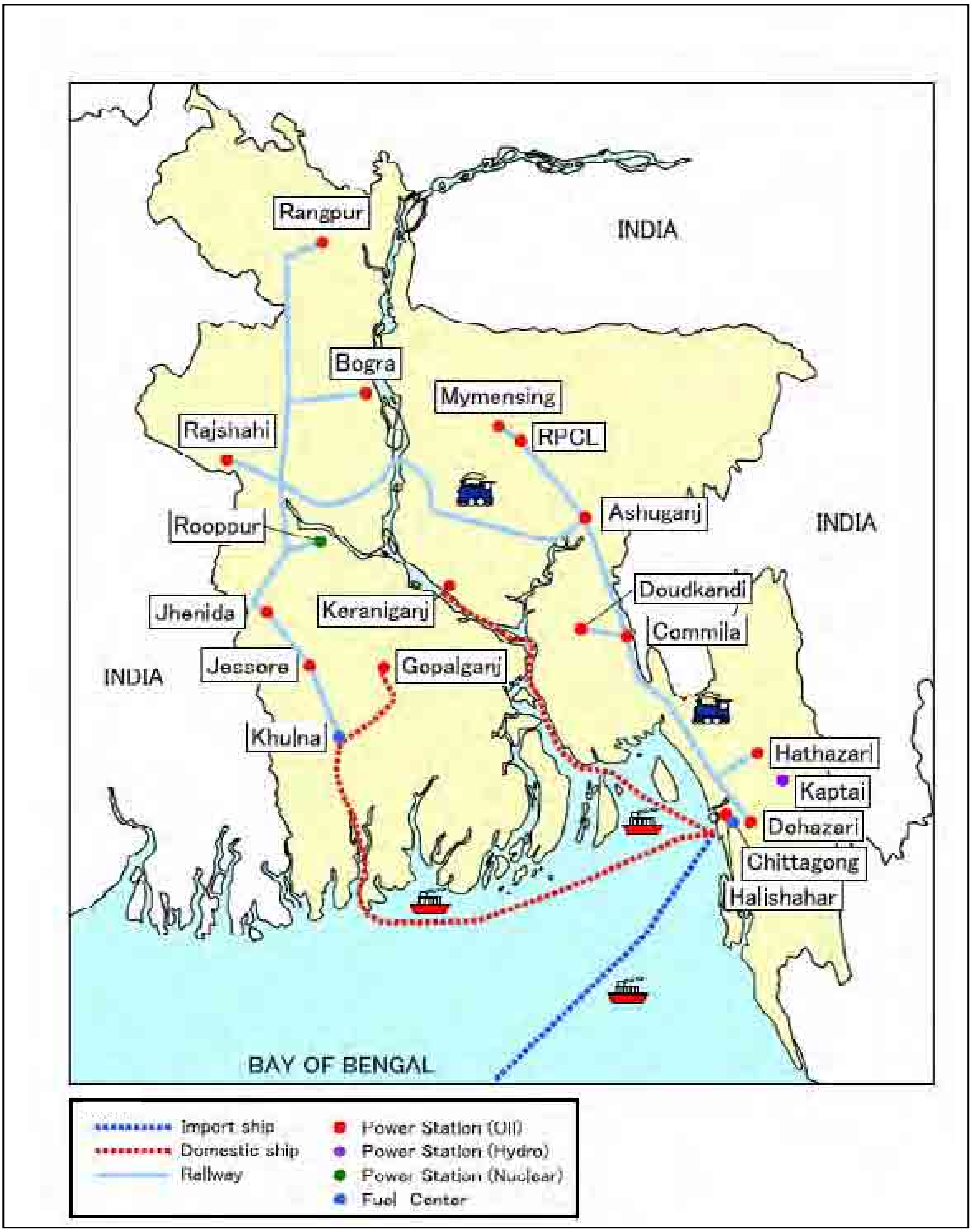
According to the BPDB’s new plan, a total of 1200-1500MW introduction of the oil (HSD, FO) fired rental plant is due to be carried out by 2015 (the original plan was 530 MW).

It has been estimated that 200,000 tons of additional storage capacity will be newly required by 2012 with additional imports of 190,000-tons of HSD and 46,000-tons of FO by the end of 2010 in order that the oil supply capability in Bangladesh will not be affected.

6.1.3 Situation and subject of fuel infrastructure

As for the oil transportation organization inside Bangladesh, the BPC is a single managing body. After the products are refined by ERL, which is a subsidiary of BPC, and the imported products are collected to MI in Chittagong, they are distributed to many parts of Bangladesh. There are five large-scale oil depots in MI Chittagong, Godenail, Futullah, Daulatpur, Baghabari, six medium depots in Srimangal, Bhairab, Chandpur, Parbatipur, Barishal, Jhalakathi, and other small-scale depots in Sylhet, Rangpur, Natore, Rashahi, Harian, Ashuganj, Balashi, Chilamari, etc. Petroleum products are delivered to places by demand all over the country directly or via these depots from MI.

As a domestic carriage measure, transportation by river ships is 90%, railroads 8%, and the tracks has become 2%. There are two kinds of river transportation by ships; the Coastal Tanker (1000-5000t) and the Shallow Draft Tanker (700-800t). These tankers have been selected according to the demand of oil and the characteristic of the inland waterway, etc. Although traffic increases in connection with future increased demand, the enlargement of a domestic tanker is needed in order to improve transport efficiency and transportation cost reductions. For that purpose, the deep-dredging of a waterway is required, and the dredge method, frequency, and cost are issues that must eventually be dealt with.. Large scale inland water transportation is also needed in line with the first-track installation plan of the aforementioned power generation equipment.



Source: PSMP Study Team

Fig. 6-1 Petroleum transportation by ship and railway in Bangladesh

6.1.4 Price scenario

According to the National Energy Policy, the oil price of domestic production will be determined by market prices, after making a comparison with the Asia Pacific Petroleum Index (APPI). Moreover, the price of imported oil will be decided based on the Import Parity Price (IPP).

6.1.5 Risk evaluation

(1) Technical risk

Petroleum power station is introduced as a rental. Hence it is constructed in a short time. The term of contract is limited to 3 to 5 years. At the power plant, electricity is generated by a diesel engine. Its technique is almost established. The risk is low unless the fuel is continually provided.

(2) Political risk

Petroleum is imported for more than 10 years. Relationships with other countries concerning petroleum exports are well. Political risks are low, unless the policy regarding petroleum is vastly changed.

(3) Economic risk

Petroleum fired power station will be operated until the coal fired power stations start operation. If the start of operations of coal fired power stations becomes delayed, the petroleum fired power station may be continually operated. Since the petroleum cost is higher than other primary energy, there is the possibility that the operating cost becomes high, if the shift from petroleum to coal is late.

6.2 Renewable Energy Sector

6.2.1 Current status and issue

(1) Current status

Table 6-1shows the status of renewable energy currently developed in Bangladesh. As the table indicates, development of renewable energy is not progressing very much in Bangladesh.

Table 6-1 capacity of Renewable Energy Developed (as of June 2010)

Resources	Present status
Solar	30 MW
Wind	2 MW
Biomass based electricity	< 1 MW
Biogas based electricity	< 1 MW
Hydro	230 MW
Others	< 1 MW
Total	265 MW (about)

Source: Power Division

(2) Organizations

Renewable Energy Policy indicates that an independent organization, Sustainable Energy Development Authority (SEDA) will be established to promote the development of renewable energy and the utilization of energy effectively.

More precisely, SEDA is involved in promoting the use of renewable energy by managing trust funds collected from entire power generation sectors.

(3) Promotion measures

Renewable Energy Policy proposes the following incentive schemes.

- Exemption of customs duty and VATs
- Grant to public corporative bodies who will install a renewable energy system
- Exemption of corporate tax for 15 years
- Purchase electricity at high prices (1.25 times of the maximum purchase price from private electricity companies)
- Accelerated depreciation of up to 80% in the initial year
- Others

6.2.2 Target and future estimation

(1) Target of developing renewable energy

According to "Renewable Energy Policy of Bangladesh" released by the Power Division in November 2008, Bangladesh sets a target that 5% of total electricity demand will be fulfilled by renewable energy by 2015 and 10% by 2020.

The government estimates that electricity demand will reach approx. 10,283 MW in 2015. This means approx. 510 MW will be generated by renewable energy to cover 5% of the demand. Similarly, it estimates that electricity demand in 2020 will reach approx. 17,600 MW and 1,760 MW should be generated by renewable energy to cover 10% of the demand. (Assuming that electricity demand defined by Renewable Energy Policy is equivalent to actual electricity demand, renewable energy power generation facilities must be developed to cover more than double of the above power generation volume, because the ratio of utilizing renewable energy is low i.e. less than approx. 30%.)

As for the use of renewable energy, the country promotes the introduction of SHS (solar home system) using solar panels, in order to increase the ratio of electrification (currently 48.5 % in terms of population) as a priority basis as of now.

(2) Renewable energy

The renewable energy such as photovoltaic, solar thermal and wind power will be incorporated as power supply if their generation cost is reasonably dropped due to technical and/or economical breakthrough. If the renewable energy becomes feasible, other power supply such as oil and imported coal, imported LNG will be reduced accordingly. Renewable energy is important especially for isolated rural area with technical difficulty of connection to the grid system. However, the promotion for such renewable energy needs to be undertaken by programs other than this Master Plan.

(3) Future estimation

Although solar power generation (photovoltaic, solar thermal) is estimated to have enormous potential, the solar power generation cost at this point in time is more than five times higher than the power generation cost of conventional thermal power generation. In the future, the large-scale introduction of solar power generation cannot be expected unless the cost of solar panels becomes significantly lower or government provides large amount of subsidies.

In terms of wind power generation, past surveys have identified several candidate sites with an average wind speed of 6 m/s, which is a generally accepted borderline level of profitability for wind-power generation. At this moment, however, wind power generation is poor in profitability because the purchase price of electric power generated by wind power generation is low, and is not in an environment where active introduction by private power producers is expected. If the purchase price increases and such preferential measures as tax reductions are continuously taken in the future, private power producers may introduce wind power generation at some sites. Given the average wind speed on the borderline level of profitability, extensive introduction cannot be expected.

In terms of biomass, although Bangladesh has abundant agricultural residues, almost all of them are effectively used for fuels, fertilizers, feed and other commodities and the amount of biomass applicable to power generation is estimated to be extremely small.

In terms of waste, waste power generation has some potential chiefly in urban areas but much cannot be expected in light of the amount of electricity.

In terms of hydropower, while there are a few sites suitable for power generation within Bangladesh, there is much potential in the surrounding areas along national boundaries.

Judging from the above conditions, it is quite unlikely that domestic renewable energy will be greatly advanced by 2030, the last year of this MP. It is also assumed that the target values shown in the Renewable Energy Policy would unlikely be achieved. On the other hand, some projects which develop potential of hydro-energy in neighboring countries and export to Bangladesh are considered. If the imported electricity from such projects is also counted in the supplied electricity in Bangladesh from the renewable energy, it will be possible to supply 10% of total electricity demand by renewable energy by 2030.

6.2.3 Risk evaluation

Until 2030, which is the last year of this study, it is unlikely that the capacity of renewable energy in Bangladesh increases dramatically. Therefore, it is hard to hold excessive expectations of additional power capacity via renewable energy development in Bangladesh. On the other hand, there is the risk that recent major donor's willing support for renewable energy development makes it more difficult to secure the development fund required for the implementation of the master plan. In this study, imported electricity from hydropower plants in neighboring countries, such as Myanmar, Bhutan and Nepal etc., counted in the electricity from renewable energy. Bilateral meeting for the project of the hydropower development in Myanmar and interconnection with Bangladesh has been implemented and specific project sites (Lemro area: approximately 500MW) are considering in the meeting. Therefore the project is likely to be implemented and accomplished by 2030. The projects to inter connect hydropower plants in Bhutan and Nepal to Bangladesh's power grid, which interconnection should pass through India, will be discussed under the framework of the South Asia Association for Regional Cooperation (SAARC). Therefore it is possible but requires much time to implement these projects, which means the risk not to realize the condition in this study by 2030.

Chapter 7 Power Demand Forecasts

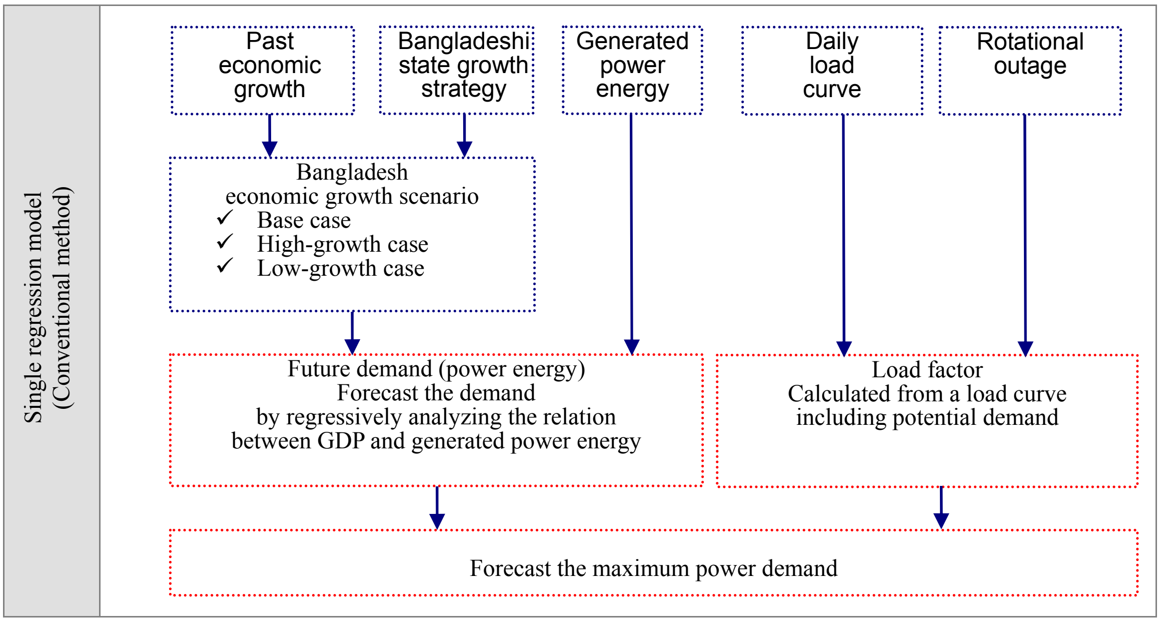
7.1 Objective

This section provides power demand forecasts until 2030, including assumed annual and daily load curves, while taking into account the economic growth rate of Bangladesh, degree of promotion of heavily energy consuming industries in the country, growth of the electrification rate in the country, etc. In making assumptions, PSMP Study Team first review PSMP 2006, which is the latest power system master plan of Bangladesh, to verify the forecast method adopted in the PSMP and then validate it from a macroscopic point of view through the formulation of a counterproposal.

7.2 Current states and evaluation of the power demand forecasts

7.2.1 Evaluation method

In Bangladesh, the Power System Master Plan (SPMP) is reviewed every 10 years, and its latest version is PSMP 2006, which was conducted in 2005. Power demand forecasts in Bangladesh have been performed by the System Planning Directorate of BPDB. The basic method used is to calculate the power usages of all systems by adding up the power usages of consumers by categories (e.g., household use, industrial use, and commercial use). Then, the annual maximum power is forecast by performing back calculation based on the annual load factor.

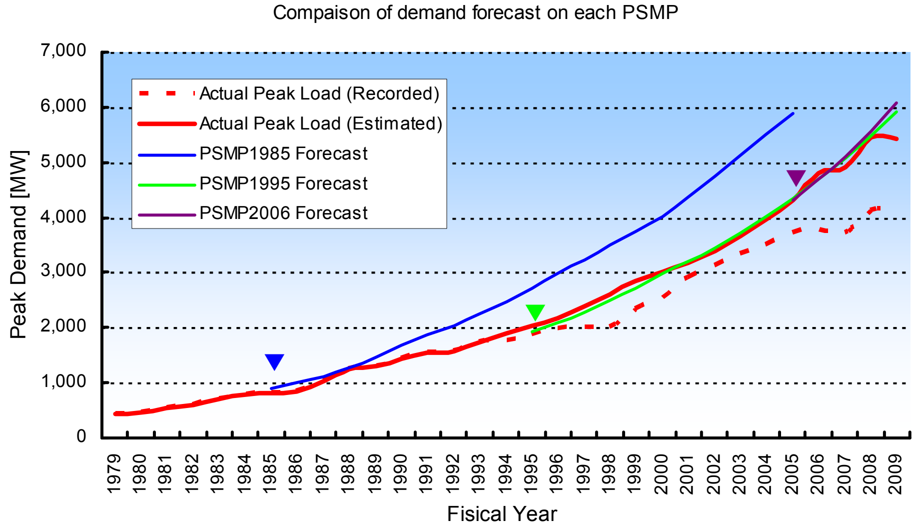


Source: PSMP Study Team

Fig. 7-1 Flow of forecasting/examining the demand in Bangladesh

7.2.2 Demand forecast by past PSMP

The following figure shows the comparison between the demand forecast scenario by past Power System Master Plan (PSMP1985,1995 and 2006) and actual peak demand.



Source: PSMP1985, PSMP1995, PSMP2006, PSMP Study Team

Fig. 7-2 Comparison of demand forecast by past PSMP

The demand forecast scenario by past PSMP shows a tendency to be higher than actual recorded data. However the data which is estimated with potential demand shown in 7.3.3 are close to the scenario by PSMP 1995 and 2005.

7.2.3 Economic growth scenarios of PSMP 2006

In 2006, when PSMP was formulated, the average economic growth rate for the approximate 10-year period from 1994 to 2004 was 5.2%. Given the past record of economic growth, PSMP 2006 forecasts demands based on the assumption of three scenarios: 5.2% on average in the base case, 8.0% in the high-growth case, and 4.5% in the low-growth case.

Table 7-1 PSMP 2006 economic growth scenarios

	Base Case		High Case		Low Case	
Fiscal Year	GDP (million Taka)	Growth Rate	GDP (million Taka)	Growth Rate	GDP (million Taka)	Growth Rate
2005	2,634,409	5.3%	2,664,431	6.5%	2,634,409	5.3%
2006	2,792,474	6.0%	2,850,941	7.0%	2,766,130	5.0%
2007	2,960,022	6.0%	3,050,507	7.0%	2,904,436	5.0%
2008	3,137,623	6.0%	3,264,043	7.0%	3,049,658	5.0%
2009	3,325,881	6.0%	3,508,846	7.5%	3,202,141	5.0%
2010	3,525,434	6.0%	3,789,553	8.0%	3,362,248	5.0%
2011	3,719,332	5.5%	4,092,718	8.0%	3,513,549	4.5%
2012	3,923,896	5.5%	4,440,599	8.5%	3,671,659	4.5%
2013	4,139,710	5.5%	4,818,050	8.5%	3,836,883	4.5%
2014	4,367,394	5.5%	5,227,584	8.5%	4,009,543	4.5%
2015	4,607,601	5.5%	5,698,066	9.0%	4,189,972	4.5%
2016	4,837,981	5.0%	6,210,892	9.0%	4,378,521	4.5%
2017	5,079,880	5.0%	6,738,818	8.5%	4,575,555	4.5%
2018	5,333,874	5.0%	7,311,618	8.5%	4,781,455	4.5%
2019	5,600,568	5.0%	7,933,105	8.5%	4,996,620	4.5%
2020	5,880,596	5.0%	8,567,754	8.0%	5,221,468	4.5%
2021	6,145,223	4.5%	9,253,174	8.0%	5,430,327	4.0%
2022	6,421,758	4.5%	9,993,428	8.0%	5,647,540	4.0%
2023	6,710,737	4.5%	10,742,935	7.5%	5,873,441	4.0%
2024	7,012,720	4.5%	11,548,655	7.5%	6,108,379	4.0%
2025	7,328,292	4.5%	12,357,061	7.0%	6,352,714	4.0%
Average		5.2%		8.0%		4.5%

Source: PSMP 2006, Bangladesh

7.2.4 Estimation of the maximum power that includes potential demands

In Bangladesh, the power supply has constantly remained strained in peak hours. Potential demands have not been met, and rotational outage has frequently occurred. The actual recorded maximum power has not included these potential demands. To estimate the maximum power that includes potential demands, PSMP 2006 adopts a method for calculating the generated power energy with which a compound daily load curve is produced by adding the evening peak demand for lighting, calculated from a daily load curve with no rotational outage on weekends and holidays in winter, to a daily load curve suppressed by rotational outage on weekdays in summer. By regressively analyzing the relation between the generated power energy calculated this way and the economic level indicated by the actual GDP and setting the load factor from a load curve that includes potential demands, PSMP 2006 estimates the maximum power energy. The following table shows the result of the forecast of power demands indicated in PSMP 2006.

Table 7-2 PSMP 2006 demand forecast scenarios

Fiscal Year	Base Case		High Case		Low Case		Projected Load Factor
	Net Generation (GWh)	Net Peak Load (MW)	Net Generation (GWh)	Net Peak Load (MW)	Net Generation (GWh)	Net Peak Load (MW)	
2005	21,964	4,308	22,336	4,381	21,964	4,308	58.2%
2006	23,945	4,693	24,692	4,839	23,611	4,627	58.2%
2007	26,106	5,112	27,297	5,345	25,382	4,970	58.3%
2008	28,461	5,569	30,177	5,904	27,286	5,339	58.3%
2009	31,028	6,066	33,592	6,567	29,333	5,734	58.4%
2010	33,828	6,608	37,652	7,355	31,533	6,160	58.4%
2011	36,622	7,148	42,202	8,237	33,659	6,569	58.5%
2012	39,647	7,732	47,627	9,288	35,928	7,007	58.5%
2013	42,922	8,364	53,749	10,473	38,351	7,473	58.6%
2014	46,467	9,047	60,659	11,810	40,937	7,970	58.6%
2015	50,306	9,786	68,924	13,408	43,697	8,501	58.7%
2016	54,079	10,512	78,316	15,223	46,643	9,066	58.7%
2017	58,135	11,291	88,384	17,166	49,788	9,670	58.8%
2018	62,496	12,128	99,746	19,357	53,145	10,313	58.8%
2019	67,183	13,027	112,568	21,827	56,728	11,000	58.9%
2020	72,222	13,993	126,172	24,445	60,553	11,732	58.9%
2021	77,092	14,924	141,419	27,377	64,178	12,424	59.0%
2022	82,290	15,917	158,510	30,661	68,020	13,157	59.0%
2023	87,839	16,977	176,448	34,103	72,092	13,934	59.1%
2024	93,761	18,107	196,415	37,931	76,408	14,756	59.1%
2025	100,083	19,312	217,137	41,899	80,982	15,626	59.2%

Source: PSMP 2006, Bangladesh

7.3 PSMP 2010 power demand forecast using the conventional method

In the first step of PSMP 2010, the power demand will be forecast using a similar method as that used in PSMP 2006.

7.3.1 Formulating of economic growth scenarios

Since its independence in 1971, Bangladesh has striven to improve its socioeconomic conditions and grow its economy with support from domestic and international society. The average annual growth rate in the 14-year period from 1995 to 2008 was 5.6%. In the past three years, a high growth rate has been maintained since the stable and high growth of the mining and industrial sectors and the service sector has covered the low growth rate of the agricultural sector. The midterm macroeconomic framework of the Poverty Reduction Strategy Paper (PRSP), which the government has formulated, set a goal of achieving a GDP growth rate of 6.8% in fiscal 2007 and 7.0% in fiscal 2008 and 2009. However, due to negative factors such as increased pressure for inflation, soaring international prices of crude oil, disasters caused by floods and cyclones, and serious power shortages, the real GDP growth rate in fiscal 2008 was only 6.2%. The World Bank has drawn up a mid- to long-term growth scenario that by judging from circumstances, including the following facts: the country has assets required for growth, its economic fundamentals have improved and it has succeeded in first-stage reforms, its workforce is young, and corporate spirit and cultures have been established, the country will break away from its present status of being the poorest country and advance to become a medium-income country in approximately 10 years[1].

Given such an environment, PSMP Study Team assume economic growth scenarios until 2030 in Bangladesh as follows.

Table 7-3 Record of economic growth rates

Fiscal Year	GDP (million Taka, at	Annual
1994	1,515,139	
1995	1,589,762	4.9%
1996	1,663,240	4.6%
1997	1,752,847	5.4%
1998	1,844,478	5.2%
1999	1,934,291	4.9%
2000	2,049,276	5.9%
2001	2,157,353	5.3%
2002	2,252,609	4.4%
2003	2,371,006	5.3%
2004	2,501,813	5.5%
2005	2,669,740	6.7%
2006	2,846,726	6.6%
2007	3,029,709	6.4%
2008	3,217,855	6.2%
2009	3,406,524	5.9%
Average		5.6%

Source: Bangladesh Bureau of Statistics, as of May 2010

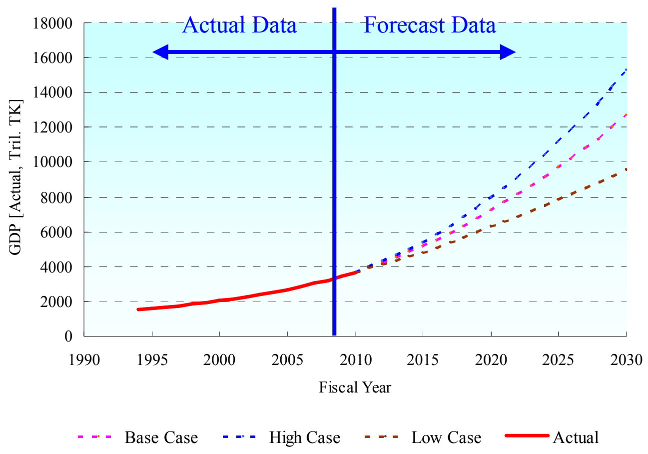
Table 7-4 Economic growth scenarios

<table>
<tr><th rowspan="2">Scenario</th><th>Mid-term forecast</th><th>Long-term forecast</th></tr>
<tr><th>2010-2015</th><th>2016-2030</th></tr>
<tr><td>Base case</td><td>7% growth rate, a goal set by the Bangladeshi government in the Poverty Reduction Strategy Paper (PRSP), continues.</td><td rowspan="3">It is assumed that although the economic growth will continue, the growth rate will decrease by 0.5% every 5 years due to maturity of economic activities.</td></tr>
<tr><td>High growth case</td><td>Case in which the economy grows at 8.0%, which is 1.0% higher than the growth rate set by the government.</td></tr>
<tr><td>Low growth case</td><td>Case in which the economy grows at 5.5%, which is 1.5% lower than the growth rate set by the government. It is equivalent to the average growth rate in the past 14 years.</td></tr>
</table>

Source: PSMP Study Team

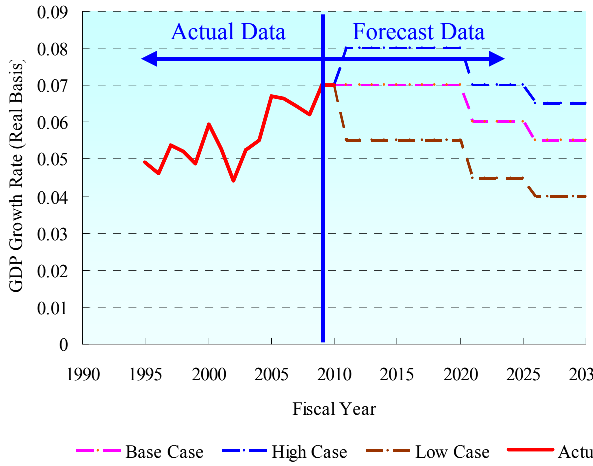
The economic growth change from 1994 to 2008 and the economic growth scenarios until 2030 are indicated in Fig. 7-3 and Fig. 7-4.

1 World Bank, "Bangladesh: Strategy for Sustained Growth," July 2007



Source: PSMP Study Team

Fig. 7-3 GDP change and forecasts

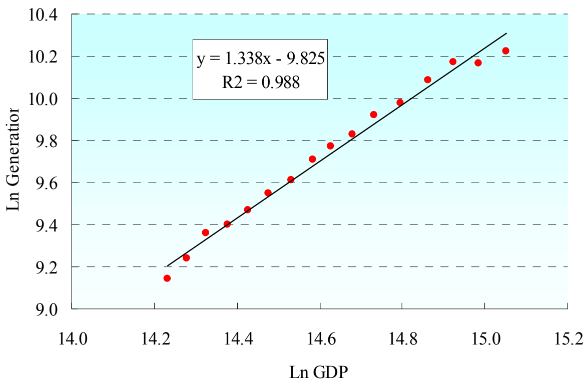


Source: PSMP Study Team

Fig. 7-4 GDP growth rate change and forecasts

7.3.2 Result of regression analysis of the economic growth and the generated power energy

The result of regression analysis of the GDP and the generated power energy indicates that there is a strong correlation between them as shown in the figure below. Therefore, PSMP Study Team judge that it is appropriate to examine the result with a similar method in this examination.



Source: PSMP Study Team

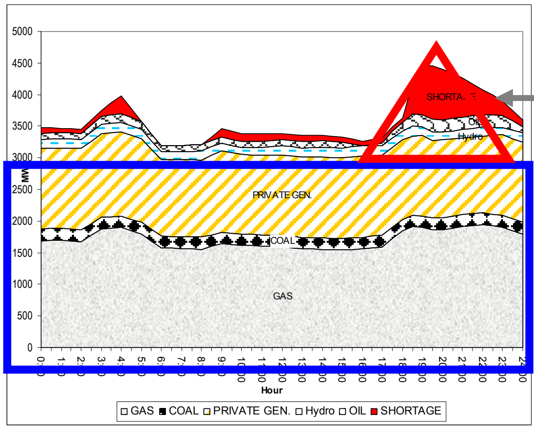
Fig. 7-5 Result of regression analysis of the GDP and the generated power energy

7.3.3 Assumption of the maximum power that includes potential demands

(1) Concept

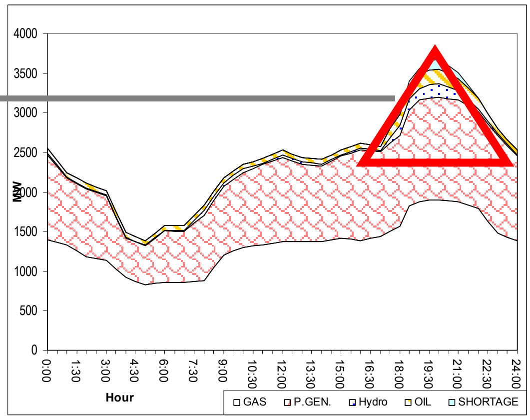
As described in the section above, to forecast the maximum demand that includes potential demands more accurately, it is necessary to theoretically estimate the load curve from daily operation data while placing focus on seasonal variation characteristics of the daily load curve and the rotational outage.

As shown in the figures below, rotational outage occurs relatively less frequently on weekends and holidays in winter, and the daily load curve looks very close to the actual peak load (lighting peak). To produce a compound load curve of the base load in summer and the lighting peak in winter, a PSMP Study Team collected and analyzed data from Daily-Generation Reports (PGCB-DGR), which are published on a daily basis by the electricity transmission company PGCB, in the past 16 years.



Source: PGCB Operation Data

Fig. 7-6 Typical load curve in summer



Source: PGCB Operation Data

Fig. 7-7 Typical load curve in winter

(2) Examination flow

The specific examination flow is as shown below.

Step-1: Capture half hourly load data for eastern and western zones from daily report furnished by PGCB for all days in a month;

↓

Step-2: Calculate the total of half hourly load data of both zones

↓

Step-3: Capture half hourly recorded load shedding for all days in a month.

↓

Step-4: Add half hourly recorded load shedding with half hourly load data of each day.

↓

Step-5: Find the Peak load of each day by taking maximum of each day.

↓

Step-6: Determine the base load of each day considering load at 6.00pm from April to October and load at 5.00pm from November to March. Then calculate incremental peak over base for each day by subtracting the base load from the corresponding Peak Load.

↓

Step-7: Determine the maximum base load and maximum peak over base for each month by taking the maximum of all days in a month.

↓

Step-8: Add maximum incremental peak over base of the fiscal year with maximum base load of that fiscal year to determine the estimated Peak Load of that fiscal year.

Source: PSMP Study Team

Fig. 7-8 Examination flow

(3) Result of examination

The analysis result is as shown in the table below. For the assumed maximum load in 2009, the analysis result is as shown in the table below. The actual recorded maximum load in fiscal 2009 was 4162 MW. However, the assumed maximum load, to which the base load of 4150 MW and the potential peak load of 1500 MW are added, is approximately 5500 MW, and the load factor is 57%.

Therefore, the annual average growth rate in the 16-year period from 1994 to 2009 is inferred to be 7.4%.
Consequently, in performing long-term demand forecast until 2030, PSMP Study Team adopt 5500 MW, which was derived in this examination, as the starting value for fiscal 2009.

Table 7-5 Estimated maximum load in 1994–2009

Fiscal year	Estimated Gross Base Load (MW)	Est Gross Peak over Base Load (MW)	Estimated Gross Peak Load (MW)	Actual Net/Gross	Estimated Net Peak Load (MW)	Growth (%)	Recorded Net Peak load (MW)	Growth (%)
1994	1,350	650	2,000	0.945	1,890		1,772	
1995	1,450	700	2,150	0.945	2,032	7.5%	1,862	5.1%
1996	1,550	750	2,300	0.945	2,174	7.0%	1,972	5.9%
1997	1,725	800	2,525	0.945	2,386	9.8%	1,998	1.3%
1998	1,900	850	2,750	0.945	2,599	8.9%	2,019	1.1%
1999	2,100	900	3,000	0.951	2,853	9.8%	2,330	15.4%
2000	2,200	950	3,150	0.952	2,999	5.1%	2,538	8.9%
2001	2,300	1,025	3,325	0.956	3,179	6.0%	2,904	14.4%
2002	2,450	1,100	3,550	0.956	3,394	6.8%	3,110	7.1%
2003	2,600	1,200	3,800	0.964	3,663	7.9%	3,333	7.2%
2004	2,850	1,250	4,100	0.964	3,952	7.9%	3,491	4.7%
2005	3,097	1,379	4,476	0.962	4,306	8.9%	3,713	6.4%
2006	3,600	1,413	5,013	0.959	4,808	11.7%	3,782	1.9%
2007	4,050	1,063	5,113	0.96	4,908	2.1%	3,717	-1.7%
2008	4,190	1,484	5,674	0.961	5,453	11.1%	4,130	11.1%
2009	4,150	1,500	5,650	0.962	5,435	-0.3%	4162	0.8%
Annual Average Load Growth Rate						7.4%		

Source: PSMP Study Team

Table 7-6 Estimated generated power energy and load factor in 1994–2009

Fiscal year	Recorded Net Energy Generation (GWh)	Recorded Load Shedding (GWh)	Estimated Load Shedding (GWh)	Est. Net Energy Generation (GWh)	Recorded Net Peak Load (MW)	Rec. Max. Load Shedding (MW)	Est.Load Shedding (MW)	Estimated Net Peak Load (MW)	Estimated Load Factor (%)
1994	9,221	99	149	9,370	1,772	540	118	1,890	56.6%
1995	10,166	87	131	10,297	1,862	537	170	2,032	57.9%
1996	10,833	500	750	11,583	1,972	545	202	2,174	60.8%
1997	11,243	550	825	12,068	1,998	674	388	2,386	57.7%
1998	12,194	516	774	12,968	2,019	711	580	2,599	57.0%
1999	13,638	264	396	14,034	2,330	774	523	2,853	56.2%
2000	14,739	121	182	14,921	2,538	536	461	2,999	56.8%
2001	16,254	119	179	16,433	2,904	663	275	3,179	59.0%
2002	17,445	70	105	17,550	3,110	367	284	3,394	59.0%
2003	18,422	69	104	18,526	3,333	468	330	3,663	57.7%
2004	20,062	147	221	20,283	3,491	694	461	3,952	58.6%
2005	21,162	258	387	21,549	3,713	895	593	4,306	57.1%
2006	22,741	810	1,215	23,956	3,782	1,342	1,026	4,808	56.9%
2007	22,783	1,251	1,877	24,660	3,717	1,427	1,191	4,908	57.3%
2008	24,311	1,286	1,929	26,240	4,130	1,140	1,323	5,453	54.9%
2009	25,621	1,372	2,058	27,679	4,162	1,538	1,273	5,435	58.1%

Source: Commercial Operation Statistics, BPDB

(4) Long-term demand forecasts until fiscal 2030

As with PSMP, the result of forecasting the demand through single regression analysis of the GDP and the generated power energy in terms of fiscal year 2030 is approximately 30 GW[1] in the base case, approximately 40 GW in the high case, and approximately 20 GW in the low case,

7.4 PSMP 2010 power demand forecast using the energy intensity method

7.4.1 Examination flow

In general, there is a certain tendency in the relation between economic growth and power consumptions. In an economic situation where the GDP per capita is approximately several hundred dollars, the electricity intensity significantly increases with the economic growth. However, if the GDP per capita exceeds approximately 1,000 dollars, the growth rate of electricity intensity with the economic growth slows down. As economic growth advances as in advanced counties, the electricity intensity hardly increases even if the GDP per capita grows. Major backgrounds for such a tendency in various countries include the following.

- With economic growth, the mainstay industry shifts from the industrial to the service industry.
- With the progress or reform of technologies, or the development/introduction of highly efficient fuels, the energy consumption efficiency of the industry increases.

Focusing on such a relation between economic growth and energy intensity, this section verifies the result of long-term demand forecasts in Bangladesh by referring to the process of economic growth in neighboring countries. Specifically, PSMP Study Team will first incorporate the records of neighboring countries and then perform verification by setting an approximation formula for estimating electricity intensity based on the GDP per capita and comparing this with the maximum load calculated using the conventional method of PSMP 2006 and PSMP 2010. The major steps of the verification are as follows.

- Setting an approximation formula for electricity intensity through regression analysis
- Calculating the GDP per capita until 2030 based on the economic growth forecasts of Bangladesh
- Calculating the power consumptions and the maximum load until 2030 by calculating electricity intensity until 2030 using the approximation formula, and multiplying the electricity intensity by the GDP
- Comparing the above calculation result with the forecast values obtained using the conventional method

7.4.2 Setting an approximation formula

For regression analysis, the log-quadratic approximation method is adopted. This method is designed to approximate electric intensity using a log-quadratic function with the GDP per capita as the parameter, as indicated below. Although the records of the respective countries show similar forms with this method, they have different positions. Therefore, in regression analysis, PSMP Study Team perform regression calculation using dummy variables so that the intercepts represent unique values of the respective counties, while the coefficients of GDP per capita are common for both the first-order and second-order terms.

$$e = \alpha + \beta y + \chi y^2 \left(+ \lambda_1 D_1 + \lambda_2 D_2 + \ldots + \lambda_{n-1} D_{n-1} \right)$$

e : power consumption per GDP 1 dollar

y : GDP per capita of population (logarithm)

D_i : dummy variable of foreign country i

n : number of foreign countries to be referred to

1 Value reported at the first seminar held during the third field survey.

7.4.3 Conditions for multiple regression analysis

The conditions used for analysis are as indicated in the table below.

Table 7-7 Conditions for multiple regression analysis

Fiscal Year	GDP (million Taka, at 1995-96 constant price)	GDP (million USD, at 2000 constant price)	GDP per capita USD, at 2000 constant price)	GDP Growth Rate	Population (mill, No.)	Total Sales (GWh)	Per Capita Consumption(kWh)	Consumption per GDP(Wh)
1994	1,515,139	33,659	290		116.2	6,149	64.08	0.221
1995	1,589,762	35,316	301	4.9%	117.4	6,935	71.32	0.237
1996	1,663,240	36,949	312	4.6%	118.6	7,454	75.88	0.243
1997	1,752,847	38,939	325	5.4%	119.7	7,822	78.89	0.243
1998	1,844,478	40,975	324	5.2%	126.5	8,382	80.44	0.248
1999	1,934,291	42,970	336	4.9%	128.0	9,305	88.69	0.264
2000	2,049,276	45,524	350	5.9%	130.0	10,083	95.85	0.274
2001	2,157,353	47,925	363	5.3%	132.0	11,409	106.08	0.292
2002	2,252,609	50,042	374	4.4%	134.0	12,535	113.80	0.305
2003	2,371,006	52,672	395	5.3%	133.4	13,877	122.43	0.310
2004	2,501,813	55,974	413	5.5%	135.4	15,332	133.11	0.322
2005	2,669,740	61,400	447	6.7%	137.4	16,338	139.68	0.313
2006	2,846,726	65,400	469	6.6%	139.5	18,128	150.22	0.320
2007	3,029,709	69,600	493	6.4%	141.2	18,776	149.98	0.304
2008	3,217,855	73,922	517	6.2%	143.0	20,415	158.20	0.306
2009	3,406,524	78,256	540	5.9%	144.8	21,955	165.32	0.306
2010	3,644,981	83,734	564	7.0%	148.5			
2011	3,900,129	89,596	589	7.0%	152.2			
2012	4,173,138	95,867	615	7.0%	155.9			
2013	4,465,258	102,578	643	7.0%	159.6			
2014	4,777,826	109,759	672	7.0%	163.3			
2015	5,112,274	117,442	703	7.0%	167.0			
2016	5,470,133	125,663	736	7.0%	170.7			
2017	5,853,042	134,459	771	7.0%	174.4			
2018	6,262,755	143,871	808	7.0%	178.1			
2019	6,701,148	153,942	847	7.0%	181.8			
2020	7,170,229	164,718	888	7.0%	185.6			
2021	7,672,145	176,248	940	7.0%	187.4			
2022	8,209,195	188,586	996	7.0%	189.3			
2023	8,783,838	201,787	1,055	7.0%	191.2			
2024	9,398,707	215,912	1,118	7.0%	193.1			
2025	10,056,617	231,026	1,185	7.0%	195.0			
2026	10,760,580	247,197	1,257	7.0%	196.7			
2027	11,513,820	264,501	1,334	7.0%	198.3			
2028	12,319,788	283,016	1,416	7.0%	199.9			
2029	13,182,173	302,828	1,502	7.0%	201.6			
2030	14,104,925	324,025	1,595	7.0%	203.2			

Source: PSMP Study Team

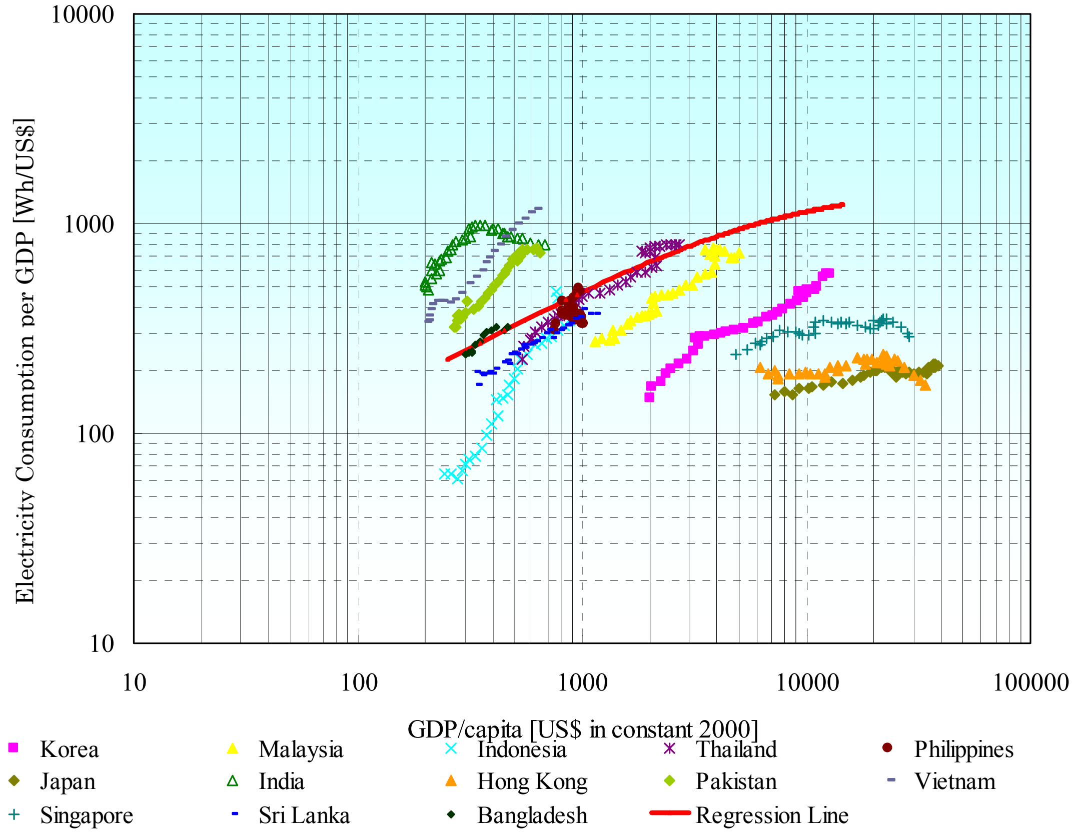
7.4.4 Result of regression analysis

The result of regression analysis is provided in the table below. The second coefficient of GDP per capita is a negative value, as assumed (the increase in electricity intensity slows down with the increase in GDP per capita). By countries, the dummy variable coefficients of advanced countries such as Japan, Singapore and Hong Kong are lower than those of other countries. This means that the regression curves of these countries are located lower than those of other countries. Overall, since the P-value is sufficiently small for any of the variables and the determination coefficient adjusted for the degrees of freedom is high at 0.83, it is judged that a favorable regression result was obtained.

Table 7-8 Result for multiple regression analysis

	Coefficient	Standard Error	t-Value	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	-1.179	0.216	-5.449	0.000	-1.604	-0.754	-1.604	-0.754
LOG(GDP.pc)	1.850	0.137	13.508	0.000	1.581	2.119	1.581	2.119
LOG(GDP.pc^2)	-0.200	0.021	-9.676	0.000	-0.241	-0.160	-0.241	-0.160
Vietnam	0.542	0.029	18.792	0.000	0.485	0.599	0.485	0.599
Korea	-0.410	0.046	-8.868	0.000	-0.501	-0.319	-0.501	-0.319
Malaysia	-0.115	0.041	-2.838	0.005	-0.195	-0.035	-0.195	-0.035
Indonesia	-0.060	0.031	-1.971	0.049	-0.121	0.000	-0.121	0.000
Japan	-0.788	0.061	-12.980	0.000	-0.908	-0.669	-0.908	-0.669
Thailand	0.069	0.036	1.931	0.054	-0.001	0.139	-0.001	0.139
Philippines	0.066	0.034	1.931	0.054	-0.001	0.133	-0.001	0.133
India	0.690	0.029	23.985	0.000	0.634	0.747	0.634	0.747
Hong Kong	-0.737	0.057	-13.008	0.000	-0.848	-0.626	-0.848	-0.626
Pakistan	0.436	0.029	14.793	0.000	0.378	0.494	0.378	0.494
Singapore	-0.540	0.054	-9.963	0.000	-0.647	-0.434	-0.647	-0.434
Sri Lanka	0.016	0.031	0.501	0.617	-0.045	0.076	-0.045	0.076
China	0.704	0.030	23.656	0.000	0.645	0.762	0.645	0.762
Nepal	0.199	0.030	6.580	0.000	0.140	0.259	0.140	0.259

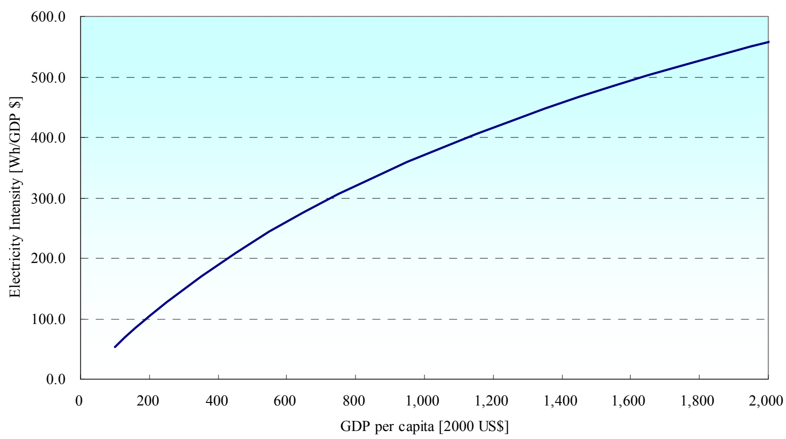
Source: PSMP Study Team



Source: IEA Energy Balance and IMF Economic data base, 2009

Fig. 7-9 Relation between GDP per capita and energy intensity (comparison with neighboring countries)

The relation between the GDP per capita and the electricity intensity in Bangladesh based on this regression result is indicated in the figure below. Reflecting case examples in other countries, the figure represents a tendency that as the GDP per capita exceeds approximately 1,000 dollars, the increase in electricity intensity slows down.



Source: PSMP Study Team

Fig. 7-10 Result of analysis in Bangladesh

7.4.5 Long-term demand forecasts until FY 2030

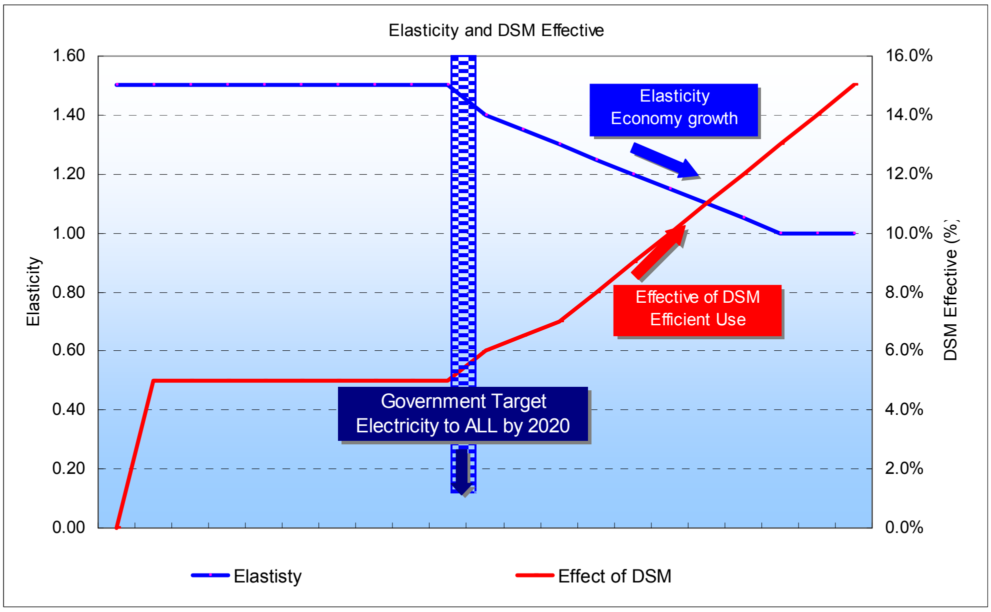
This section compares the base cases of PSMP 2006 and PSMP 2010 in terms of FY 2009 and FY 2025. In terms of FY 2009, PSMP 2006 forecasts a value approximately 10% higher than the present potential demand of 5500 MW. However, in terms of FY 2025, PSMP 2010 forecasts a value approximately 15% higher. This means that this evaluation method may result in a large variation in long-term forecasts depending on the gradient obtained through regression analysis of GDP and generated power energy and on the GDP scenario setting.

If power demand forecast is performed using the energy intensity method, it forecasts long-term demands based on the relation between economic growth and energy intensity by referring to the process of economic growth in neighboring countries. Therefore, it is possible to make a relative comparison, and a model in which the growth rate when economic growth has reached a certain level slows down is assumed. As a result, long-term demands are suppressed to a more realistic level than the conventional single regression analysis method with the GDP.

In terms of FY2025, the forecast value using the energy intensity method is almost equal to the values of PSMP 2006 and the gas master plan. In addition, in comparison to the conventional method, it is approximately 10% lower in terms of FY 2030. In this MP, the demand is calculated using a method that takes into account the relation between economic growth and energy intensity.

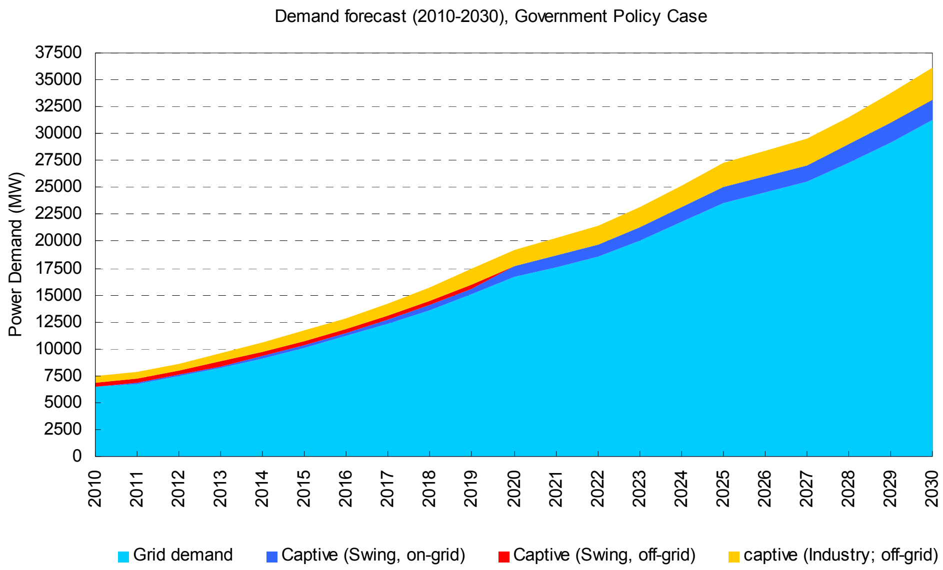
7.5 Demand forecast based on government policy

The Bangladesh government declares the policy "electricity to all by 2021", targeting the electrification rate 100% achievement and 600kWh per capita is set to the catchphrase, and the government develops the coherent strategy of the power supply plan for the government targets.
In this Master Plan, power demand forecast is also determined to attain those government targets, and power supply plan is developed in line with the demand forecast.
At the same time, the power load reduction strategy by DSM is included from the viewpoint of the power supply investment reduction in this scenario.



Source: PSMP Study Team

Fig. 7-11 Load factor reduction scenario by introducing DSM



Source: PSMP Study Team

Fig. 7-12 Government policy scenario for power demand forecast

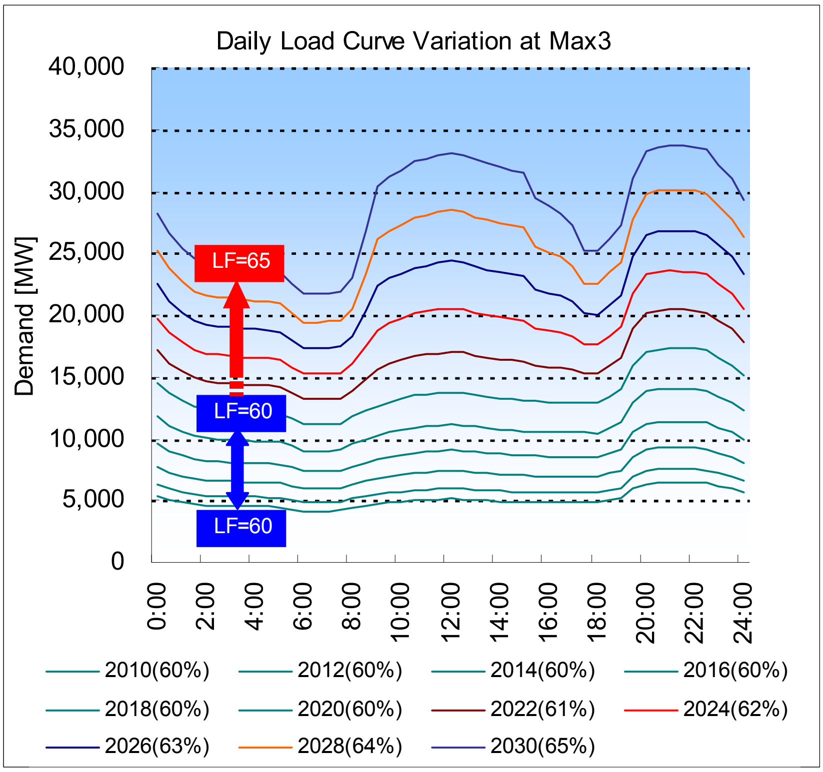
Table 7-9 Result of demand forecast based on government policy

FY	GDP growth rate	Elasticity	Effect of DSM	Electricity growth rate	Total Demand without DSM	Total Demand with DSM	Off-grid captive demand	Grid System Demand with DSM for MP
Unit	[%]	-	[%]	[%]	[MW]	[MW]	[MW]	[MW]
2010	5.5%	1.50	5.0%		7,454	7,454	1,000	6,454
2011	6.7%	1.50	5.0%	4.5%	8,203	7,793	1,027	6,765
2012	7.0%	1.50	5.0%	10.5%	9,064	8,611	1,093	7,518
2013	7.0%	1.50	5.0%	10.5%	10,016	9,515	1,166	8,349
2014	7.0%	1.50	5.0%	10.5%	11,068	10,514	1,246	9,268
2015	7.0%	1.50	5.0%	10.5%	12,230	11,618	1,335	10,283
2016	7.0%	1.50	5.0%	10.5%	13,514	12,838	1,433	11,405
2017	7.0%	1.50	5.0%	10.5%	14,933	14,186	1,542	12,644
2018	7.0%	1.50	5.0%	10.5%	16,501	15,676	1,662	14,014
2019	7.0%	1.50	5.0%	10.5%	18,233	17,322	1,794	15,527
2020	7.0%	1.40	6.0%	8.6%	20,020	18,819	1,515	17,304
2021	7.0%	1.35	6.5%	8.9%	21,912	20,488	1,649	18,838
2022	7.0%	1.30	7.0%	8.5%	23,906	22,233	1,790	20,443
2023	7.0%	1.25	8.0%	7.6%	25,998	23,918	1,925	21,993
2024	7.0%	1.20	9.0%	7.2%	28,182	25,645	2,064	23,581
2025	7.0%	1.15	10.0%	6.9%	30,450	27,405	2,206	25,199
2026	7.0%	1.10	11.0%	6.5%	32,795	29,187	2,349	26,838
2027	7.0%	1.05	12.0%	6.1%	35,205	30,981	2,494	28,487
2028	7.0%	1.00	13.0%	5.8%	37,670	32,773	2,638	30,134
2029	7.0%	1.00	14.0%	5.8%	40,306	34,664	2,790	31,873
2030	7.0%	1.00	15.0%	5.8%	43,128	36,659	2,951	33,708

Source: PSMP Study Team

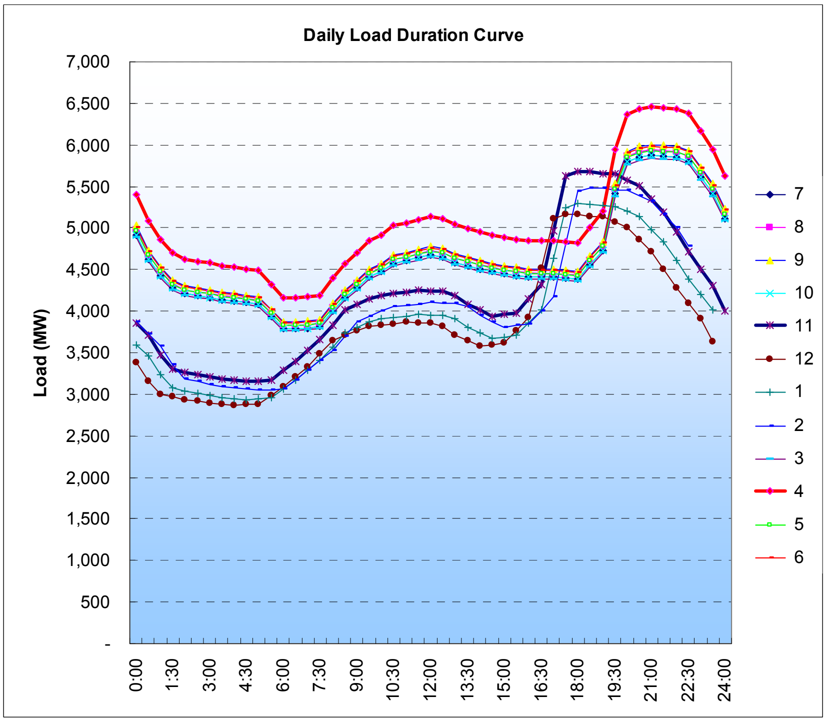
7.6 Setting of load factor

The load factor is set at 60% constant for ten years from 2010 to 2020, and it improves by 0.5% every year afterwards, reaching at 65% by 2030.



Source: PSMP Study Team

Fig. 7-13 Load factor scenario

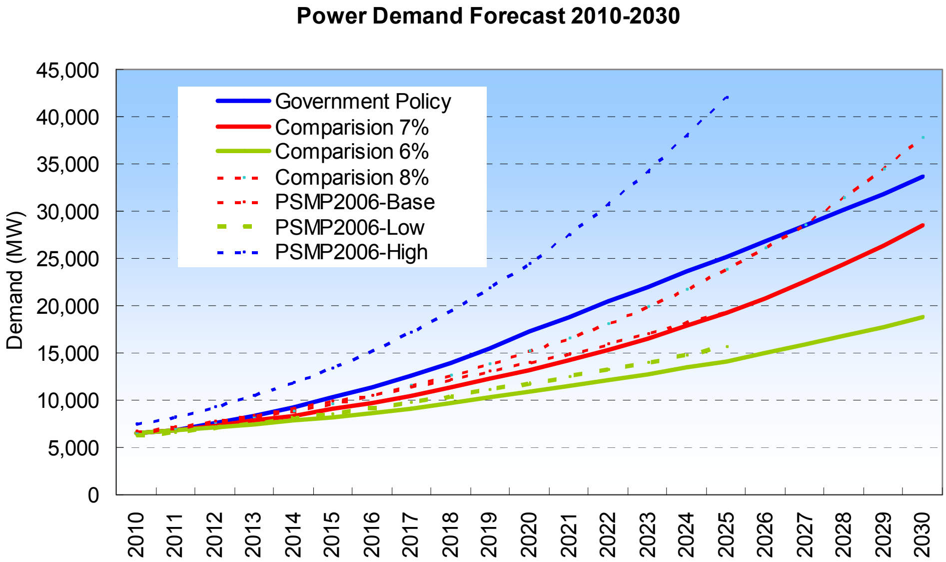


Source: PSMP Study Team

Fig. 7-14 Government policy scenario for power demand forecast

7.7 Adopted scenario of the power demand forecast

The adoption scenarios of the power demand forecast in this MP are as shown in the figure below. The figure indicates three scenarios; (i) GDP 7% scenario and (ii) GDP 6% scenario, based on energy intensity method, and (iii) government policy scenario.



Source: PSMP Study Team

Fig. 7-15 Three scenarios for power demand forecast

Table 7-10 Result of demand forecast (3 scenario)

FY	Government Policy Scenario		Comparison GDP7% Scenario		Comparison GDP6% Scenario	
	Peak Demand [MW]	Generation [GWH]	Peak Demand [MW]	Generation [GWH]	Peak Demand [MW]	Generation [GWH]
2010	6,454	33,922	6,454	33,922	6,454	33,922
2011	6,765	35,557	6,869	36,103	6,756	35,510
2012	7,518	39,515	7,329	38,521	7,083	37,228
2013	8,349	43,882	7,837	41,191	7,436	39,084
2014	9,268	48,713	8,398	44,140	7,819	41,097
2015	10,283	54,047	9,019	47,404	8,232	43,267
2016	11,405	59,945	9,705	51,009	8,680	45,622
2017	12,644	66,457	10,463	54,994	9,165	48,171
2018	14,014	73,658	11,300	59,393	9,689	50,925
2019	15,527	81,610	12,224	64,249	10,255	53,900
2020	17,304	90,950	13,244	69,610	10,868	57,122
2021	18,838	99,838	14,249	75,517	11,442	60,640
2022	20,443	109,239	15,344	81,992	12,056	64,422
2023	21,993	118,485	16,539	89,102	12,713	68,490
2024	23,581	128,073	17,840	96,893	13,416	72,865
2025	25,199	137,965	19,257	105,432	14,167	77,564
2026	26,838	148,114	20,814	114,868	14,979	82,666
2027	28,487	158,462	22,509	125,209	15,848	88,156
2028	30,134	168,943	24,353	136,533	16,776	94,053
2029	31,873	180,089	26,358	148,928	17,768	100,393
2030	33,708	191,933	28,537	162,490	18,828	107,207

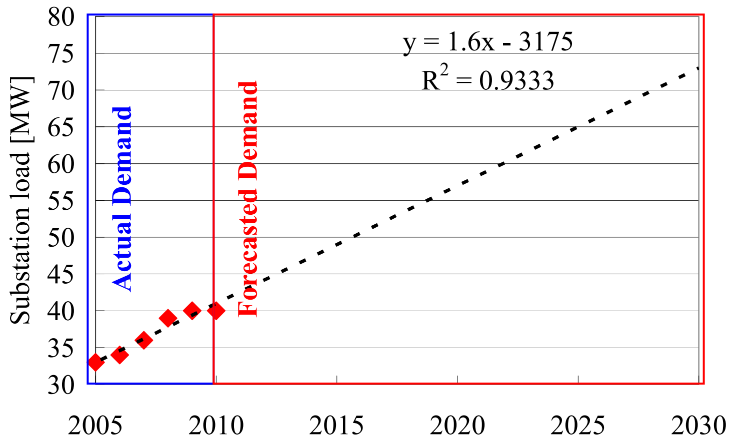
Source: PSMP Study Team

7.8 Each substation load forecast

7.8.1 Methodology

Each substation load forecast is carried out by the following methods.

- Maximum load data at each 132/33kV substation is collected from the past six years (FY 2005-2010).
- Regression analyses by 2030 are carried out based on the aforementioned data.
- The load forecast at each 132/33kV substation is estimated by using the regression equation, and proportionally distributed via the microanalysis power demand.



Source: PSMP Study Team

Fig. 7-16 Basic concept for substation load forecast

7.8.2 Analysis of the historical substation load data

The maximum load data at each 132/33kV substation over the period FY 2005-2010 is presented in Table 7-11. As for the calculation of the slope, only the year of increasing maximum load (shaded area) was considered. Meanwhile, the regional average slope was adopted for the substation of the no increased maximum load over the period due to the substation expansion etc.

Table 7-11 Maximum load data at each 132/33kV substation (2005-2010)

East or West	Region	Substation	Substation load (MW)						Slope Rev
			2005	2006	2007	2008	2009	2010	
East	Southern	Kaptai	5	5	7.5	7.5	8	5	0.85
East	Southern	Chandraghona	26.6	29.7	32.2	32.2	19.4	22.6	2.80
East	Southern	Hathazari	60	63	66	66	60	62	2.10
East	Southern	Madunaghat	0	42	42	42	52	52	3.00
East	Southern	Sikalbaha	37.1	37.1	37.1	37.1	34	34	2.91
East	Southern	Dohazari	38	42	42	49	52	58	3.91
East	Southern	Cox's bazar	33	34	36	39	40	40	1.60
East	Southern	Halishahar	108	114	114	114	109	109	1.80
East	Southern	Agrabad	0	0	0	0	0	0	2.91
East	Southern	Kulsi	119	132	132	132	118	118	3.90
East	Southern	Baraulia	0	60	65	65	58	66	2.50
East	Southern	Baroirhat, Ctg	0	0	0	0	0	0	2.91
East	Southern	Feni	40	50	54	54	60	65	4.43
East	Southern	Chowmuhani	68	0	68	68	65	70	0.30
East	Southern	Ramganj	0	0	0	0	0	0	2.91
East	Southern	Comilla (N)	35	35	35	37	58	59	5.46
East	Southern	Comilla (S)	89	98	98	98	100	122	4.89

East or West	Region	Substation	Substation load (MW)						Slope Rev
			2005	2006	2007	2008	2009	2010	
East	Southern	Chouddagram	0	68	0	0	0	0	2.91
East	Southern	Chandpur	41	42	0	51	47	62	5.50
East	Southern	Rangamati	0	0	0	0	0	0	2.91
East	Southern	Khagrachari	0	0	0	0	0	0	2.91
East	Southern	Julda	0	0	15	16	15	18	0.80
East	Southern	Bakulia	0	56	72	73	81	82	6.10
East	Southern	Shahmirpur	0	0	0	0	0	0	2.91
East	Southern	Abul Khair Steel Mills	7	8	12.9	12.9	10	19.2	1.91
East	Southern	Daudkandi	0	124	0	124	0	0	2.91
West	Western	Goalpara	7.4	7.4	7.4	7.4	4	5	2.22
West	Western	Khulna(C)	99	99	99	99	90	90	2.22
West	Western	Gallamari	0	0	0	0	0	36	2.22
West	Western	Noapara	24	24	31.2	32.6	32	35	2.30
West	Western	Jessore	87	93	93	93	80	102	1.03
West	Western	Jhenaidah	64	64	64	64	63	72	1.06
West	Western	Magura	0	0	0	0	0	0	2.22
West	Western	Kustia(Bottail)	60	60	60	68	58	72	1.77
West	Western	Chuadanga	0	0	0	0	0	0	2.22
West	Western	Bheramara&GKProject	22	25.8	25.8	25.8	26	30.6	1.25
West	Western	Faridpur	46.2	49.2	49.2	57	56	58.6	2.58
West	Western	Madaripur	53	65.2	65.2	65.2	54.4	58	3.66
West	Western	Barisal	56	58	58	58	62	66.5	1.84
West	Western	Barisal (N)	58	0	0	0	0	0	2.22
West	Western	Bhandaria	16	17	18	22	20	31	2.51
West	Western	Bagerhat	28.5	28.5	34	56	30	37.4	2.03
West	Western	Mongla	19	19	19	24	25	18.2	1.70
West	Western	Patuakhali	33.2	33.2	0	34	41	42.5	4.25
West	Western	Gopalganj	0	13	13	16.6	21.6	21.6	2.58
West	Western	Satkhira	0	0	28	33.8	33.6	36.5	2.53
East	Central	Ashuganj	44.3	44.3	58	58	52	53	1.90
East	Central	Kishoreganj	33	36	40	40.5	42	47	2.53
East	Central	Mymensingh	71	77	80	80	80	81	1.69
East	Central	Bhaluka	0	0	0	0	0	0	2.91
East	Central	Jamalpur	41.5	55	62	78	71	78	7.04
East	Central	Sherpur	109	0	0	0	113	0	2.91
East	Central	Netrokona	26.8	26.8	31	44.5	33	33	1.80
East	Central	Shahjibazar	29	29	30	30	28	46	2.34
East	Central	Sreemangal	30	31	34	34	34	36	1.11
East	Central	Fenchuganj	26	26	26	26	31	34	1.57
East	Central	Sylhet	89	92	95	106	111	127	7.37
East	Central	Sylhet New	0	0	0	0	0	0	2.91
East	Central	Chhatak	24	25	25	30	29	33	1.77
East	Central	Brahmanbaria	0	0	0	0	0	0	2.91
West	Northern	Ishurdi	35.3	35.3	21	21	26.4	26.4	2.16
West	Northern	Natore	34	38	41	46	43	58	4.00
West	Northern	Rajshahi	54.7	54.7	57	66.5	71	78.5	5.07
West	Northern	Rajshahi New	0	0	0	0	0	0	2.91
West	Northern	Ch. Nowabganj	49	51	54	58	62	65	3.34
West	Northern	Pabna	37	44	48	48	48	46	1.63
West	Northern	Shahjadpur	27.2	27.2	28	35	39	41	3.18
West	Northern	Sirajganj	34.5	36.5	36.5	37	44	69.5	5.66
West	Northern	Bogra	74	74	82	93	101.5	113	8.24
West	Northern	Noagaon	49	78	78	86	90	85	6.40
West	Northern	Palashbari	28.8	28.8	30.8	30.8	46.6	43	3.55
West	Northern	Rangpur	41	42	53.2	57	58.8	62.3	4.59
West	Northern	Lalmonirhat	24	27	28	32	31	45	3.46

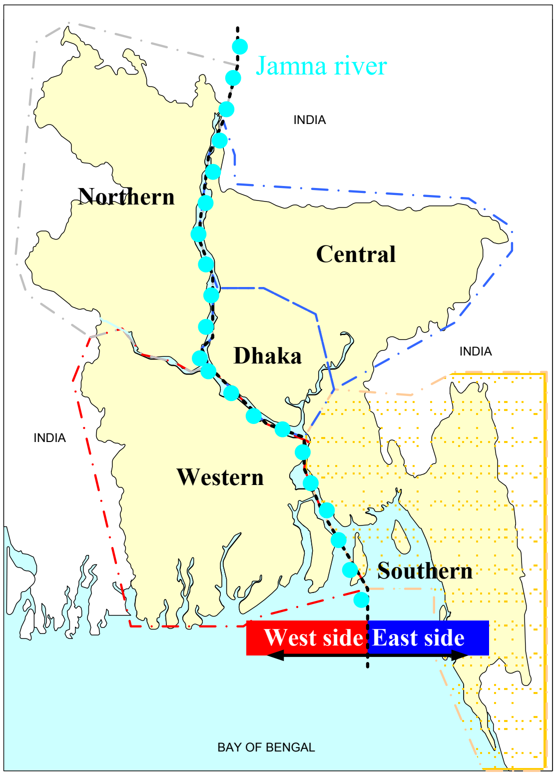
East or West	Region	Substation	Substation load (MW)						Slope Rev
			2005	2006	2007	2008	2009	2010	
West	Northern	Saidpur	54	64	64	64	57	60	0.26
West	Northern	Purbasadipur	29.7	37.2	37.5	39	41	53	3.70
West	Northern	Barapukuria	0	0	0	14	24	41	2.91
West	Northern	Panchaghar	0	0	34	0	0	0	2.91
West	Northern	Joypurhat	85	0	0	0	0	0	2.91
West	Northern	Thakurgaon	36.5	39	34	55	61	62	6.13
West	Northern	Niamatpur	0	0	0	0	0	0	2.91
East	Dhaka	Haripur	70	78	83	83	66	56	4.40
East	Dhaka	Siddhirganj	98	102	89	89	102	102	0.57
East	Dhaka	Maniknagar	64	67	67	70	64	58	1.80
East	Dhaka	Ullon	111	111	111	111	75	69	2.91
East	Dhaka	Moghbazar	111	112	112	119	110	106	2.91
East	Dhaka	Dhanmondi	0	0	124	0	147	143	2.91
East	Dhaka	Narinda	107	107	107	107	90	90	2.91
East	Dhaka	BangaBhaban	43	72	72	72	57	57	2.91
East	Dhaka	Shyampur	0	118	128	128	0	113	2.91
East	Dhaka	Madanganj	63	80	80	80	54	58	2.91
East	Dhaka	Hasnabad	100	107	107	119	91	111	5.70
East	Dhaka	Mirpur	105	116	118	121	122	122	3.03
East	Dhaka	Kalyanpur	0	134	134	138	156	156	6.60
East	Dhaka	Basundhara	144	145	145	145	107	116	9.00
East	Dhaka	Tongi	115	115	115	115	55	60	5.00
East	Dhaka	NewTongi	0	0	0	0	56	58	2.00
East	Dhaka	Kabirpur	134	93	97	112	97	98	9.50
East	Dhaka	Manikganj	52	70	70	70	60	65	5.40
East	Dhaka	Tangail	50	58	58	66	84	86	7.60
East	Dhaka	Ghorasal	75	75	75	84	50	78	2.70
East	Dhaka	Joydebpur	87	87	99	100	105	78	4.90
East	Dhaka	Bhulta	61	65	65	65	62	53	1.20
East	Dhaka	Uttara	0	12	67.3	67.3	75.7	97.1	9.78
East	Dhaka	Cantonment	0	0	42	0	0	0	2.91
East	Dhaka	Nabinagar(Md.pur)	69	0	0	0	0	0	2.91
East	Dhaka	OldAirport	0	0	0	0	0	0	2.91
East	Dhaka	DhakaUniversity	118	0	0	0	0	0	2.91
East	Dhaka	Kamrangirchar	0	0	0	45	56.8	73.6	14.30
East	Dhaka	Madartek	42	0	0	0	0	0	2.91
East	Dhaka	Gulshan	0	0	56	77.9	88	79.4	8.03
East	Dhaka	Matuail	0	0	0	23	16.4	40	8.50
East	Dhaka	Sitalakhya	57.4	86	86	86	84.4	70	5.40
East	Dhaka	Meghnaghat	0	0	0	0	0	0	2.91
East	Dhaka	Narsingdi	0	0	0	0	0	0	2.91
East	Dhaka	Savar	0	0	0	0	0	0	2.91
East	Dhaka	Purbachal	0	0	0	0	0	0	2.91
East	Dhaka	Munshiganj	0	0	0	0	0	0	2.91
East	Dhaka	Sreepur	0	0	0	0	0	0	2.91

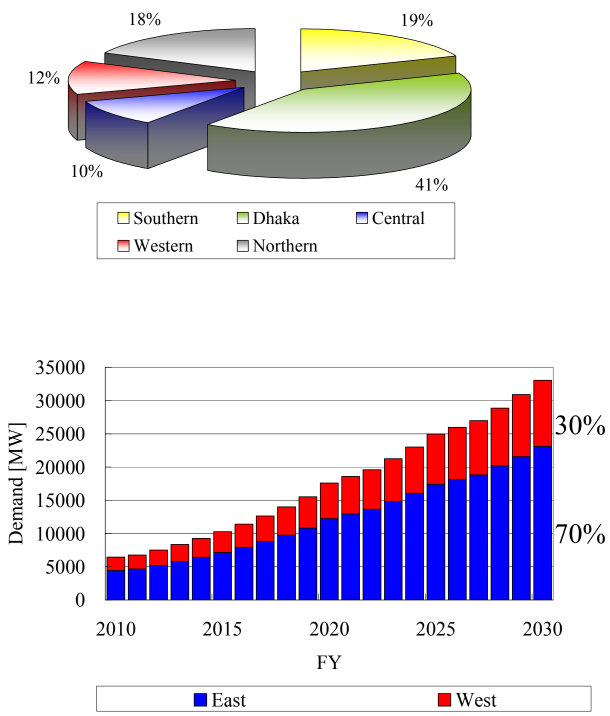
Source: PGCB

7.8.3 Results of substation load forecast

The regional substation load based on the results of the aforementioned substation load forecast is shown in Fig. 7-17. The substation load of Dhaka region is approximately 40%, which is the largest out of the five regions. Therefore, power supply from other regions to the Dhaka region is necessary.

In addition, the substation load of the east region is approximately 70%. If the amount of the power generation is equally located in both the east and west, the power flow from the west to the east will be approximately 20%. Since the Jamuna River is separated into east and west in Bangladesh, a huge amount of money will be invested to construct the river-crossing transmission line. Therefore, it is important that the power development plan be consistent with the regional load balance.





Source: PSMP Study Team

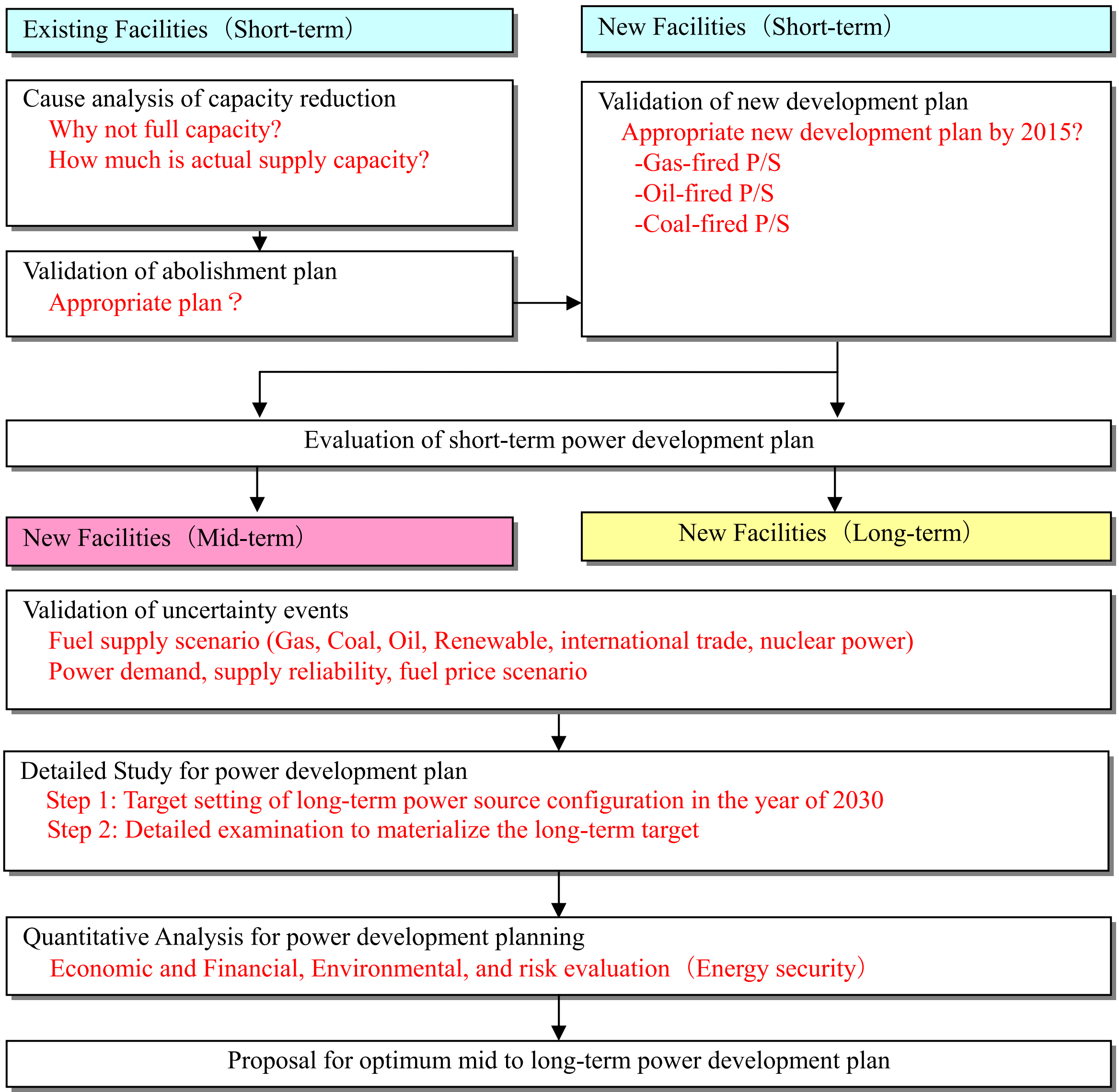
Fig. 7-17 Demand forecast by the each substation demand forecast

Chapter 8 Power Development Plan

8.1 Discussion flow for power development plan

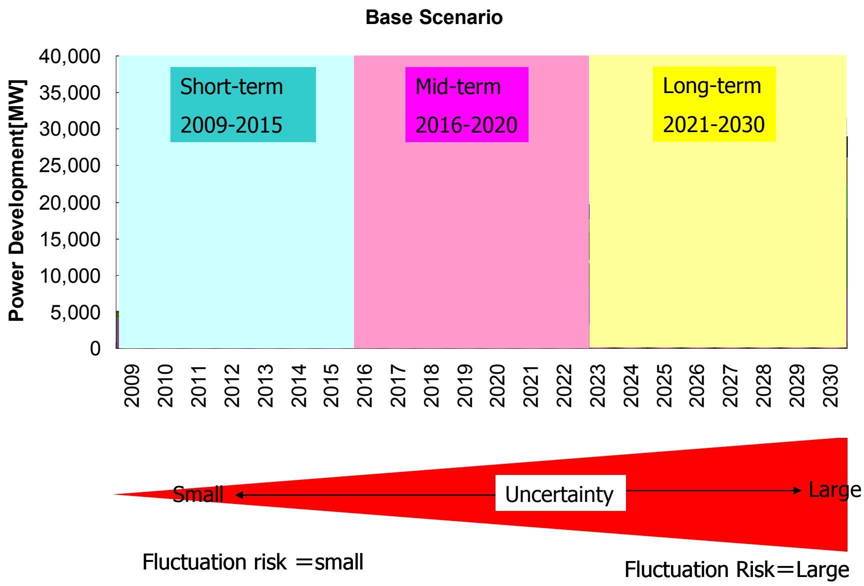
8.1.1 Flow diagram

In formulating the long-term power development plan, it is important to review the low uncertainty events which such as existing facility conditions and plan for the short term as a foundation and to build up to the mid to long-term which has a high uncertainty under the short term plan. The specific flow is depicted below.



Source: PSMP Study Team

Fig. 8-1 Flow Diagram for power development planning



Source: PSMP Study Team

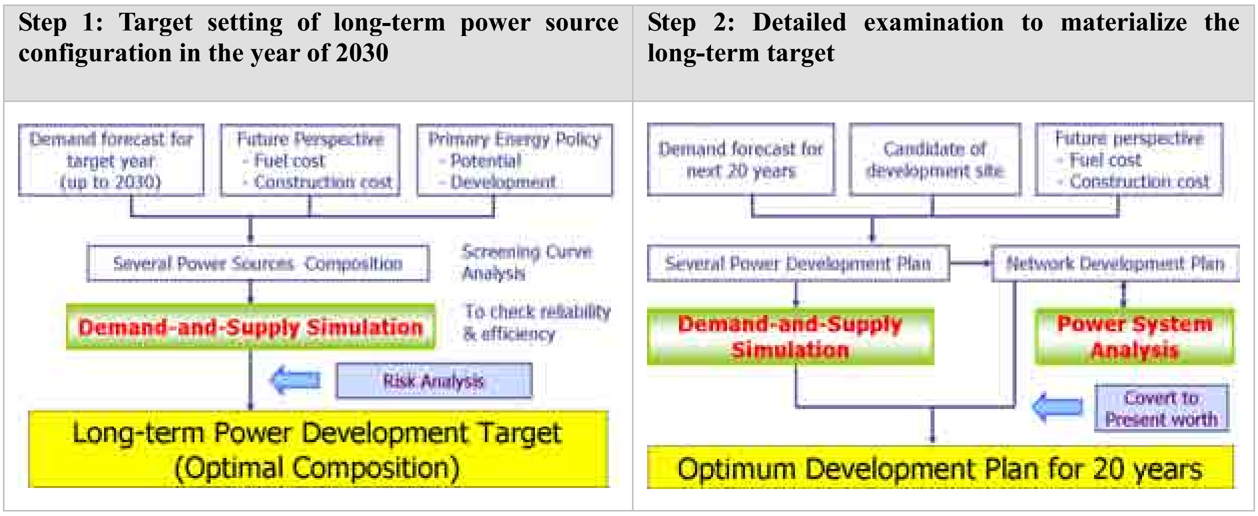
Fig. 8-2 Concept of flow diagram for power development planning

8.1.2 Detailed flow diagram for power development planning

When working out the long-term power development plan, it is necessary to verify the demand and supply of electric power in the future, required reliability for supply, fuel restriction conditions, risks, and costs, and to work out the portfolio to develop a new optimal power source.

The purpose of this chapter is, in order to contribute to the continuous growth of the country Bangladesh, to work out the electric power source plan while effectively using energy, maintaining the environment, and maximizing the energy security, satisfying various conditions required under various restrictions, and minimizing costs required for expansion and operation of the supply systems by 2030.

When working out the optimum power development plan, the two steps below are used:



Source: PSMP Study Team

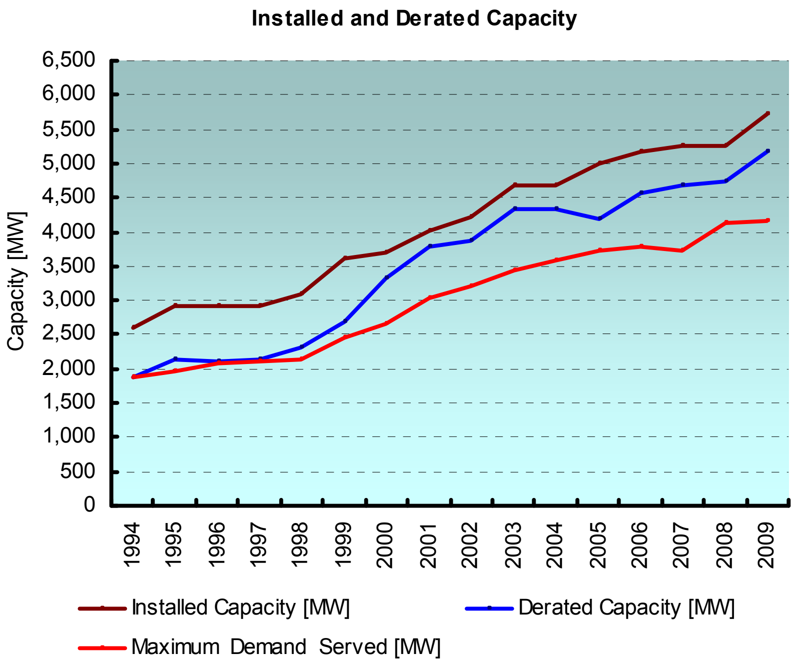
Fig. 8-3 Flow Diagram for power development planning (detail)

8.2 Analysis of the cause of reduced supply

When starting to work out the power source plan, it is necessary to arrange prerequisites and various conditions. Since, in particular, there is a great gap among installed capacity, derated capacity, and maximum demand served in Bangladesh, it is very important to analyze causes of such reduced supply and define the true supply ability of the existing facilities when working out the future power source plan.

8.2.1 Trends in installed capacity, derated capacity, and maximum demand served

The following shows the trends in installed capacity, derated capacity, and maximum demand served in Bangladesh. At the end of FY2009, installed capacity was 5,719 MW, derated capacity was 5,166 MW, and maximum demand served was 4,162 MW. Therefore, they are increased to about 2 to 3 times compared with those in 1994 and the average increase rate in 10 years (2000 to 2009) shows a high growth: 5% to 6%.



Source: BPDB, system planning

Fig. 8-4 Trends in installed capacity, derated capacity, and maximum demand served

The main reason why derated capacity is considered to be lower than installed capacity is because the performance of facilities cannot be shown as designed due to of aging. In addition, a maximum of derated capacity cannot be supplied and the max demand served is actually much lower than derated capacity, due to higher forced and maintenance outages. They seem to be caused by insufficient fuel gas, and facility outage due to maintenance or other reasons, which is as explained in the BPDB Annual Report. Detailed analyses of these differences are described in following part.

8.2.2 Relationship between installed capacity and derated capacity

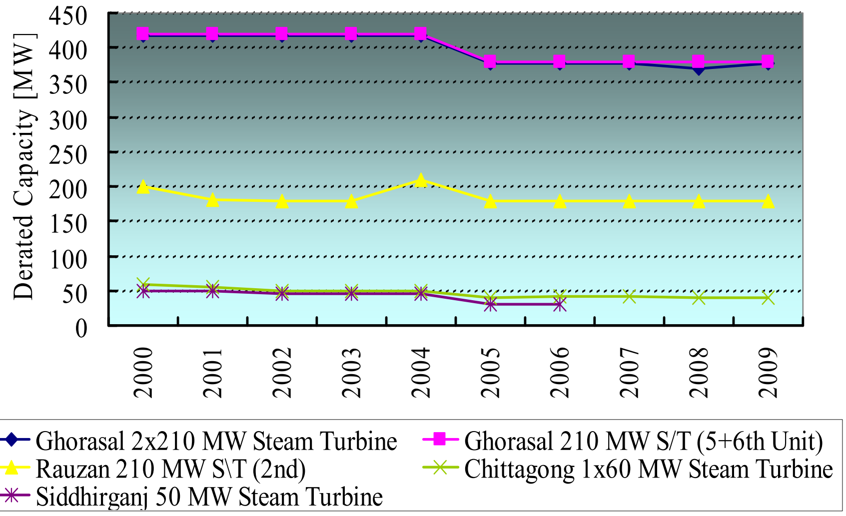
The following table shows installed capacity and derated capacity of BPDB, IPP, and rental power at the end of June 2009. It shows that the total installed capacity is 5,719 MW, but the actual possible power generation capacity considering aging deterioration is shown as 5,166 MW, i.e., lower by about 10%.

Table 8-1 Installed capacity, derated capacity of each power plant (at 2009.6.30)

Category			Power Station Name	Fuel	Type	Region	Commissioning	Installed Capacity (MW)	Derated Capacity (MW)
Ex	Pub	BPDB	Ashuganj 64MW ST #1	Gas	ST	EAST	1970/7/17	64	64
Ex	Pub	BPDB	Ashuganj 64MW ST #2	Gas	ST	EAST	1970/7/8	64	64
Ex	Pub	BPDB	Ashuganj 150 MW ST #3	Gas	ST	EAST	1986/12/17	150	100
Ex	Pub	BPDB	Ashuganj 150 MW ST #4	Gas	ST	EAST	1987/5/4	150	140
Ex	Pub	BPDB	Ashuganj 150 MW ST #5	Gas	ST	EAST	1988/3/21	150	140
Ex	Pub	BPDB	Ashuganj CC (GT 1,2,ST)	Gas	CC	EAST	1982-1987	146	98
Ex	Pub	BPDB	Shkalbaha (Chittagong) 60 MW ST	Gas	ST	EAST	1984/4/24	60	40
Ex	Pub	BPDB	Shkalbaha (Chittagong) 28 MW BMGT	Gas	GT	EAST	1986/10/13	28	10
Ex	Pub	BPDB	Fenchuganj CC (GT1,2,ST)	Gas	CC	EAST	1994-1995	97	91
Ex	Pub	BPDB	Ghorasal 55 MW ST #1	Gas	ST	EAST	1974/6/16	55	55
Ex	Pub	BPDB	Ghorasal 55 MW ST #2	Gas	ST	EAST	1976/2/13	55	30
Ex	Pub	BPDB	Ghorasal 210 MW ST #3	Gas	ST	EAST	1986/9/14	210	190
Ex	Pub	BPDB	Ghorasal 210 MW ST #4	Gas	ST	EAST	1989/3/18	210	190
Ex	Pub	BPDB	Ghorasal 210 MW ST #5	Gas	ST	EAST	1994/9/15	210	190
Ex	Pub	BPDB	Ghorasal 210 MW ST #6	Gas	ST	EAST	1999/1/31	210	190
Ex	Pub	BPDB	Haripur 33 MW GT #1	Gas	GT	EAST	1987/10/31	32	32
Ex	Pub	BPDB	Haripur 33 MW GT #2	Gas	GT	EAST	1987/11/15	32	32
Ex	Pub	BPDB	Haripur 33 MW GT #3	Gas	GT	EAST	1987/12/2	32	32
Ex	Pub	BPDB	Karnafuli Hydro #1	Hydro	-	EAST	1962/2/26	40	40
Ex	Pub	BPDB	Karnafuli Hydro #2	Hydro	-	EAST	1962/8/1	40	40
Ex	Pub	BPDB	Karnafuli(Kaptai) Hydro #3	Hydro	-	EAST	1982/8/1	50	50
Ex	Pub	BPDB	Karnafuli(Kaptai) Hydro #4	Hydro	-	EAST	1988/11/1	50	50
Ex	Pub	BPDB	Karnafuli(Kaptai) Hydro #5	Hydro	-	EAST	1988/11/1	50	50
Ex	Pub	BPDB	Rauzan (Chittagong) 210 MW ST #1	Gas	ST	EAST	1993/3/28	210	180
Ex	Pub	BPDB	Rauzan (Chittagong) 210 MW ST #2	Gas	ST	EAST	1997/9/21	210	180
Ex	Pub	BPDB	Shahjibazar 35 MW GT	Gas	GT	EAST	2000/3/28	35	34
Ex	Pub	BPDB	Shahjibazar 35 MW GT	Gas	GT	EAST	2000/10/25	35	35
Ex	Pub	BPDB	Shahjibazar GT (4 units, 2,4,5,6)	Gas	GT	EAST	1968-69	60	38
Ex	Pub	BPDB	Siddhirganj 210 MW ST	Gas	ST	EAST	2004/9/3	210	190
Ex	Pub	BPDB	Sylhet 20 MW GT	Gas	GT	EAST	1986/12/13	20	20
Ex	Pub	BPDB	Tongi 100 MW GT	Gas	GT	EAST	2005/3/28	105	105
Ex	Pv	IPP	CDC, Haripur 360MW (Haripur Power Ltd.), Narshin	Gas	CC	EAST	2001/12/1	360	360
Ex	Pv	IPP	CDC, Meghnaghat 450MW	Gas	CC	EAST	2002/11/26	450	450
Ex	Pv	IPP	NEPC (Haripur 110MW BMPP)	Gas	D	EAST	1999/6/30	110	110
Ex	Pv	IPP	RPCL (Mymensingh 210MW)	Gas	GT	EAST	2006/6/30	210	175
Ex	Pv	Rental	Feni SIPP (22 MW)	Gas	GT	EAST	2009/2/16	22	22
Ex	Pv	Rental	Jangalia, Comilla SIPP	Gas	GT	EAST	2009/6/25	33	33
Ex	Pv	Rental	Barobkundo SIPP	Gas	GT	EAST	2009/5/23	22	22
Ex	Pv	Rental	Kumargao 10 MW (15 Years)	Gas	GT	EAST	2009/3/15	10	10
Ex	Pv	Rental	Kumargoan 48MW (3 Years)	Gas	GT	EAST	2008/7/23	48	48
Ex	Pv	Rental	Sahzibazar RPP (3 Years)	Gas	GT	EAST	2008/11/13	50	50
Ex	Pv	Rental	Sahzibazar RPP (15 Years)	Gas	GT	EAST	2009/2/9	86	86
Ex	Pv	Rental	Tangail SIPP (22 MW)	Gas	GT	EAST	2008/11/12	22	22
Ex	Pv	Rental	Feni SIPP (11 MW) REB	Gas	GT	EAST	2009/4/22	11	11
Ex	Pv	Rental	Rupganj, Narayanganj, Summit SIPP, REB	Gas	GT	EAST	2009/6/9	33	33
Ex	Pv	Rental	Chandina, Comillaj Summit SIPP, REB	Gas	GT	EAST	2006/11/15	25	25
Ex	Pv	Rental	Mahdabdi, Narsindi Summit SIPP, REB	Gas	GT	EAST	2006/12/16	35	35
Ex	Pv	Rental	Ashulia, Dhaka Summit SIPP, REB	Gas	GT	EAST	2007/12/4	45	45
Ex	Pv	Rental	Mouna, Gazipur Summit SIPP, REB	Gas	GT	EAST	2009/5/12	33	33
Ex	Pv	Rental	Narsindi SIPP, REB	Gas	GT	EAST	2008/12/21	22	22
Ex	Pv	Rental	Hobiganj SIPP, REB	Gas	GT	EAST	2009/1/10	11	11
Ex	Pub	BPDB	Baghabari 71 MW GT	Gas	GT	WEST	1991/6/4	71	71
Ex	Pub	BPDB	Baghabari 100 MW GT	Gas	GT	WEST	2001/11/25	100	100
Ex	Pub	BPDB	Barapukuria 2x125 MW ST (COAL)	COAL	ST	WEST	2006/1/31	250	220
Ex	Pub	BPDB	Barisal 20 MW GT #1	HSD	GT	WEST	1984/8/5	20	16
Ex	Pub	BPDB	Barisal 20 MW GT #2	HSD	GT	WEST	1987/10/4	20	16
Ex	Pub	BPDB	Barisal Diesel (4 units)	HSD	D	WEST	1975-1980	5.5	3
Ex	Pub	BPDB	Bheramara 20 MW GT #1	HSD	GT	WEST	1976/7/28	20	18
Ex	Pub	BPDB	Bheramara 20 MW GT #2	HSD	GT	WEST	1976/4/27	20	18
Ex	Pub	BPDB	Bheramara 20 MW GT #3	HSD	GT	WEST	1980/1/19	20	18
Ex	Pub	BPDB	Bhola Diesel	FO/HSD	D	WEST	1988/10/8	3	2
Ex	Pub	BPDB	Bhola New	HSD	D	WEST	1905/6/28	2	2
Ex	Pub	BPDB	Khulna 60 MW ST	FO	ST	WEST	1973/5/25	60	35
Ex	Pub	BPDB	Khulna 110 MW ST	FO	ST	WEST	1984/7/7	110	60
Ex	Pub	BPDB	Rangpur 20 MW GT	HSD	GT	WEST	1988/8/16	20	20
Ex	Pub	BPDB	Saidpur 20 MW GT	HSD	GT	WEST	1987/9/17	20	19
Ex	Pv	IPP	KPCL (Khulna, BMPP)	FO	D	WEST	1998/10/12	110	106
Ex	Pv	IPP	WEST MONT (Baghabari BMPP)	Gas	GT	WEST	1999/6/26	90	70
Ex	Pv	Rental	Ullapara, Sirajganj Summit SIPP (REB)	Gas	GT	WEST	2009/3/2	11	11
Ex	Pv	Rental	Bogra Rental (15 Years)	Gas	GT	WEST	2008/4/11	18	18
Ex	Pv	Rental	Khulna Rental (3 Years)	HSD	GT	WEST	2008/6/12	40	40
Total Capacity (MW)								**5,719**	**5,166**
Total Public East (MW)								3,070	2,700
Total Private East (MW)								1,638	1,603
Total East (MW)								**4,708**	**4,303**
Total Public West (MW)								742	618
Total Private West (MW)								269	245
Total West (MW)								**1,011**	**863**

Source: BPDB, system planning

The reason why the derated capacity is lower than the installed capacity (each plant cannot demonstrate its full capacity) is because of aging deterioration. Generally, thermal power plants need to conduct regular inspections in order to maintain their performance levels, because long term operation leads to deteriorating performance levels due to aging or existence of scale. In Japan, every plant must conduct regular inspections per regulations and independently, so that the performance levels are maintained. However, thermal power plants in Bangladesh are always operated nonstop for long periods of time, so that regular inspections are not conducted.
When comprehensively considering problems above, there seems to be a gap of about 10% (5719 – 5166 = 553 MW) between installed capacity and derated capacity since Bangladesh does not have check/maintenance institution defined by law and no intentional regular maintenance is carried out because of tight demand. In Japan, where regular maintenance is defined by law, the gap is generally equal to zero (excluding the case where the gap is reduced by temperature increase in summer).
Regarding the possibility of recovery for the gap, although in the past there was some recovery experience when the plant was not old, currently considering the operation year and situation of operations, it is very difficult to recover lost MW fully / cost effectively. However, if the maintenance system improves, it is possible to maintain current capacity. Therefore, it is important to continue maintenance to maintain performance during the operation term of each plant.



Source: BPDB, system planning

Fig. 8-5 Example of derated capacity trend

8.2.3 Relationship between derated capacity and max demand served

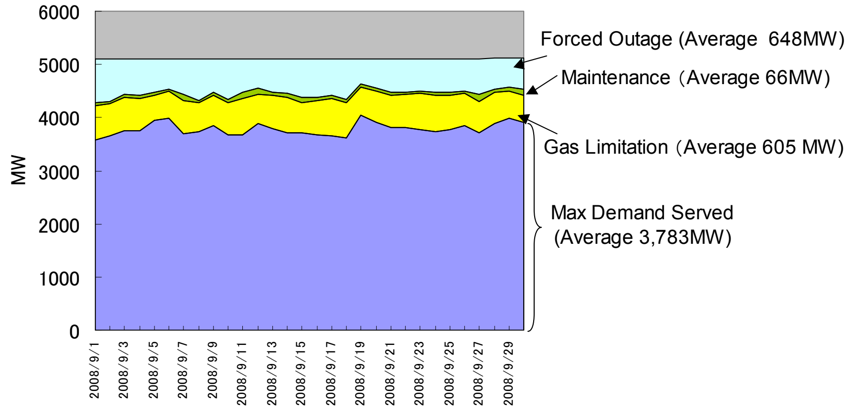
Next, PSMP Study Team analyze the cause of the difference between the derated capacity and the maximum capacity actually supplied. As shown in Table 8-1, the derated capacity is 5,166 MW and the max demand served is 4,162 MW at the end of 2009. The difference between them is considered to be caused by outage or reduced output of gas-fired power generation because of insufficient gas or by outage of facilities because of forced and maintenance outage.
The problems above are concretely analyzed as shown below. The facility operation daily report obtained from PGCB shows the daily derated capacity and the result of the max demand served for it, outage status of each facility (in some cases, reason for outage).The following shows the result of analyzing the daily reports of 12 months (from July 2008 to June 2009) in the year of 2009. a graph indicating the example of data for one month, i.e., September in 2008, and monthly average of 12 month.

Table 8-2 Cause analysis of supply restriction (4 months of FY2009)

(MW)

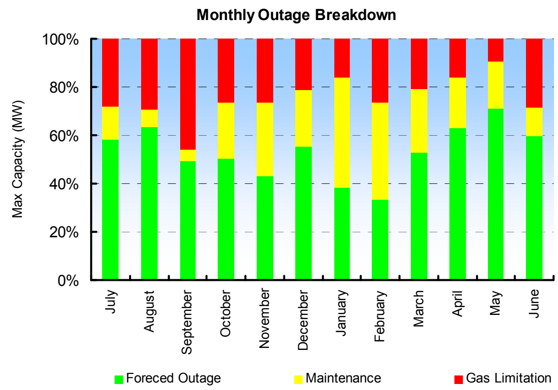
	2008		2009		Average
	Sep.	Dec.	Mar.	Jun.	
Derated Capacity	5,104	5,104	5,282	5,166	5,164
Max Demand Served	3,784	3,560	3,601	3,816	3,691
Reason for shortage					
(1) Gas limitation	605	330	354	385	418
(2) Maintenance	66	358	442	162	257
(3) Forced Outage	648	856	885	803	798

Source: PGCB



Source: PGCB

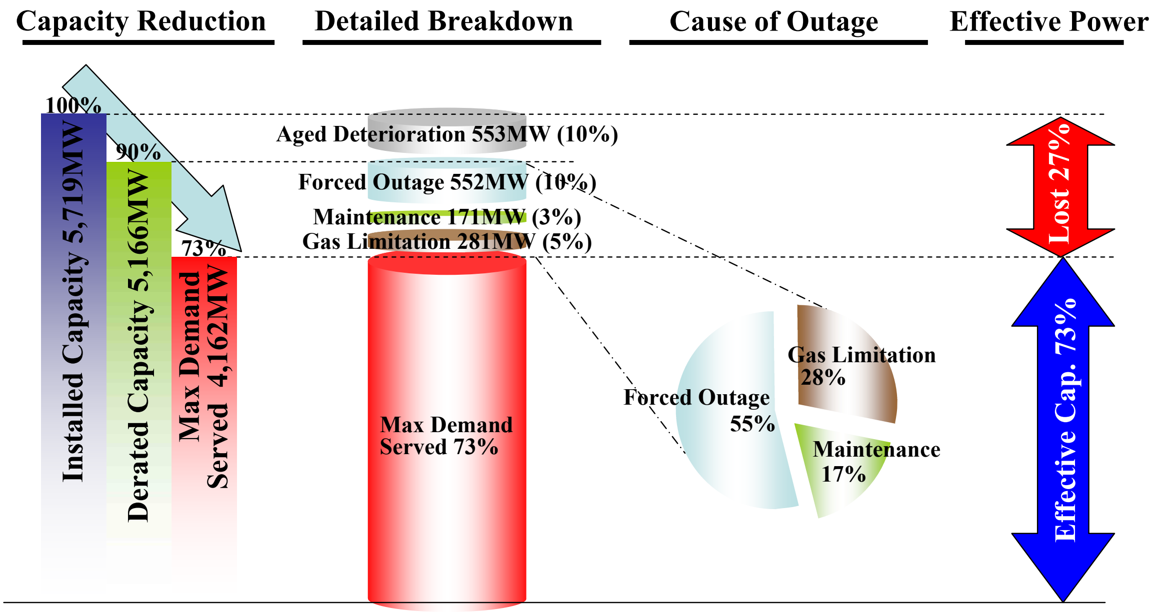
Fig. 8-6 Cause analysis of supply restriction (September 2008)



Source: PGCB

Fig. 8-7 Cause analysis of supply restriction (FY2009)

As shown above, the major cause of supply restriction is a forced outage, the reason that trouble easily occurs is due to unexpected trouble because inspections are not conducted regularly. In order to decrease such trouble, it is a good way to proceed with regular inspections. The analysis of the actual result data clarifies that the restricted operation of gas thermal plants caused by obstructed fuel gas supply is the main cause to the decrease of the maximum supply capacity, as explained above. The value in the year 2009 is equal to 400 to 600 MW. The average is 418 MW which is about 8.1% of the de-rated capacity and is equal to 109 mmcfd as the gas supply amount.



Source: PSMP Study Team

Fig. 8-8 Relationship between derated capacity and max demand served

8.2.4 Conclusion and recommendation

In summarizing the above contents, the following sentences could be read as the results of an analysis for supply shortage.

- In Bangladesh, compared with the installed capacity (5,719MW at June 2009), de-rated capacity which means the raw power of plant, is decreased by about 10% (5166MW), in addition the real max demand served is to decrease to about 20% (4162MW).
- The reason why de-rated capacity is lower than installed capacity is that the regular inspection is not working so that aged deterioration and equipment trouble would occur.
- The reason why the max demand served is lower than the de-rated capacity include stop and restriction caused by maintenance or trouble along with fuel gas shortage. The latter was about 418MW as the average on 2009, equal to about 40% of the causes, it would be a serious problem.
- The first priority in avoiding such gaps is to proceed with regular inspections. It should be considered not only for existing plants but also new constructed plants. If the situation of O&M would not be improved, new constructed plants could not keep good performance, so that the prompt improvement of O&M management should be necessary.
- At the same time, to solve the gas shortage problem is also important for the stable supply of power.

8.3 Validity evaluation of the retirement plans for existing gas-fired power plants

This section investigates the details of the existing gas-fired power plants in Bangladesh analyzes the current states, studies the retirement plans considered by our investigation team, and describes the results of validity verification of the retirement plan prepared by BPDB.

8.3.1 Current status of existing gas-fired power plants

Facilities under BPDB control can be roughly classified into 4 groups. The current state of each is shown below:

Table 8-3 Classification of gas-fired power plants under BPDB control

	Type Name	Capacity	Number	Ave.Heat Efficiency (Actual)[1]
(A)	Mid Capacity Steam Turbine Conventional Type	150～210MW	10	31.1%
(B)	Small Capacity Steam Turbine Conventional Type	55～64MW	5	25.6%
(C)	Simple Gas Turbine	15～100MW	15	24.1%
(D)	Combined Cycle	97～146MW	2	29.5%

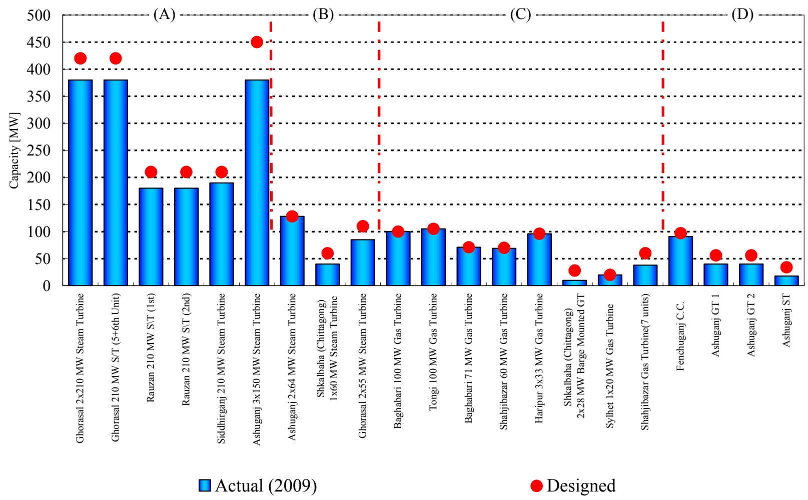
Source: Gathered by PSMP Study Team from BPDB Annual Report

(1) Investigation results of the facilities

The results of investigating specifications and basic information of each facility are as follows.
The capacity of a conventional facility using the steam turbine (ST) is from 55 MW up to 210 MW. The oldest facility was produced in 1974 and many facilities are from China and Russia. For the steam conditions mainly adopted, the pressure is 13 MPa for a 210 MW unit (maximum capacity), 9.0 MPa for re-heat type with a temperature of 540 °C/540 °C and other small-capacity type, and non-re-heat type with a temperature of 535 °C. None of them are used for the business facilities in Japan. Their design performance (thermal efficiency) is 30% or so, which is lower than that of the coal thermal power generation facility mainly used in Japan.
Almost all gas turbine facilities (GT) are old, small-capacity, and low thermal efficient types, excluding large-capacity types recently installed in Tongi and Baghabari. The oldest type was produced in 1968. Various manufacturers supply the facilities, e.g., GE (USA), ALSTOM (France), Mitsubishi (Japan), and Hitachi (Japan).

(2) Investigation results of operation states

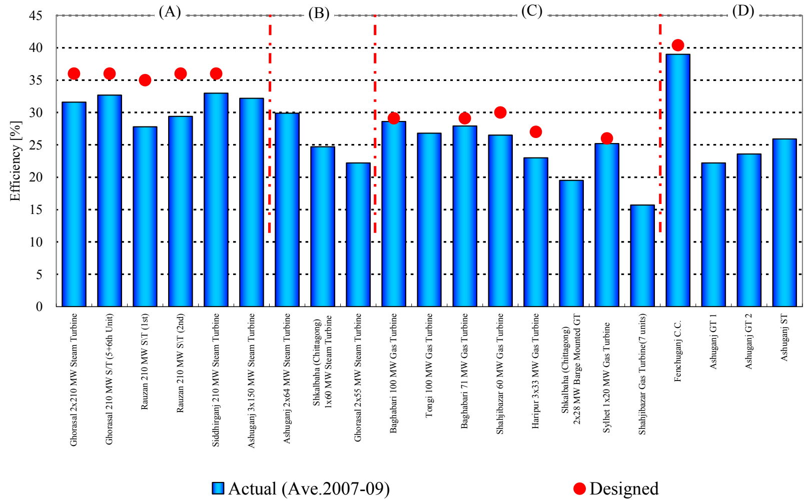
Fig. 8-9 and Fig. 8-10 show the results of investigating the current states of capacity and efficiency of each facility. They show that both capacity and efficiency do not satisfy the design performance as a whole.



Source: BPDB, system planning

Fig. 8-9 Actual capacity of gas-fired power plants

[1] The average thermal efficiency is the average in 3 years from 2007.



Source: BPDB, system planning

Fig. 8-10 Actual efficiency of gas-fired power plants

8.3.2 Verification of operation status and management organization and selection of problems to improve efficiency

Four evaluation items are set to analyze the current state of each facility, i.e., a) performance (thermal efficiency), b) forced outage, c) operation years, and d) power generation cost, and each item is analyzed and evaluated as shown below:

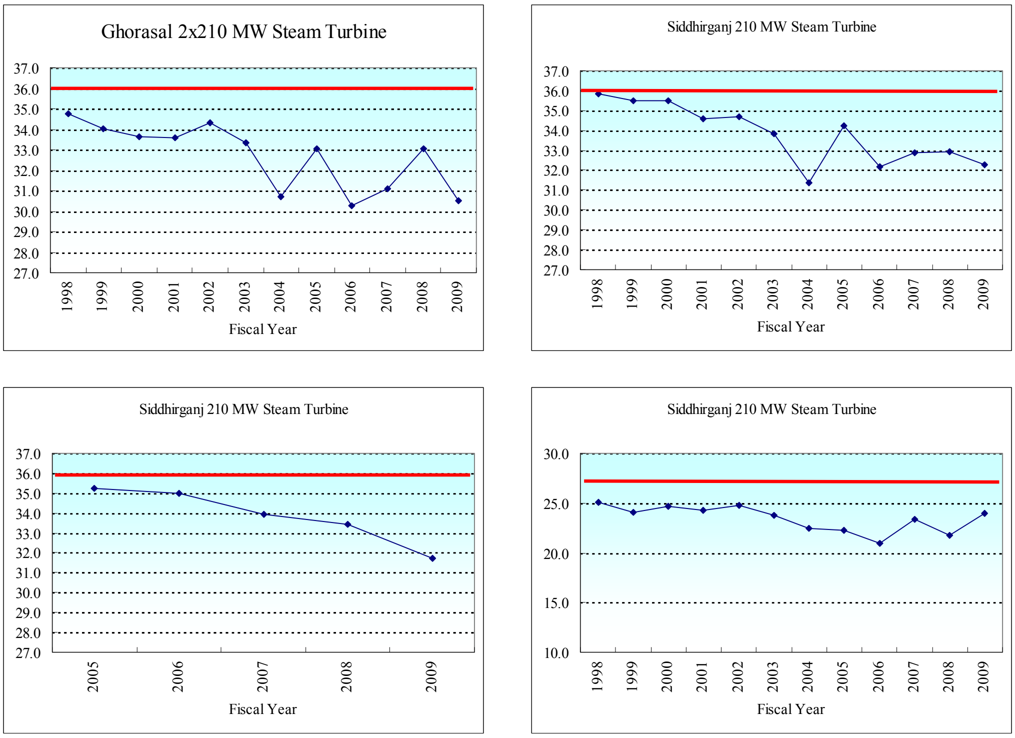
(1) Analysis of actual data

(a) Performance (thermal efficiency)

Fig. 8-11 shows the actual thermal efficiency of each facility in the past 10 years. The red lines in the figure show the design values.

In particular, the steam turbine facility shows the remarkable reduction of efficiency caused by aging. The investigation result shows that regular maintenance were not made as a whole. While a boiler is regularly inspected once every two years and a turbine was inspected once every four years in Japan (including simple check), they were not inspected in the period of 10 to 16 years in Bangladesh Therefore, it is considered that reduced efficiency of the steam turbine facilities was caused by the difficulty to keep the efficiency because of the steam leakage from the turbine, the impossibility to use a high-pressure heater, difficulty to keep a vacuum in condenser, and leakage from thin pipes in the condenser.

On the other hand, some gas turbine facilities may not satisfy the design performance, but they do not clearly show reduced efficiency because of aging. The reason is considered to be that almost all gas turbines were produced by various manufacturers such as GE, ALSTOM, Mitsubishi, and Hitachi, and maintenance required minimum is carried out. However, it is considered that the maintenance is not carried out as scheduled but as required. In addition, many gas turbine facilities in Bangladesh are small-capacity types (excluding Baghabari and Tongi) and low-efficient; therefore, they should be used for peak-corresponding type in the future from the viewpoint of the efficient use of natural gas.



Source: BPDB system planning

Fig. 8-11 Efficiency performance

(b) Forced outage

Table 8-4 shows the result that is obtained by arranging the past performance data of forced outage rate of each facility (forced outage rate = (forced outage time) ÷ (operation time + forced outage time) × 100%). For data analysis, the steps below are used to calculate the performance values:

- The average value and the standard deviation (σ) in the past 10 years (max.) are calculated.
- If σ is less than 10%, the average value is used as the performance value.
- If the deviation is large, i.e., σ is 10% or more, incorrect data are judged to be included, i.e., data out of the average value ±σ are excluded and the average value is calculated again to obtain the performance value.

Table 8-4 Performance of forced outage ratio

	Unit Name	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	Average
(A) ST over 150MW	Ghorasal 4x210 ST (#3,4,5,6)	6.84%	9.28%	4.67%	5.14%	1.01%	22.20%	20.47%	2.13%	1.48%	0.00%	6.12%
		13.97%	19.76%	13.21%	58.82%	2.45%	5.38%	2.32%	2.99%	1.36%	1.54%	
		2.61%	1.45%	1.34%	3.79%	2.73%	1.27%	20.47%	2.13%	1.48%	0.00%	
		16.19%	12.29%	4.65%	2.75%	9.52%	5.49%	2.32%	2.99%	1.36%	1.54%	
	Raozan 210 ST #1	11.46%	2.98%	34.62%	6.99%	1.80%	1.97%	4.97%	1.61%	0.00%	10.50%	5.29%
	Raozan 210 ST #2	27.96%	15.61%	22.47%	1.39%	2.74%	1.95%	2.31%	0.00%	0.00%	5.56%	4.93%
	Siddhirgonj 210 MW ST						10.42%	0.12%	0.33%	0.11%	0.07%	0.16%
	Ashuganj 3x150 MW ST (#3,4,5)	0.66%	0.95%	0.27%	2.21%	3.69%	0.88%	3.63%	2.27%	3.84%	0.36%	2.01%
		0.62%	0.56%	0.64%	0.51%	2.85%	9.39%	41.50%	3.89%	2.43%	2.10%	
		0.60%	0.57%	0.06%	1.53%	3.47%	3.33%	100.00%	100.00%	0.27%	2.66%	
(B) ST under 150MW	Ashuganj 2x64 MW ST (#1,2)	1.44%	6.97%	3.60%	1.01%	2.78%	14.00%	11.52%	12.06%	10.09%	11.05%	5.69%
		7.57%	4.60%	2.85%	2.61%	3.91%	5.42%	1.49%	2.78%	4.36%	3.73%	
	Shikalbaha(Chittagong) 60 MW ST	9.29%	2.45%	0.77%	1.74%	3.08%	1.81%	2.04%	2.03%	6.36%	3.04%	3.26%
	Ghorasal 2x55 ST	9.33%	25.60%	15.41%	24.49%	70.63%	22.82%	3.77%	0.00%	18.37%	0.00%	10.89%
		7.25%	15.29%	6.01%	7.25%	20.82%	10.95%	5.00%	5.55%	0.97%	2.39%	
(C) Gas Turbine	Baghabari 100 MW CT	80.08%	0.78%	0.32%	1.54%	1.82%	2.50%	7.11%	0.00%	0.09%	4.44%	9.75%
	Tongi 80 MW GT							16.64%		11.41%		13.94%
	Baghabari 71 MW CT			1.33%	0.97%	2.06%	6.07%	6.68%	0.32%	0.12%	0.68%	2.28%
	Shahjibazar2x35MW CT			24.13%	100.00%	17.97%	2.52%	26.19%	92.34%	4.81%	0.53%	9.91%
				0.00%	0.00%	100.00%	92.51%	9.65%	100.00%	2.49%	0.87%	
	Haripur 3x33 CT	5.36%	1.71%	2.62%	3.75%	0.14%	0.96%	100.00%	0.00%	0.00%	0.07%	4.12%
		0.07%	0.64%	1.43%	0.55%	0.34%	0.05%	34.50%	0.00%	0.03%	24.67%	
		1.16%	2.81%	0.55%	0.02%	0.71%	1.27%	100.00%	0.00%	0.00%	11.31%	
	Shikalbaha 2x28MW CT	11.01%	20.95%	67.91%	98.04%	97.29%	94.02%	21.40%	7.94%			25.84%
	Sylhet 20 MW CT					4.02%	4.08%	3.19%	0.00%	2.73%	4.09%	14.27%
	Shahjibazar CT	1.39%	7.08%	3.94%	93.30%	0.78%	2.32%	2.32%	46.34%	11.73%	0.00%	9.72%
		1.45%	4.05%	0.18%	55.60%	34.49%	0.00%	0.63%	72.40%	24.22%	0.00%	
		5.60%	14.68%	95.58%	0.00%	3.39%	50.72%	0.00%	71.17%	3.69%	9.45%	
		18.38%	0.90%	0.89%	0.00%	1.45%	1.25%	1.91%	1.84%	2.91%	1.69%	
(D) Combined Cycle	Ashuganj 90 MW CC (GT1,2 +ST)	16.19%	9.10%	2.36%	13.79%	27.06%	15.01%	16.08%	4.79%	5.87%	1.39%	13.70%
		22.45%	24.23%	13.18%	20.39%	24.87%	69.26%	47.41%	20.40%	14.42%	3.67%	
		80.39%	19.14%	1.78%	6.55%	15.46%	16.12%	40.12%	3.17%	1.56%	0.71%	
	Fenchuganj CC (#1,2)		0.75%	0.14%	0.08%	5.72%	3.05%	0.61%	0.78%	0.00%	0.00%	3.03%
			7.22%	3.89%	8.17%	44.52%	70.72%	0.61%	0.78%	0.00%	0.00%	
			6.01%	0.27%	3.74%	2.50%	11.22%	1.84%	0.00%	0.00%	0.09%	

Source: BPDB system planning

The performance values are in the range from a large one-digit value to a small 10s value with partial exception. The table generally shows that while the forced outage rate in Japan is a small one-digit value, that in Bangladesh is a large value. It is considered that this is caused since regular maintenance is not carried out and the operation is basically done with the policy

"Operation proceed until outage occurs because of a failure." Therefore, there seems to be a sufficient possibility that intentional maintenance may allow the forced outage to reduce.

(c) Operation years

Table 8-5 shows the operation start date and operation years of each facility (as of June 30, 2009).

Table 8-5 Operation start date and operation years

	Unit Name	Operation Start Date	Operation Years	Planned Retire Year by BPDB
(A) ST over 150MW	Ghorasal 4x210 ST (#3,4,5,6)	1986/9/14	22	2029
		1989/3/18	20	2029
		1994/9/15	14	2029
		1999/1/31	10	2029
	Raozan 210 ST #1	1993/3/28	16	2026
	Raozan 210 ST #2	1997/9/21	11	2028
	Siddhirgonj 210 MW ST	2004/9/3	4	2035
	Ashuganj 3x150 MW ST (#3,4,5)	1986/12/17	22	2023
		1987/5/4	22	2023
		1988/3/21	21	2023
(B) ST under 150MW	Ashuganj 2x64 MW ST (#1,2)	1970/7/17	38	2014
		1970/7/8	38	2014
	Shikalbaha(Chittagong) 60 MW ST	1984/4/24	25	2019
	Ghorasal 2x55 ST	1974/6/16	36	2016
		1976/2/13	34	2016
(C) Gas Turbine	Baghabari 100 MW CT	2001/11/25	7	2022
	Tongi 80 MW GT	2005/3/28	4	2030
	Baghabari 71 MW CT	1991/6/4	18	2016
	Shahjibazar2x35MW CT	2000/3/28	9	2023
		2000/10/25	8	2023
	Haripur 3x33 CT	1987/10/31	21	2014
		1987/11/15	21	2014
		1987/12/2	21	2014
	Shikalbaha 2x28MW CT	1986/10/13	22	2010
	Sylhet 20 MW CT	1986/12/13	22	2014
	Shahjibazar CT	1968-69	41	2010
(D) Combined Cycle	Ashuganj 90 MW CC (GT1,2 +ST)	1982-1987	22-27	2014
	Fenchuganj CC (#1,2)	1994-1995	15	2022

Source: BPDB system planning

The oldest introduction time is the year of 1968, when Bangladesh was founded, and the newest time is the year of 2005. Old facilities which have been used for 20 years or more are mainly included in the small-capacity steam turbine and small-capacity gas turbine facilities.

(d) Power generation costs

Table 8-6 shows the power generation cost of each facility. The simple average values are used as the average values.

Table 8-6 Power generation costs (Taka/kWh)

	Unit Name	2004-05	2005-06	2006-07	2007-08	2008-09	Average
(A) ST over 150MW	Ghorasal 4x210 ST (#3,4,5,6)	1.38	1.37	1.37	1.35	1.32	1.358
	Raozan 210 ST #1	1.60	1.33	1.6	1.76	1.94	1.65
	Raozan 210 ST #2						
	Siddhirgonj 210 MW ST	1.11	2.37	1.52	1.86		1.715
	Ashuganj 3x150 MW ST (#3,4,5)						
(B) ST under 150MW	Ashuganj 2x64 MW ST (#1,2)						
	Shikalbaha(Chittagong) 60 MW ST	2.21	1.92	2.9	2.56	12.21	4.36
	Ghorasal 2x55 ST	1.38	1.37	1.37	1.35	1.32	1.36
(C) Gas Turbine	Baghabari 100 MW CT	1.69	1.59	1.9	1.9	1.56	1.728
	Tongi 80 MW GT		1.81	2.68	1.76	1.54	1.9475
	Baghabari 71 MW CT	1.69	1.59	1.9	1.9	1.56	1.728
	Shahjibazar2x35MW CT	3.72	2.88	6.16	2.93	1.83	3.50
	Haripur 3x33 CT	2.28	4.5	9.99	2.72	3.26	4.55
	Shikalbaha 2x28MW CT	2.21	1.92	2.9	2.56	12.21	4.36
	Sylhet 20 MW CT						
	Shahjibazar CT	3.72	2.88	6.16	2.93	1.83	3.504
(D) Conbined Cycle	Ashuganj 90 MW CC (GT1,2 +ST)						
	Fenchuganj CC (#1,2)	2.66	1.97	1.05	1.74	1.2	1.724

Source: BPDB Annual Report

It is found that as a whole trend, small-capacity facilities, in particular, gas turbines, include those with high generation costs.

(2) Comprehensive evaluation of each facility

Each facility is evaluated comprehensively using the result of analyzing four types of data. AHP method is used for the evaluation (for details of AHP method, see Chapter 12).

(a) Weighting of items

Four evaluation items (thermal efficiency, forced outage, operation years, and power generation costs) are weighted as shown below:

- Basically, the older the facility is, the lower the performance is. Therefore, efficient operation cannot be achieved; it should be abolished first. That is, the operation years is the important evaluation item.
- Since the reduced performance (thermal efficiency) and the increased force outage ratio are considered to be improved greatly by the execution of intentional regular check, they seem not to be very important when considering retirement.
- Since the power generation cost includes fuel cost, which is important for the performance and structural problems, i.e., there cannot be a simple solution, the power generation cost is the item considered as important when examining abolition.

The results of weighting items using AHP method based on the considerations above are shown in the table below:

Table 8-7 Weighting of evaluation items using AHP method

	Item	1	2	3	4	Geometric Average	Level of Importance	Point Allocation
1	Heat Efficiency	1	1	1/5	1	0.66874	0.151555	15.2
2	Forced Outage Ratio	1	1	1/3	1/3	0.57735	0.130843	13.1
3	Operation Years	3	3	1	2	2.059767	0.466799	46.7
4	Generation Costs	1	3	1/2	1	1.106682	0.250804	25.1

Source: PSMP Study Team

General evaluation is shown in the table below:

Table 8-8 General evaluation

	Unit Name	Efficiency	Forced Outage Ratio	Operation Year	Generation Cost	Total	Rank
		15.2	13.1	46.7	25.1		
1	Ghorasal 4x210 ST (#3,4,5,6)	0.5986	0.6475	2.6699	2.3877	6.3036	6
2	Raozan 210 ST #1	0.4073	0.7553	2.5934	2.0468	5.8028	9
3	Raozan 210 ST #2	0.4399	0.8158	3.6332	2.0468	6.9357	4
4	Siddhirgonj 210 MW ST	0.5131	1.2949	5.7431	1.8235	9.3747	1
5	Ashuganj 3x150 MW ST (#3,4,5)	0.8465	1.1537	1.8338	1.1053	4.9394	10
6	Ashuganj 2x64 MW ST (#1,2)	0.8465	0.7268	0.7497	1.1053	3.4283	17
7	Shikalbaha(Chittagong) 60 MW ST	0.8465	0.9516	1.3176	0.7521	3.8678	14
8	Ghorasal 2x55 ST	0.8465	0.4758	0.8714	2.3877	4.5813	11
9	Baghabari 100 MW CT	1.5083	0.5550	4.8309	1.5041	8.3984	2
10	Tongi 80 MW GT	0.8465	0.4079	5.7431	1.3400	8.3376	3
11	Baghabari 71 MW CT	1.1972	1.1101	2.3477	1.5041	6.1591	7
12	Shahjibazar2x35 MW CT	0.5542	0.5139	4.1561	0.9117	6.1360	8
13	Haripur 3x33 CT	0.4751	0.8811	1.9365	0.6700	3.9627	13
14	Shikalbaha 2x28 MW CT	0.8465	0.3497	1.6868	0.7521	3.6351	16
15	Sylhet 20 MW CT	1.3965	0.3776	1.6868	1.1053	4.5663	12
16	Shahjibazar CT	0.8465	0.5995	0.6640	0.8442	2.9541	18
17	Ashuganj 90 MW CC (GT1,2 +ST)	0.8465	0.4405	1.3693	1.1053	3.7617	15
18	Fenchuganj CC (#1,2)	1.2930	1.0278	2.8462	1.6883	6.8553	5

Source: PSMP Study Team

8.3.3 Recommendation of measures to improve the efficiency

BPDB prepares the retirement plan for the existing power generation facilities. The validity of the plan is evaluated by comparing it with the results of investigation by our team.

Classification is made as shown below using total points in the comprehensive evaluation of the investigation results by our team (Table 8-8). Table 8-9 shows the results of comparing the evaluation based on the following:

(1) Less than 4 points
Rapid retirement is desired (by 2015).

(2) 4 to 5 points
Relatively early retirement is desired (by 2020).

(3) 5 points or more
Currently aggressive retirement is not required.

Table 8-9 Comparison between BPDB plan and evaluation by PSMP Study Team

	Unit Name	Planned Retire Year by BPDB	Evaluation by PSMP Study Team		
			Turn for Retire	Suggested Retire Year	
1	Ghorasal 4x210 ST (#3,4,5,6)	2029	13	After 2020	
2	Raozan 210 ST #1	2026	10	After 2020	
3	Raozan 210 ST #2	2028	15	After 2020	
4	Siddhirgonj 210 MW ST	2035	18	After 2020	
5	Ashuganj 3x150 MW ST (#3,4,5)	2023	9	2016 - 2020	(1)
6	Ashuganj 2x64 MW ST (#1,2)	2014	2	Before 2015	
7	Shikalbaha(Chittagong) 60 MW ST	2019	5	Before 2015	(2)
8	Ghorasal 2x55 ST	2016	8	2016 - 2020	
9	Baghabari 100 MW CT	2022	17	After 2020	
10	Tongi 80 MW GT	2030	16	After 2020	
11	Baghabari 71 MW CT	2016	12	After 2020	(3)
12	Shahjibazar2x35 MW CT	2023	11	After 2020	
13	Haripur 3x33 CT	2014	6	Before 2015	
14	Shikalbaha 2x28 MW CT	2010	3	Before 2015	
15	Sylhet 20 MW CT	2014	7	2016 - 2020	
16	Shahjibazar CT	2010	1	Before 2015	
17	Ashuganj 90 MW CC (GT1,2 +ST)	2014	4	Before 2015	
18	Fenchuganj CC (#1,2)	2022	14	After 2020	

Source: PSMP Study Team, BPDB system planning

As shown above, almost all parts of the evaluation by our team are consistent with the BPDB plan, except for the following:

(1) For Ashuganj 150 MW, the evaluation is reduced a little since it is relatively old in the middle-capacity steam turbine facilities. However, its life can be prolonged if intentional maintenance is carried out. Actually the rehabilitation plan is proceeding at Ashuganj.

(2) For Shikalbaha 60 MW ST, the evaluation is reduced because of high power generation cost (which is relatively new in the small-capacity steam turbine facilities). To prolong its life in the future, it is desired to find out and solve the cause of high costs.

(3) For Baghabari 71 MW CT, since items evaluated as very low cannot be found out, it is considered that it can be operated for 30 years considering the life of the gas turbine.

8.3.4 Conclusion and recommendation

In summarizing the above, the following sentences could be read about the evaluation for a retirement plan,

- To investigate current status and after that to make the retirement plan of PSMP Study Team, and to evaluate their plan by comparing these plans.
- The evaluation results are almost the same.
- That means that the PSMP Study Team thinks that the plan of the BPDB is reasonable.

8.4 Validity evaluation of the new power plant development plan

This section investigates the current state of the plan for a newly installed gas-fired power plant already carried out by Bangladesh and evaluates its validity.

8.4.1 Planning and construction schedule of standard thermal power plant

For the evaluation of the new power plant development plan, a comparison with standard schedule is being conducted. The following shows the standard schedule from the planning, construction to the operation of the thermal power plant.

(1) From planning to construction

From the planning to construction, it is different between the public sector by BPDB and the private sector like IPP.

(a) Public sector

1) F/S (Feasibility Study), D/D(Detail Design)

About the candidate site, to investigate the detailed conditions concerning the construction of the power plant, to determine whether or not it is realistic to construct (F/S). If it is realistic, to determine the detailed specifications for the selection of the manufacturer such as the size, type (D/D). Generally, the large project or in the case of no experience, the required time is long, it takes 9 months for F/S and 6 months for D/D.

2) Development Project Proposal (DPP)

At the timing of the completion of F/S, to obtain this government agreement is needed.

3) Manufacture Selection

After the detailed specifications of the equipment has been determined, to proceed with the selection of the manufacturer. To create Procurement document (Request for Proposal in the case of an EPC contract) and collect proposals from the manufacturers, generally it takes 2 months.

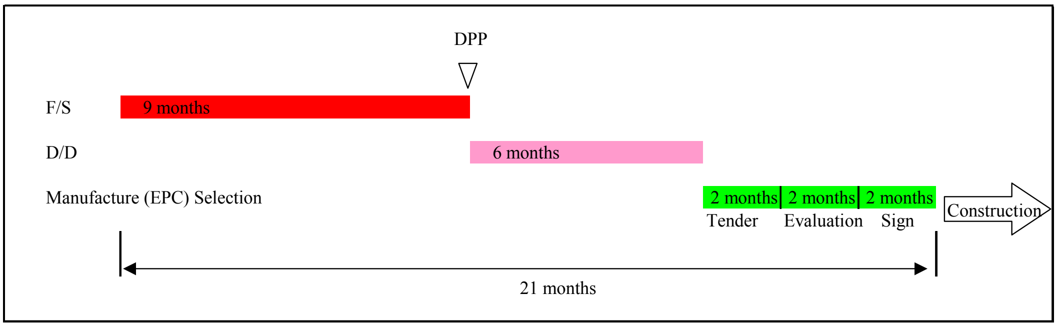
4) Evaluation

To evaluate each proposal to choose an appropriate one. To evaluate from a technical and economic perspective and put priority on negotiation, generally it takes 2 months.

5) Signing Contract

To proceed with negotiations according to the priority, and sign the contract. It takes about 2 months.

The following is the schedule for the above.



Source: PSMP Study Team

Fig. 8-12 Standard schedule toward signing (Public sector)

(b) Private sector

1) P/Q

To proceed with a pre-qualification prior to inviting the contractor. It takes about 4 months.

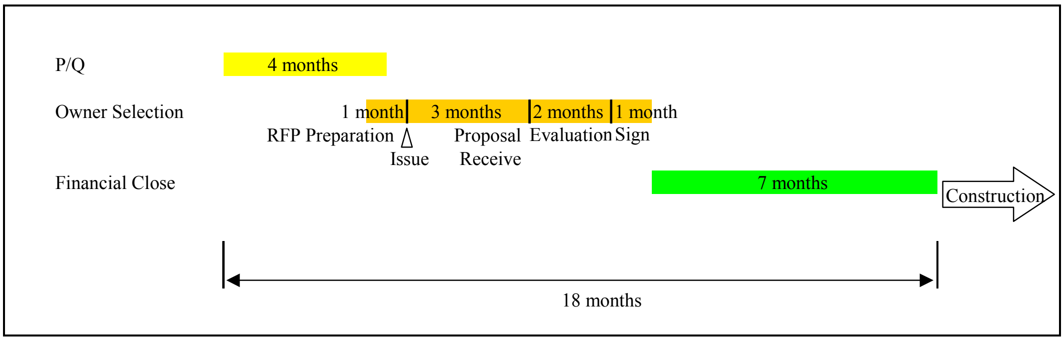
2) Contractor Selection

To select a contractor after P/Q. To issue the RFP and collect proposals (3 months), evaluation (2 month2), sign contract (1 month).

3) Loan agreement

The selected contractor will proceed with construction after signing the loan agreement. It takes about 7 months.

The following is the schedule for the above.



Source: PSMP Study Team

Fig. 8-13 Standard schedule toward signing (Private sector)

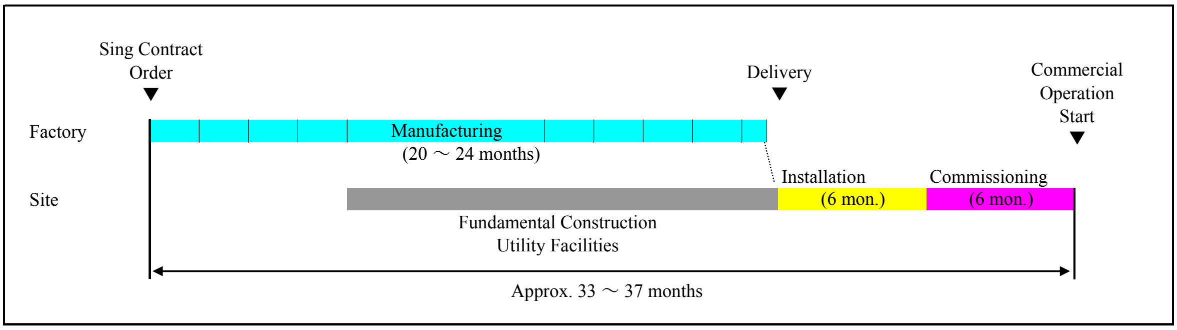
Public and private procedures are different, both of which takes 20 months to sign the contract.

(2) Construction period

The construction schedule of each type of plant is as follows. Each schedule does not include land preparation period.

(a) Gas or oil fired steam turbine (conventional type) and combined cycle facility

The following shows the standard construction schedule for a steam turbine and combined cycle power plant.



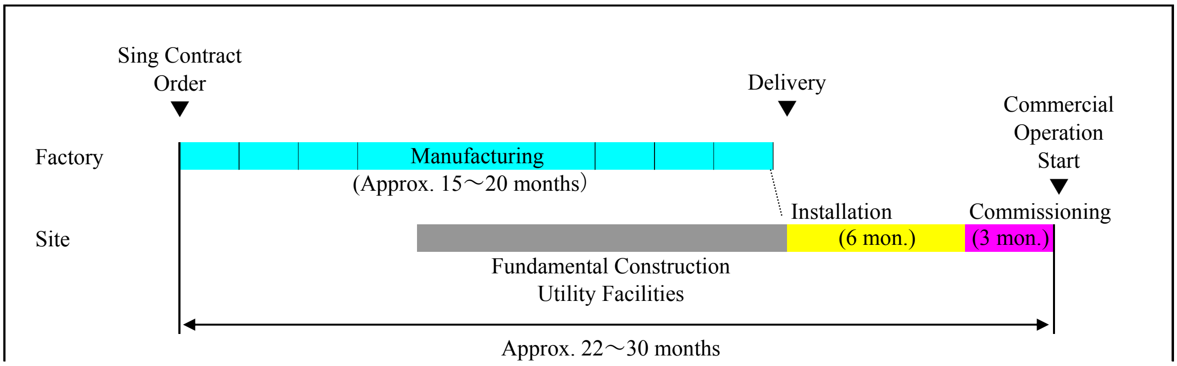
Source: PSMP Study Team

Fig. 8-14 Standard construction schedule for steam turbine and combined cycle power plant

For main facilities (boiler (or HRSG), turbine, power generator), a long time (about 25 months) is required until they are produced after ordering them (it changes depending on reception status of the manufacturer). During this period, the foundation work and the work for common facilities are carried out in advance on the power plant site and about one year is required until the test run is executed after delivering and installing the main facilities (it changes depending on the type of required items). Therefore, 3 years or more are required until the commercial operation starts after ordering (contract).

(b) Simple gas turbine facility

The following shows the standard building processes for a single gas turbine facility.



Source: PSMP Study Team

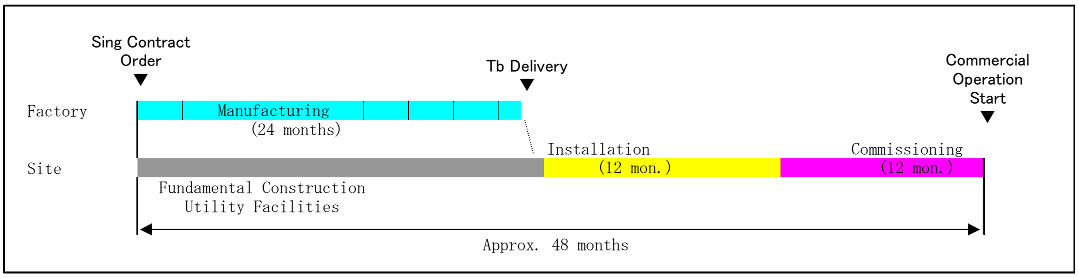
Fig. 8-15 Standard construction schedule for a gas turbine power plant

For the main body of the gas turbine and the power generator, a long time is also required until they are produced after ordering them (it changes depending on the reception status of the manufacturer). However, since the power generation facilities of it are simpler than those of a steam turbine and the combined cycle, the required time for work (installation and commission) at the site after delivering the main facilities is relatively short. According to the standard processes of the manufacturer, about 22 to 30 months are required until starting the commercial operation after ordering, i.e., it can be started sooner than the steam turbine and combined cycle.

(c) Coal-fired power plant (USC)

The USC coal-fired power plant has more auxiliary equipment than gas and oil-fired ones, it takes more time for installation. Moreover, during the test run, many test items and detailed tuning for each type of coal are needed, so it takes a long time.

The following shows the standard construction schedule of a coal-fired power plant:



Source: PSMP Study Team

Fig. 8-16 Standard construction schedule for a coal-fired power plant

The following table is a summary of the above schedules. This table shows the standard lead time of each period.

Table 8-10 Construction period and lead time (toward signing)

Step	Public Sector (BPDB)	Lead Time (Month)	Private Sector (IPP, Rental)	Lead Time (Month)
1	F/S,	9	P/Q(after F/S)	4
2	D/D	6	Selection (RFP)	4
3	Selection (Tender)	2	(Evaluation)	2
4	(Evaluation)	2	(Sign Contract)	1
5	(Sign Contract)	2	Financial Close	7

Source: PSMP Study Team

Table 8-11 Construction period and lead time (from start of construction)

Step		Lead Time (Month)			
		CT	ST/CC	GE	USC
6	Construction (0-30%)	10	16	6	28
7	Construction (30-70%)	6	7	3	12
8	Construction (70-100%)	6	9	3	12

Source: PSMP Study Team

The required construction time differs according to plant type.

8.4.2 Review for current status of new power development

For Bangladesh's new power development plan as of Aug.31.2010, the evaluation preceded in comparison with the above standard schedule.

For example, Ashuganj 50

Current status: Contract Signed

It is on the 5th step. That means the remaining term is step 6 to step 8, the type of plant is GE, so that the remaining time is assumed to be 4+5+3=12 months, this is the evaluation conducted by the PSMP Study Team.

The following shows the results of the evaluation using this method:

Table 8-12 Current status and evaluation result of new power development toward 2015 (BPDB)

Plant name	Fuel	Type	Cap. [MW]	Step	Planned Commercial Operation	Period until commercial operation (months)	
						Plan	Evaluation
Ashuganj 50	Gas	GE	50	5	Mar-11	6	12
Ghorasal, Dual Fuel, Peaking Plant	Gas	GE	290	5	Jun-12	21	12
Khulna 150MW , Dual Fuel, Peaking Plant	Gas	CT	150	4	Jun-12	21	27
Sirajganj 150MW , Dual Fuel, Peaking Plant	Gas	CT	150	4	Jun-12	21	27
Sylhet 150 MW CCPP (BPDB), U/C	Gas	CC	150	6	Oct-11	13	16
Chandpur 150 MW CCPP (BPDB), U/C	Gas	CC	150	6	Mar-12	18	16
Siddhirgonj 450 MW CC	Gas	CC	450	4	Jan-13	28	34
Bhola 150MW CCPP(Ist unit), BPDB	Gas	CC	150	1	Jan-13	28	44
Sikalbaha 225 MW Dual Fuel, CC	Gas	CC	225	2	Dec-13	39	43
Ashuganj 150 MW	Gas	CC	150	2	Dec-13	39	38
Haripur 360 MW CCPP (EGCB)	Gas	CC	360	3	Jan-14	40	36
Bheramara 360 MW CCPP (NWPGC)	Gas	CC	360	2	Jan-14	40	38

Plant name	Fuel	Type	Cap. [MW]	Step	Planned Commercial Operation	Period until commercial operation (months)	
						Plan	Evaluation
Kodda (North Dhaka) 450MW CCPP	Gas	CC	450	2	Jun-14	45	38
Ashuganj 450 MW CCPP	Gas	CC	450	1	Mar-15	56	44
FaridpurPeaking Plant	FO	GE	50	5	Aug-11	11	12
Gopalgonj Peaking Plant	FO	GE	100	5	Aug-11	11	12
Bera, Pabna, Peaking Plant	FO	GE	70	5	Aug-11	11	12
Dohazari Peaking Plant	FO	GE	100	5	Sep-11	12	12
Hathazari Peaking Plant	FO	GE	100	5	Sep-11	12	12
Baghabari Peaking Plant	FO	GE	50	5	Sep-11	12	12
Daudkandi	FO	GE	50	5	Sep-11	12	12
Katakhali Peaking Plant	FO	GE	50	5	Dec-11	15	12
Santahar Peaking Plant	FO	GE	50	5	Dec-11	15	12
Gazipur 50 MW	FO	GE	50	4	Jun-12	21	14
BPDB & RPCL, 150MW	FO	GE	150	2	Jun-12	21	18
Raujan 20 MW	FO	GE	20	2	Jun-12	21	18
Barapukuria 250MW (3rd unit)	Coal	ST	125	2	Dec-13	39	38

Source: PSMP Study Team

Table 8-13 Current status and evaluation result of new power development toward 2015 (IPP)

Plant name	Fuel	Type	Cap. [MW]	Step	Planned Commercial Operation	Period until commercial operation (months)	
						Plan	Evaluation
Comilla Peaking, Dual Fuel, Peaking Plant	Gas	GE	50	3	May-12	20	26
Kaliakair, Dual Fuel, Peaking Plant	Gas	GE	100	4	Jan-13	28	12
Savar, Dual Fuel, Peaking Plant	Gas	GE	100	3	Jan-13	28	26
Bhola CCPP(2nd unit)	Gas	CC	225	3	Dec-12	27	40
Madanganj,Keraniganj CCPP Dual Fuel	Gas	CC	225	3	Dec-12	27	40
Bibiana 450 MW CCPP(Ist Unit)	Gas	CC	450	3	Dec-12	27	40
Bibiana 450 MW CCPP(2nd Unit)	Gas	CC	450	3	Jan-13	28	40
Meghnaghat CCPP (2nd unit) Dual Fuel	Gas	CC	450	3	Jan-13	28	40
Serajganj 450 MW CCPP	Gas	CC	450	3	Jun-14	45	46
Syedpur Peaking Plant	FO	GE	100	3	Apr-12	19	20
Jamalpur Peaking Plant	FO	GE	100	3	May-12	20	20
Chapai Nababgonj Peaking Plant	FO	GE	100	3	May-12	20	20
Khulna Peaking Plant	FO	GE	100	3	May-12	20	18
Tangail 20 MW	FO	GE	20	2	Jan-12	16	20
Chandpur 15 MW	FO	GE	15	2	Jan-12	16	20
Narayanganj 30MW	FO	GE	30	2	Jan-12	16	20
Khulna South 600 MW ST #1	Coal	ST	650	1	Jun-15	57	46
Khulna South 600 MW ST #2	Coal	ST	650	1	Jun-15	57	46
Chittagong 600 MW ST #1	Coal	ST	650	1	Jun-15	57	46
Chittagong 600 MW ST #2	Coal	ST	650	1	Jun-15	57	46

Source: PSMP Study Team

Table 8-14 Current status and evaluation result of new power development toward 2015 (Rental)

Plant name	Fuel	Type	Cap. [MW]	Step	Planned Commercial Operation	Period until commercial operation (months)	
						Plan	Evaluation
Fenchuganj – 3 Yrs rental, U/C	Gas	GE	50	8	Oct-10	1	1
Bogra –3 yrs rental, U/C	Gas	GE	20	8	Oct-10	1	1
Kadda, Sidhirganj(quick rental)	FO	GE	100	6	Oct-10	1	6
Noapara, Jessore, Rental, U/C	FO	GE	100	5	Nov-10	2	12
Barisal, Rental,U/C	FO	GE	50	6	Dec-10	3	6
Kadda, Meghna(quick rental)	FO	GE	100	6	Jan-11	4	5
Khulna(quick rental)	FO	GE	115	5	Mar-11	6	9
Modanganj(quick rental)	FO	GE	102	5	Mar-11	6	9
Keranigong(quick rental)	FO	GE	100	5	Mar-11	6	9
Meghnagat(quick rental)	FO	GE	100	5	Mar-11	6	9
Chapai Nawabgonj(quick rental)	FO	GE	50	5	Mar-11	6	9
Katakhali(quick rental)	FO	GE	50	5	Mar-11	6	9
Julda(quick rental)	FO	GE	100	5	Aug-11	11	9
Noapara(quick rental)	FO	GE	40	5	Aug-11	11	9
Bheramara, Rental , U/C	HSD	GE	100	8	Sep-10	0	1
Pagla, Narayaganj(quick rental)	HSD	GE	50	6	Nov-10	2	5
Siddirganj(quick rental)	HSD	GE	100	5	Mar-11	6	9

Source: PSMP Study Team

A quick rental refers to a rental contract which can be in service after 6 or 9 months from signing.

Regarding the period until commercial operation, in many cases, the evaluation is shorter than planned, or a little longer but no longer than 6 months. The evaluation is based on the standard schedule, so it is possible to shorten the actual schedule to about 6 months via smooth procedures, it means that generally there are no impediments to proceeding on schedule. Some plants show that the evaluation is very long compared with the plan. It means that strict schedule control should be required for the procedures on schedule.

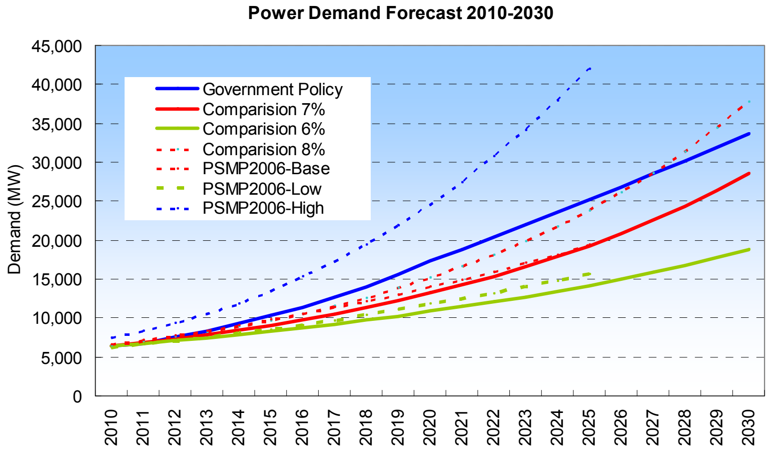
8.4.3 New import coal projects

In November 2010, BPDB commenced the bidding process for two smaller projects in the range of 150MW to 300MW in Chittagong and Khulna, and also two larger projects in the range of 300MW to 650MW in Chittagong Coastal Area and Maowa-Munshiganj area, total four imported coal fired power projects on BOO basis. These projects are on the same area where the Master Plan considered for potential site of coal power station projects. These projects are expected to commission by 2015. Implementation of these projects will help in lowering overall cost of production. However, these were the recent development and were not included in the Master Plan. If these fast track IPP projects are implemented on time successfully, the generation output by imported coal fired power stations in the Master Plan can be reduced.

8.5 Validation of uncertainty events for power development plan

8.5.1 Long term demand forecast

As indicated in the previous chapter, the power demand growth of the government policy scenario for 2030 has been forecasted at 34,000MW. The demand will reach 29,000MW on the comparison scenario (GDP=7%) with neighboring countries, and it will attain 19,000MW on the comparison scenario (GDP=6%).

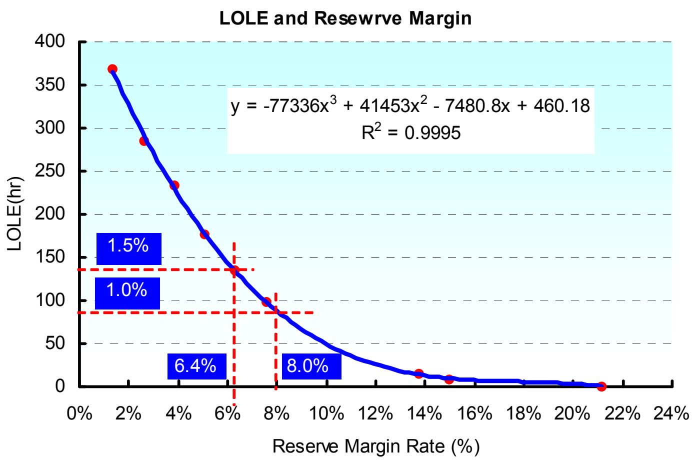


Source: PSMP Study Team

Fig. 8-17 Result of power demand forecast

8.5.2 Setting the appropriate reserve margin by consideration of the reliability level over the long term

The relationship between the supply reliability level and the reserve margin is as shown in the figure below. When LOLE is assumed to be 1% to 1.5%, the necessary reserve margin becomes 6.4 to 8.0%. In this examination, an appropriate reserve margin has been set at 10% over the long-term for the developing power supply plan.

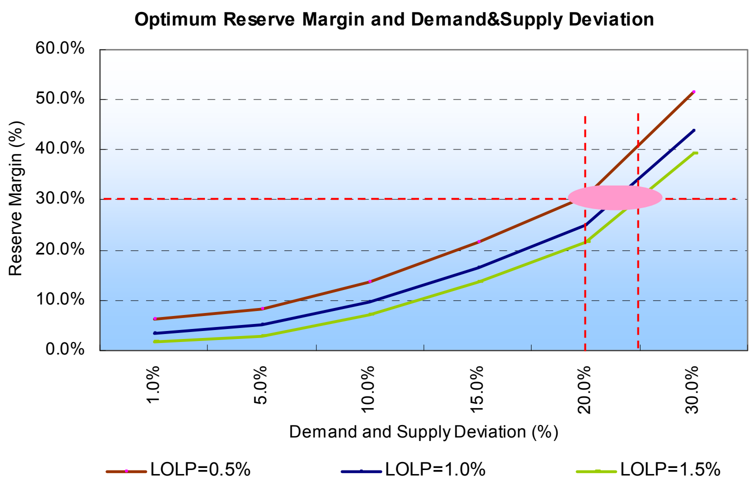


Source: PSMP Study Team

Fig. 8-18 Relationship between reliability and reserve margin

8.5.3 Setting appropriate reserve margin by consideration of delay risk of the project implementation

In the case of developing an appropriate power supply plan that corresponds to the assumed power demand, it is necessary to set an appropriate reserve margin in consideration of delay risks connected to project implementation, and fluctuation risks of the power demand forecast. As indicated in the following figure, the appropriate reserve margin is assumed to be at around 30% when the fluctuation probability of such risks is considered.

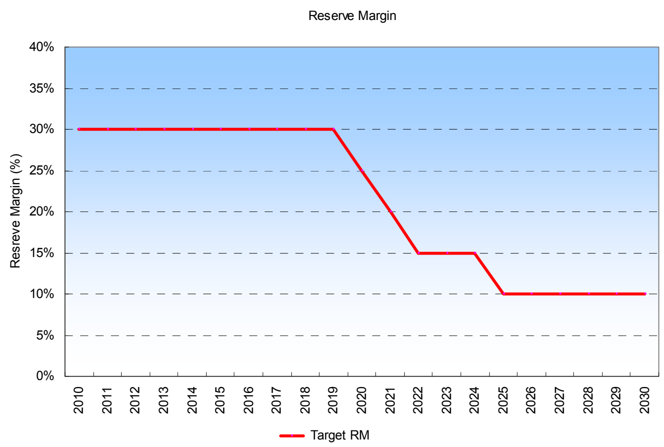


Source: PSMP Study Team

Fig. 8-19 Demand and fluctuation of supply and reserve margin

8.5.4 Reserve margin scenario

Therefore, over the short and mid-terms, the reserve margin is targeted at around 30% in consideration of the delay risks of project implementation, and the reserve margin will decrease gradually afterwards, and will reach 10% by the long-term period. The power supply plan is to be established based on such a reserve margin scenario.

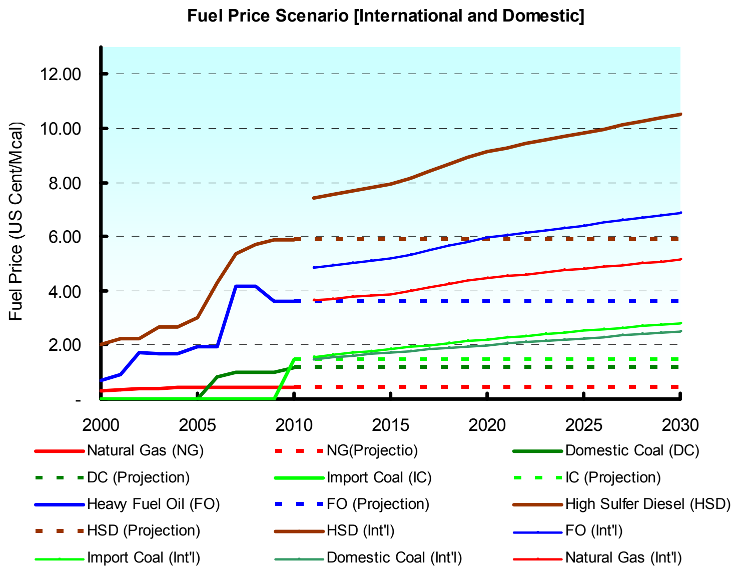


Source: PSMP Study Team

Fig. 8-20 Reserve margin scenario

8.5.5 Setting of fuel prices

The fuel price of gas in Bangladesh is overwhelmingly cheaper than the international price and the price of gas is controlled to be 1/8 of the international price. Under circumstances where primary energy demand is considered to increase greatly as economic growth expands, two cases have been studied; (i) where the domestic controlled price is kept and (ii) where the price changes to the international price, as shown below. Note that for the long-term forecast of the international price, IEA's forecast values are used.



Source: PSMP Study Team

Fig. 8-21 Fuel price scenario (international and domestic price case)

The fuel price scenario which is adopted in this MP is as follows;

Table 8-15 Fuel price scenario towards 2030

Fuel	Unit	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Revised Levelized
Crude Oil Price (2009 US$) 1 IEA E	$/BBL	61.3	79.8	81.2	82.5	83.9	85.3	86.67	89.3	92.0	94.7	97.3	100.0	101.5	103.0	104.5	106.0	107.5	109.0	110.5	112.0	113.5	115.0	77.89
Crude Oil price (2009 US$)	$/MT	468.24	609.55	620.05	630.54	641.04	651.53	662.03	682.39	702.76	723.12	743.48	763.85	775.31	786.76	798.22	809.68	821.14	832.59	844.05	855.51	866.97	878.43	594.96
Crude Oil price (2009 US$)	$/GJ	11.67	15.19	15.45	15.71	15.97	16.23	16.49	17.00	17.51	18.01	18.52	19.03	19.32	19.60	19.89	20.17	20.46	20.74	21.03	21.31	21.60	21.88	14.82
Heavy Fuel Oil Price 2	$/GJ	8.75	11.39	11.59	11.78	11.98	12.17	12.37	12.75	13.13	13.51	13.89	14.27	14.49	14.70	14.91	15.13	15.34	15.56	15.77	15.98	16.20	16.41	11.12
Heavy Fuel Oil Price 2	Cents/Mcal	3.66	4.76	4.84	4.92	5.01	5.09	5.17	5.33	5.49	5.65	5.81	5.97	6.06	6.14	6.23	6.32	6.41	6.50	6.59	6.68	6.77	6.86	4.65
Low Sulfur Diesel 3	$/GJ	14.00	18.22	18.54	18.85	19.16	19.48	19.79	20.40	21.01	21.62	22.23	22.84	23.18	23.52	23.86	24.21	24.55	24.89	25.23	25.58	25.92	26.26	17.79
Low Sulfur Diesel 3	Cents/Mcal	5.85	7.62	7.75	7.88	8.01	8.14	8.27	8.53	8.78	9.04	9.29	9.55	9.69	9.83	9.97	10.12	10.26	10.40	10.55	10.69	10.83	10.98	7.43
High Sulfur Diesel 3	$/GJ	13.41	17.46	17.76	18.06	18.37	18.67	18.97	19.55	20.13	20.72	21.30	21.88	22.21	22.54	22.87	23.20	23.53	23.85	24.18	24.51	24.84	25.17	17.05
High Sulfur Diesel 3	Cents/Mcal	5.61	7.30	7.43	7.55	7.68	7.80	7.93	8.17	8.42	8.66	8.90	9.15	9.28	9.42	9.56	9.70	9.83	9.97	10.11	10.25	10.38	10.52	7.13
Natural Gas Price 4	$/GJ	6.56	8.54	8.69	8.84	8.98	9.13	9.28	9.56	9.85	10.13	10.42	10.70	10.86	11.03	11.19	11.35	11.51	11.67	11.83	11.99	12.15	12.31	8.34
Natural Gas Price 4	Cents/Mcal	2.74	3.57	3.63	3.69	3.75	3.82	3.88	4.00	4.12	4.24	4.36	4.47	4.54	4.61	4.68	4.74	4.81	4.88	4.94	5.01	5.08	5.15	3.49
LPG 7	$/GJ	8.53	11.10	11.30	11.49	11.68	11.87	12.06	12.43	12.80	13.17	13.54	13.92	14.12	14.33	14.54	14.75	14.96	15.17	15.38	15.59	15.79	16.00	10.84
LPG 7	Cents/Mcal	3.57	4.64	4.72	4.80	4.88	4.96	5.04	5.20	5.35	5.51	5.66	5.82	5.90	5.99	6.08	6.17	6.25	6.34	6.43	6.51	6.60	6.69	4.53
Imported Coal 5	$/Ton	73.80	73.80	78.10	82.10	86.20	90.00	93.80	97.50	101.10	104.60	108.10	111.40	114.70	118.00	121.20	124.30	127.40	130.50	133.40	136.40	139.30	142.20	83.22
Imported Coal 5	$/GJ	3.48	3.48	3.68	3.87	4.06	4.24	4.42	4.60	4.77	4.93	5.10	5.25	5.41	5.56	5.71	5.86	6.00	6.15	6.29	6.43	6.57	6.70	3.92
Imported Coal 5	Cents/Mcal	1.45	1.45	1.54	1.62	1.70	1.77	1.85	1.92	1.99	2.06	2.13	2.19	2.26	2.32	2.39	2.45	2.51	2.57	2.63	2.69	2.74	2.80	1.64
Imported coal incl. transport	$/Ton	88.80	88.80	93.10	97.10	101.20	105.00	108.80	112.50	116.10	119.60	123.10	126.40	129.70	133.00	136.20	139.30	142.40	145.50	148.40	151.40	154.30	157.20	96.89
Imported coal incl. transport	$/GJ	4.19	4.19	4.39	4.58	4.77	4.95	5.13	5.30	5.47	5.64	5.80	5.96	6.11	6.27	6.42	6.57	6.71	6.86	6.99	7.14	7.27	7.41	4.57
Imported coal incl. transport	Cents/Mcal	1.75	1.75	1.83	1.91	1.99	2.07	2.14	2.22	2.29	2.36	2.43	2.49	2.56	2.62	2.68	2.74	2.81	2.87	2.92	2.98	3.04	3.10	1.91
Domestic coal 6	$/Ton	85.38	85.38	89.51	93.36	97.30	100.95	104.61	108.16	111.63	114.99	118.36	121.53	124.70	127.87	130.95	133.93	136.91	139.89	142.68	145.57	148.35	151.14	93.16
Domestic coal	$/GJ	3.35	3.35	3.51	3.66	3.82	3.96	4.10	4.24	4.38	4.51	4.64	4.77	4.89	5.02	5.14	5.25	5.37	5.49	5.60	5.71	5.82	5.93	3.65
Domestic coal	Cents/Mcal	1.40	1.40	1.47	1.53	1.60	1.65	1.71	1.77	1.83	1.89	1.94	1.99	2.04	2.10	2.15	2.20	2.24	2.29	2.34	2.39	2.43	2.48	1.53

Source: PSMP Study Team

8.6 Target setting of long-term power source configuration in FY2030

8.6.1 Screening analysis

(1) Methodology

The screening analysis consists of a combination of the fuel/cost graph (upper) and the electric power demand duration curve (lower), shows which demand uses which power supply, i.e., economically optimal combination of power supplies. Therefore, this study, in its 1st step, calculates the optimal power supply configuration using the screening analysis.

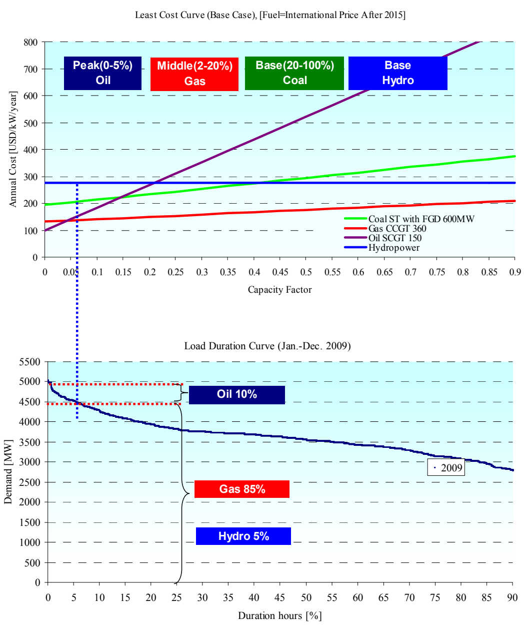
(2) Study result

(a) Domestic controlled price case

If the current model where the fuel price is controlled is used as the basic case, the analysis result shows the optimal power supply configuration of oil: 10%, gas: 85%, and hydroelectric power: 5%; i.e., the current configuration is judged to be economically superior.

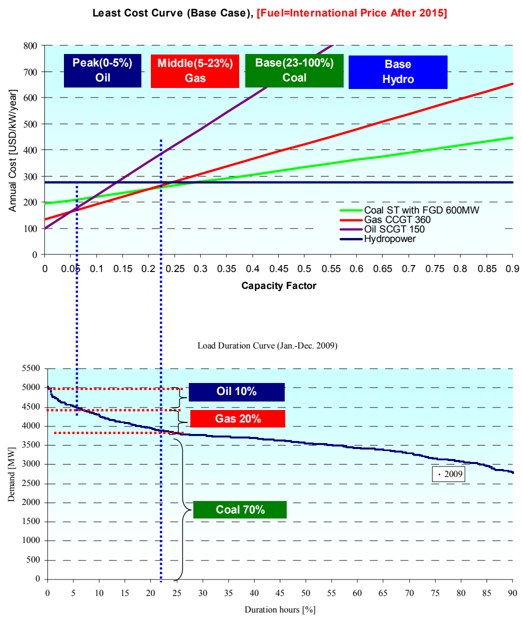
(b) International price case

The prerequisite that allows the current optimal power supply configuration is that the gas price is greatly cheaper than the international price. If the fuel price is assumed to increase because of the tight demand of primary energy, the optimal power supply configuration ratio will be oil: 10%, gas: 20%, and coal: 70%.



Source: PSMP Study Team

Fig. 8-22 Screening analysis (base case)

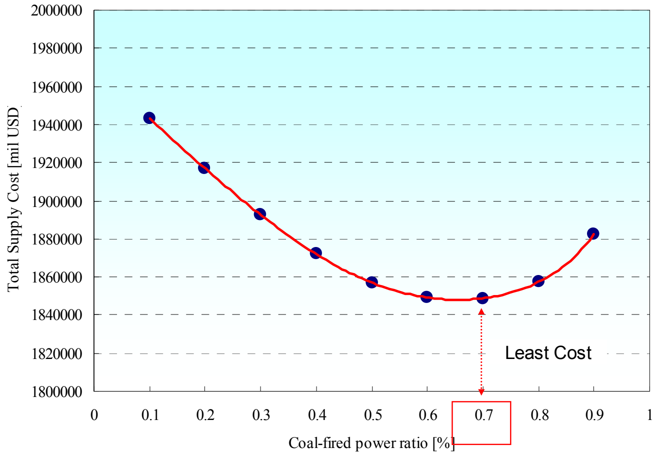


Source: PSMP Study Team

Fig. 8-23 Screening analysis (high case)

8.6.2 Calculation of optimal power supply configuration (PDPAT calculation value)

Since, in the screening analysis, the study is done with the prerequisite that all the power plants have the same economic characteristics and fuel efficiency in each power source type, the result is a little different from the actual operation level in the power plant. Therefore, in step 2, a study is done using the demand/supply operations simulation, which allows for a more realistic power plant operation pattern to be considered. As a result, when the ratio of coal is about 70%, the power source is the most economic as shown in the screening analysis result and as shown below



Source: PSMP Study Team

Fig. 8-24 Calculation of optimal power supply configuration (PDPAT calculation value)

8.6.3 Formulation of most economic scenario

The figure below depicts the general demand fluctuation and generating operational conditions on a typical day. Both nuclear and coal-fired power stations demonstrate several advantages over a stable fuel supply system and economic efficiency, so that the systems are suitable for base generation power. Gas (LNG) power stations are more suitable for mid-generation power due to environmental adaptability and operations capability as compared with other generations. Oil and hydro powers are able to operate flexibly over demand fluctuations; hence these powers are suitable for peak generations in general. In Bangladesh, domestic gas prices are one tenth of the international market prices. If the fuel price is assumed to increase because of the tight demand for primary energy, the optimal power supply configuration ratio will be oil: 10% for peak, gas: 20% for middle and peak, and coal: 70% for base generation.

Table 8-16 characteristic of base-middle-peak generation

		Base			Middle	Peak		
		Hydro	Nucear	coal	Gas/LNG	Oil	Hydro (Pumped storage)	Hydro (Dam/ Pndage)
Economic condition	Fixed	High			Low			High
	Variable	-	Low		Middle	High		-
Operational condition	Start up duration	Fast	Slow	Middle			Fast	
	Load control			Slow	Middle		Fast	

Source: PSMP Study Team

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8.7 Detailed study for realizing long-term target

8.7.1 Setting scenario of power development plan

The following scenarios are examined in consideration of uncertain events in regards to the power development plan.

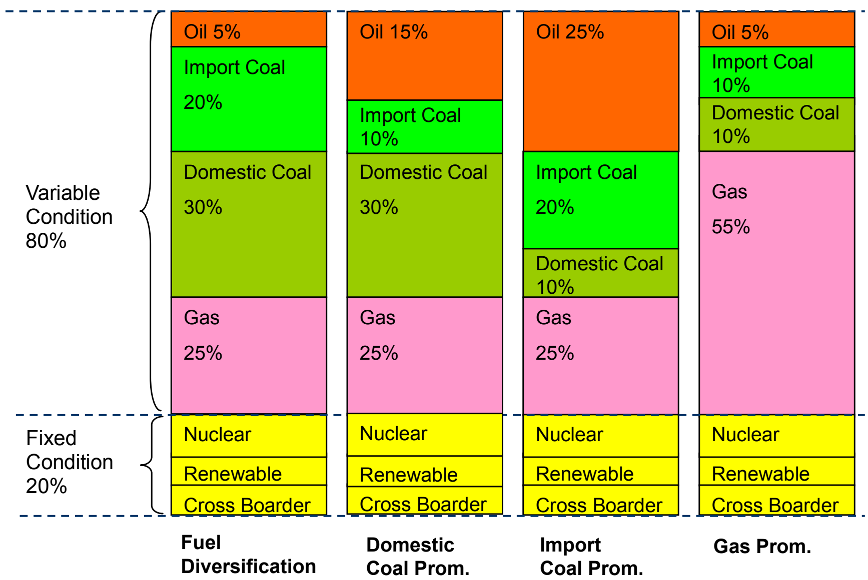
Table 8-17 Power development scenario

Scenario	Concept
Fuel Diversified Scenario (Base case)	Optimum power sources development plan, securing fuel supply via multiple sources based on coal development (developing new domestic mining, increasing existing mining capacity, securing imported coal) ; natural gases, fossil fuels (heavy and light oil), renewable energy.
Domestic Coal Promotion Scenario	For the Base Scenario, fuel supply mainly via a large-scale increase in production at domestic mining including strip mining is considered.
Import Coal Promotion Scenario	For the Base Scenario, fuel supply comes mainly from imported coal due to considerations regarding the impossibility or a long period to develop domestic mining.
Gas Promotion Scenario	For the Base Scenario, fuel supply mainly comes from new domestic gas development, and gas procurement secured from a long-term perspective.

Source: PSMP Study Team

8.7.2 Determination of power development scenario, being closely-interlinked with primary energy supply

The power development plan is closely-interlinked with prime energy supply. The government plan for renewable, cross boarder, and the nuclear power generation plan is provided in light of the power development plan. As detailed in chapter 5, the gas supply scenario will decrease gradually from its peak in 2017. In considering factors such as the construction lead time for gas-fired power stations, the government plan for the gas fired power station should be given in regards to the power development plan in the same manner. Therefore, the power development scenario is to be determined in combination with coal and oil as a variable condition.



Source: PSMP Study Team

Fig. 8-25 Fuel-wise composition for each scenario

8.7.3 Cross border trading

The cross border trading with the neighboring countries is meaningful not only for import power to supplement Bangladesh's power supply, but also for export power to the neighboring countries when sufficient power in Bangladesh due to seasonal and/or time difference. This could improve the overall system efficiency and reliability by effective plant utilization.

8.7.4 Power development plan

The detailed plan of power development by fuel diversification scenario is as follows,

Table 8-18 Unit additions and system reliability indices (Fuel Diversification scenario)

FY		Unit Additions, Number of Unit								Cross Border [MW]	Installed Capacity [MW]	System Reliability Indices		
	Peak Load [MW]	Domestic Coal 600MW	Domestic Coal 1,000MW	Import Coal 600MW	Gas CC 750MW	Gas CC 450MW	FO Engine 100MW	Nuclear 1,000MW	Hydro 100MW			LOLP [%]	ENS. GWH	Reserve Margin [%]
2016	11,405			2		1			1	250	14,943	0.001%	0	20.57
2017	12,644			3	1	1					16,399	0.000%	0	23.38
2018	14,014			1	1			1		500	19,249	0.000%	0	31.16
2019	15,527	2					2				20,649	0.000%	0	26.26
2020	17,304	1			1		2	1			22,509	0.000%	0	26.71
2021	18,838						1			500	23,809	0.006%	0	18.39
2022	20,443	1					1			750	24,961	0.017%	0	14.96
2023	21,993	1		1			1			1,000	26,954	0.006%	0	16.57
2024	23,581	2						1			28,966	0.011%	0	15.72
2025	25,199						1	1			29,717	0.079%	0	12.19
2026	26,838	1		2			2				31,388	0.114%	0	11.37
2027	28,487		1	2			1				33,513	0.126%	0	11.20
2028	30,134		2				1				35,253	0.277%	0	9.11
2029	31,873		2	2			2				37,263	0.110%	0	11.94
2030	33,708		1	1							38,685	0.321%	0	9.14
Total		8	6	14	3	2	14	4	1					
TotalMW		4,800	6,000	8,400	2,250	900	1,400	4,000	100	3,000	30,600			

Source: PSMP Study Team

Table 8-19 Year-wise power development plan (Fuel diversification scenario)

Station Name	Fuel Type	Type	Installed Cap. (MW)	In Service FY	Retirement FY
2011					
Fenchuganj – 3 Yrs rental, U/C	Gas-New	GE	50	2011	2014
Bogra –3 yrs rental, U/C	Gas-New	GE	20	2011	2014
Sikalbaha 150MW Peaking Plant, U/C	Gas-New	CT	150	2011	2031
Siddhirgonj 2X120 MW Peaking Plant (U/C)	Gas-New	CT	210	2011	2031
Fenchuganj CC(2nd Phase), U/C	Gas-New	CC	108	2011	2036
Khulna(quick rental)	FO-New	GE	115	2011	2017
Modanganj(quick rental)	FO-New	GE	102	2011	2017
Julda(quick rental)	FO-New	GE	100	2011	2017
Kadda, Meghna(quick rental)	FO-New	GE	100	2011	2017
Kadda, Sidhirganj(quick rental)	FO-New	GE	100	2011	2017
Keranigong(quick rental)	FO-New	GE	100	2011	2017
Meghnagat(quick rental)	FO-New	GE	100	2011	2017
Noapara, Jessore, Rental, U/C	FO-New	GE	100	2011	2017
Barisal, Rental,U/C	FO-New	GE	50	2011	2017
Chapai Nawabgonj(quick rental)	FO-New	GE	50	2011	2017
Katakhali(quick rental)	FO-New	GE	50	2011	2017

Station Name	Fuel Type	Type	Installed Cap. (MW)	In Service FY	Retirement FY
Noapara(quick rental)	FO-New	GE	40	2011	2017
Ghorashal (quick rental)	HSD-New	GE	145	2011	2014
Bheramara, Rental , U/C	HSD-New	GE	100	2011	2014
Siddirganj(quick rental)	HSD-New	GE	100	2011	2014
Khulna(quick rental)	HSD-New	GE	55	2011	2014
Pagla, Narayaganj(quick rental)	HSD-New	GE	50	2011	2014
Thakurgao, Rental, U/C	HSD-New	GE	50	2011	2014
Total MW			2,045		
2012					
Ashuganj 50	Gas-New	GE	50	2012	2032
Syedpur Peaking Plant	FO-New	GE	100	2012	2030
Jamalpur Peaking Plant	FO-New	GE	100	2012	2030
Chapai Nababgonj Peaking Plant	FO-New	GE	100	2012	2030
Khulna Peaking Plant	FO-New	GE	100	2012	2030
Dohazari Peaking Plant	FO-New	GE	100	2012	2032
Hathazari Peaking Plant	FO-New	GE	100	2012	2032
FaridpurPeaking Plant	FO-New	GE	50	2012	2032
Baghabari Peaking Plant	FO-New	GE	50	2012	2032
Katakhali Peaking Plant	FO-New	GE	50	2012	2032
Santahar Peaking Plant	FO-New	GE	50	2012	2032
Gopalgonj Peaking Plant	FO-New	GE	100	2012	2032
Bera, Pabna, Peaking Plant	FO-New	GE	70	2012	2032
Doudkandi	FO-New	GE	50	2012	2032
Total MW			1,070		
2013					
Ghorasal, Dual Fuel, Peaking Plant	Gas-New	GE	290	2013	2033
Comilla Peaking, Dual Fuel, Peaking Plant	Gas-New	GE	50	2013	2028
Khulna 150MW , Dual Fuel, Peaking Plant	Gas-New	CT	150	2013	2033
Sirajganj 150MW , Dual Fuel, Peaking Plant	Gas-New	CT	150	2013	2033
Chandpur 150 MW CCPP (BPDB), U/C	Gas-New	CC	150	2013	2038
Sylhet 150 MW CCPP (BPDB), U/C	Gas-New	CC	150	2013	2038
Gazipur 50 MW	FO-New	GE	50	2013	2033
Katakhali, Rajshahi, Peaking Plant	FO-New	GE	50	2013	2028
Raujan 20 MW	FO-New	GE	20	2013	2033
Tangail 20 MW	FO-New	GE	20	2013	2028
Chandpur 15 MW	FO-New	GE	15	2013	2028
Narayanganj 30MW	FO-New	GE	30	2013	2028
Sarishabari, Jamalpur(Solar)	Hydro/RE-New	SP	3	2013	2063
Rajabarihat Goat Development Firm(Solar)	Hydro/RE-New	SP	3	2013	2063
Kaptai Power Plant(Solar)	Hydro/RE-New	SP	5	2013	2063
Patenga Offshore, Chittagong(Wind)	Hydro/RE-New	WP	100	2013	2063
BAHARAMPUR to BHERAMARA Phase-1	Int-conect	IC	500	2013	2063
Total MW			1,736		
2014					
Barapukuria 250MW (3rd unit)	Coal-New-D	ST	125	2014	2044
Kaliakair, Dual Fuel, Peaking Plant	Gas-New	GE	100	2014	2029
Savar, Dual Fuel, Peaking Plant	Gas-New	GE	100	2014	2029
Siddhirgonj 2X150 MW CT(450CC)	Gas-New	CC	450	2014	2039
Haripur 360 MW CCPP (EGCB)	Gas-New	CC	360	2014	2039
Bhola CCPP(2nd unit)	Gas-New	CC	225	2014	2039
Madanganj,Keraniganj CCPP Dual Fuel	Gas-New	CC	225	2014	2039

Station Name	Fuel Type	Type	Installed Cap. (MW)	In Service FY	Retirement FY
Sikalbaha 225 MW Dual Fuel, CC	Gas-New	CC	225	2014	2039
BPDB & RPCL, 150MW	FO-New	GE	150	2014	2034
Total MW			1,960		
2015					
Ashuganj 150 MW (150CC)	Gas-New	CC	150	2015	2040
Bibiana 450 MW CCPP(Ist Unit)	Gas-New	CC	450	2015	2040
Bibiana 450 MW CCPP(2nd Unit)	Gas-New	CC	450	2015	2040
Meghnaghat CCPP (2nd unit) Dual Fuel	Gas-New	CC	450	2015	2040
Serajganj 450 MW CCPP	Gas-New	CC	450	2015	2040
Bheramara 360 MW CCPP (NWPGC)	Gas-New	CC	360	2015	2040
Bhola 150MW CCPP(Ist unit), BPDB	Gas-New	CC	150	2015	2040
Total MW			2,460		
2016					
Khulna South 600 MW ST #1	Coal-New-I	ST	600	2016	2045
Khulna South 600 MW ST #2	Coal-New-I	ST	600	2016	2046
North Dhaka 450MW CCPP	Gas-New	CC	450	2016	2040
Karnafuli Hydro (#6&7, 2x50 MW)	Hydro/RE-New	HY	100	2016	2066
PALLATANA to COMILLA	Int-conect	IC	250	2016	2066
Total MW			2,000		
2017					
Chittagong 600 MW ST #1	Coal-New-I	ST	600	2017	2045
Chittagong 600 MW ST #2	Coal-New-I	ST	600	2017	2046
Chittagong South 600MW #1	Coal-New-I	ST	600	2017	2047
Meghnaghat Large #1, 750 MW, CC	Gas-New	CC	750	2017	2042
Ashuganj 450 MW CCPP	Gas-New	CC	450	2017	2041
Total MW			3,000		
2018					
Megnagatt 600MW #1	Coal-New-I	ST	600	2018	2048
Keraniganj, 750 MW, CC	Gas-New	CC	750	2018	2043
Myanmmer to Bangladesh (should refer from PGCB PP)	Hydro/RE-New	IC	500	2018	2068
Rooppur Nuclear # 1, 1000 MW	Nuclear	Nuclear	1,000	2018	2058
Total MW			2,850		
2019					
B-K-D-P 1 600MW #1	Coal-New-D	ST	600	2019	2049
B-K-D-P 1 600MW #2	Coal-New-D	ST	600	2019	2049
Comilla Peaking	FO-New	GE	100	2019	2033
Jessore Peaking	FO-New	GE	100	2019	2034
Total MW			1,400		
2020					
B-K-D-P 1 600MW #3	Coal-New-D	ST	600	2020	2050
Meghnaghat Large #2, 750 MW, CC	Gas-New	CC	750	2020	2044
Ashuganj Peaking	FO-New	GE	200	2020	2035
Rooppur Nuclear # 2, 1000 MW	Nuclear	Nuclear	1,000	2020	2061
Total MW			2,550		
2021					
Khulna Center Peaking	FO-New	GE	100	2021	2036
BAHARAMPUR to BHERAMARA Phase-2	Int-conect	IC	500	2021	2071
Total MW			600		
2022					
B-K-D-P 1 600MW #4	Coal-New-D	ST	600	2022	2052
Halishahar Peaking	FO-New	GE	100	2022	2037

Station Name	Fuel Type	Type	Installed Cap. (MW)	In Service FY	Retirement FY
SILCHAR to FENCHUGANJ 1	Int-conect	IC	750	2022	2072
Total MW			1,450		
2023					
B-K-D-P 2 600MW #1	Coal-New-D	ST	600	2023	2053
Matarbari 600MW #1	Coal-New-I	ST	600	2023	2053
Jhenaidah Peaking	FO-New	GE	100	2023	2038
Hydro from Nepal (Kishanganj (PURNIA) to Bogra)	Hydro/RE-New	IC	500	2023	2073
Hydro from Bhutan (Alipurduar to Bogra)	Hydro/RE-New	IC	500	2023	2073
Total MW			2,300		
2024					
B-K-D-P 2 600MW #2	Coal-New-D	ST	600	2024	2054
B-K-D-P 2 600MW #3	Coal-New-D	ST	600	2024	2054
Rooppur Nuclear # 3, 1000 MW	Nuclear	Nuclear	1,000	2024	2064
Total MW			2,200		
2025					
Bogra Peaking	FO-New	GE	100	2025	2040
Rooppur Nuclear # 4, 1000 MW	Nuclear	Nuclear	1,000	2025	2065
Total MW			1,100		
2026					
B-K-D-P 2 600MW #4	Coal-New-D	ST	600	2026	2056
Matarbari 600MW #2	Coal-New-I	ST	600	2026	2056
Megnagatt 600MW #2	Coal-New-I	ST	600	2026	2056
Keraniganj Peaking	FO-New	GE	200	2026	2041
Total MW			2,000		
2027					
B-K-D-P 3 1000 MW #1	Coal-New-D	ST	1,000	2027	2057
Mawa 600MW #1	Coal-New-I	ST	600	2027	2057
Mawa 600MW #2	Coal-New-I	ST	600	2027	2057
Rajshahi Peaking	FO-New	GE	100	2027	2042
Total MW			2,300		
2028					
B-K-D-P 3 1000 MW #2	Coal-New-D	ST	1,000	2028	2058
B-K-D-P 4 1000 MW #1	Coal-New-D	ST	1,000	2028	2058
Daudkandi Peaking	FO-New	GE	100	2028	2043
Total MW			2,100		
2029					
B-K-D-P 4 1000 MW #2	Coal-New-D	ST	1,000	2029	2059
B-K-D-P 5 1000 MW #1	Coal-New-D	ST	1,000	2029	2059
Matarbari 600MW #3	Coal-New-I	ST	600	2029	2059
Zajira 600MW #1	Coal-New-I	ST	600	2029	2059
Mymensingh Peaking	FO-New	GE	100	2029	2044
Rangpur Peaking	FO-New	GE	100	2029	2044
Total MW			3,400		
2030					
B-K-D-P 5 1000 MW #2	Coal-New-D	ST	1,000	2030	2060
Matarbari 600MW #4	Coal-New-I	ST	600	2030	2060
Total MW			1,600		

Source: PSMP Study Team

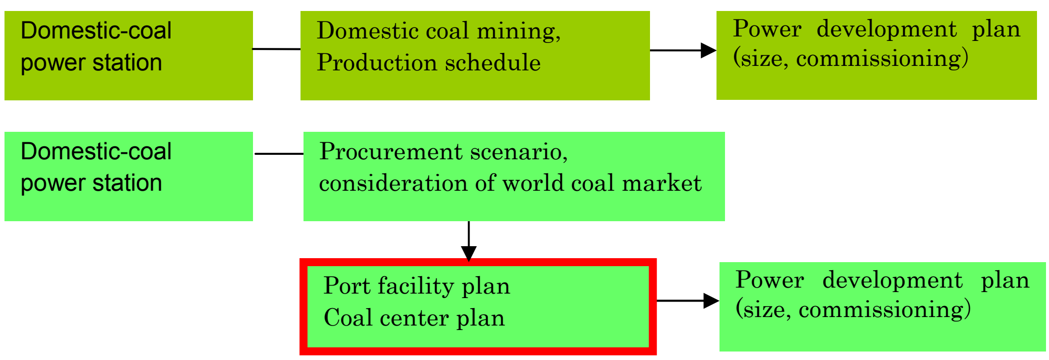
Table 8-20 Net Generation and Fuel consumption (Fuel diversification scenario)

	Net Generation							Fuel Consumption				
	Total [GWH]	D-Coal [GWH]	I-Coal [GWH]	Gas [GWH]	FO [GWH]	HSD [GWH]	Others [GWH]	D-Coal [1,000t/y]	I-Coal [1,000t/y]	Gas [mmcfd]	FO [1,000t/y]	HSD [1,000t/y]
2011	35,474	659	0	28,885	3,948	1,564	416	239	0	792	882	405
2012	39,467	659	0	29,691	7,383	1,320	416	239	0	811	1,614	359
2013	43,882	659	0	32,037	5,165	1,226	4,796	239	0	851	1,205	341
2014	48,713	2,306	0	36,936	4,369	306	4,796	792	0	898	1,067	104
2015	54,047	2,306	0	42,839	3,801	306	4,796	792	0	989	960	104
2016	59,945	2,300	8,081	40,911	3,676	0	4,976	789	3,188	949	919	0
2017	66,457	2,086	19,496	37,734	2,165	0	4,976	722	7,705	921	549	0
2018	73,671	1,652	18,966	35,096	2,165	0	15,791	588	7,590	898	549	0
2019	81,610	9,474	18,539	35,380	2,281	0	15,938	2,810	7,432	898	562	0
2020	90,950	12,931	16,075	37,122	2,427	0	22,395	3,795	6,517	942	598	0
2021	99,838	13,443	18,830	38,078	2,574	0	26,911	3,938	7,542	939	634	0
2022	108,636	17,025	17,883	37,641	2,721	0	33,363	4,962	7,192	917	670	0
2023	118,485	20,407	17,992	35,078	2,867	0	42,140	5,923	7,320	867	706	0
2024	127,368	25,722	17,016	33,459	2,867	0	48,304	7,470	6,964	823	706	0
2025	137,964	26,453	17,885	33,459	3,028	0	57,141	7,669	7,286	806	745	0
2026	147,245	30,166	23,577	33,151	3,192	0	57,158	8,728	9,584	791	785	0
2027	158,456	37,319	28,891	31,401	3,347	0	57,499	10,748	11,740	754	822	0
2028	167,938	48,404	28,456	30,162	3,378	0	57,538	13,924	11,581	714	827	0
2029	180,089	60,352	31,473	27,053	3,604	0	57,608	17,327	12,882	653	886	0
2030	190,752	66,286	35,130	28,653	3,076	0	57,608	19,023	14,335	677	753	0

Source: PSMP Study Team

8.7.5 Concept for formulation of coal development

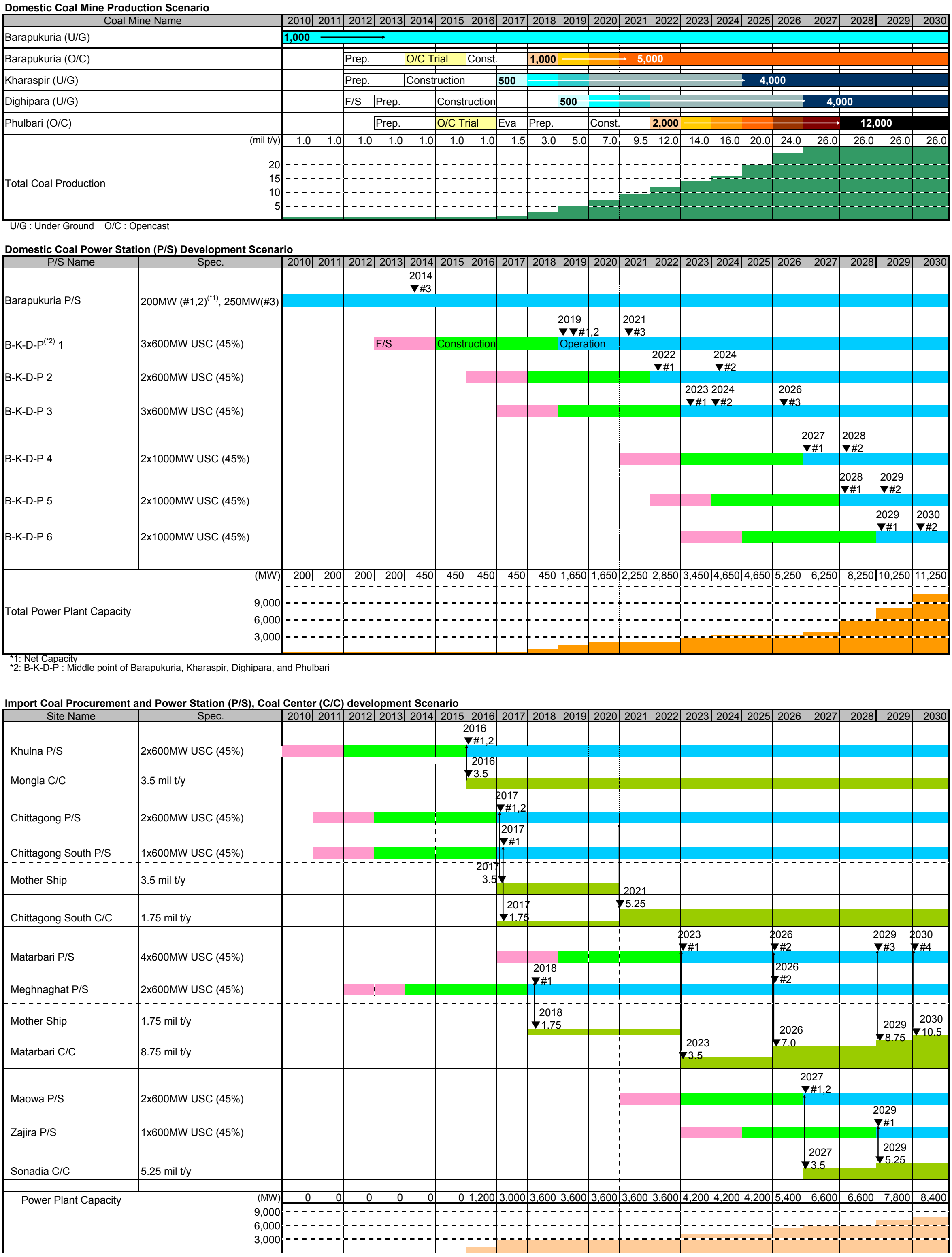
The power supply plan by the domestic coal-fired power station is determined by the mining development and production schedule, and the plan by imported coal-fired power station is also determined by the procurement scenario in consideration of coal demand and the supply balance at the world market, and the construction schedule for the port facility, which dominates the importable capacity of coal from abroad. Fig. 8-26 to Fig. 8-29 indicates coal development and supply plan on each scenario.



Source: PSMP Study Team

Fig. 8-26 Relationship between coal supply plan, infrastructure development plan and power development plan

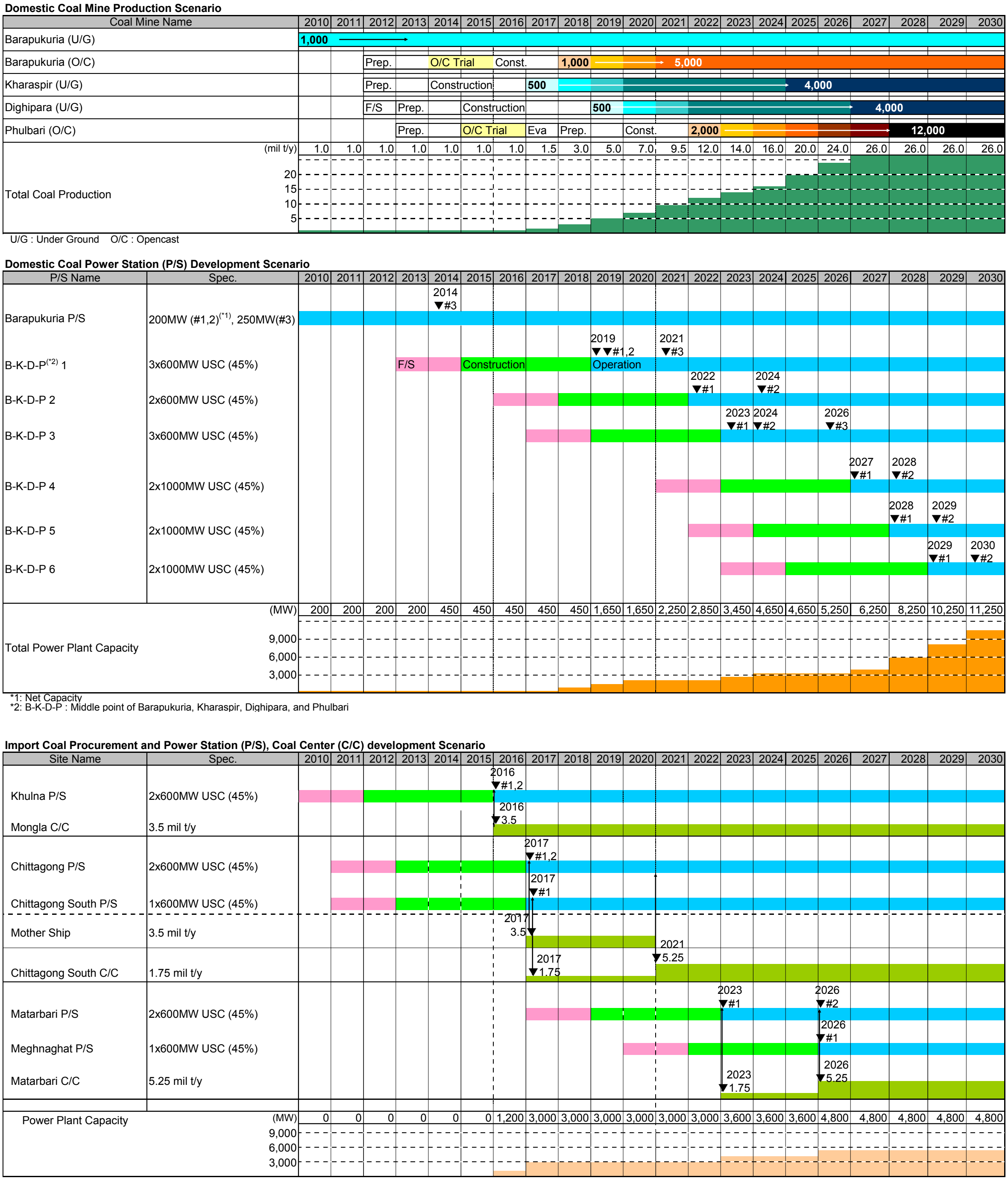
(1) Coal development and supply plan on Base scenario (Fuel Diversification)



Source: PSMP Study Team

Fig. 8-27 Coal development and supply plan on Base scenario (Fuel Diversification)

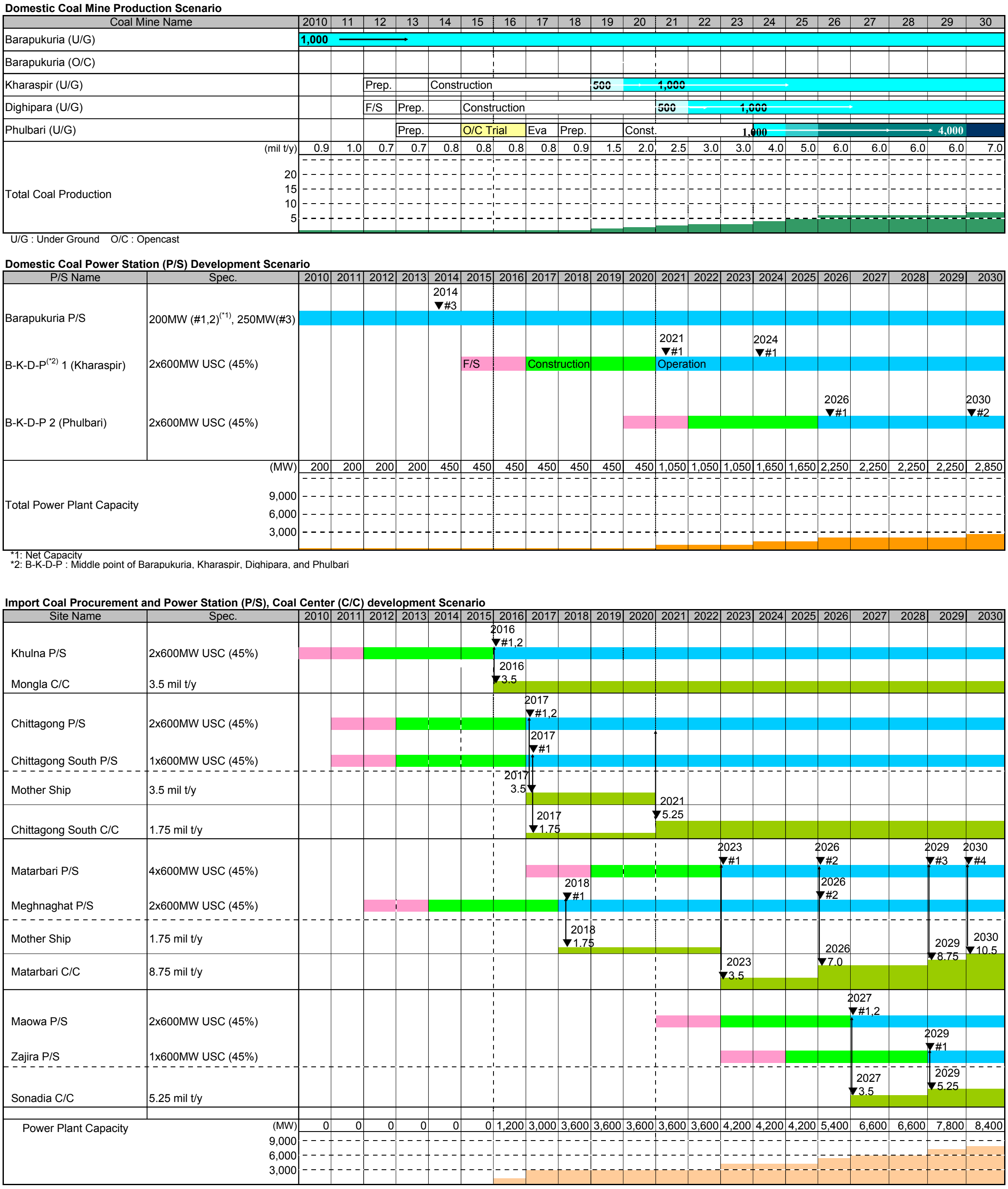
(2) Coal development and supply plan on Domestic Coal Promotion scenario



Source: PSMP Study Team

Fig. 8-28 Coal development and supply plan on Domestic Coal Promotion scenario

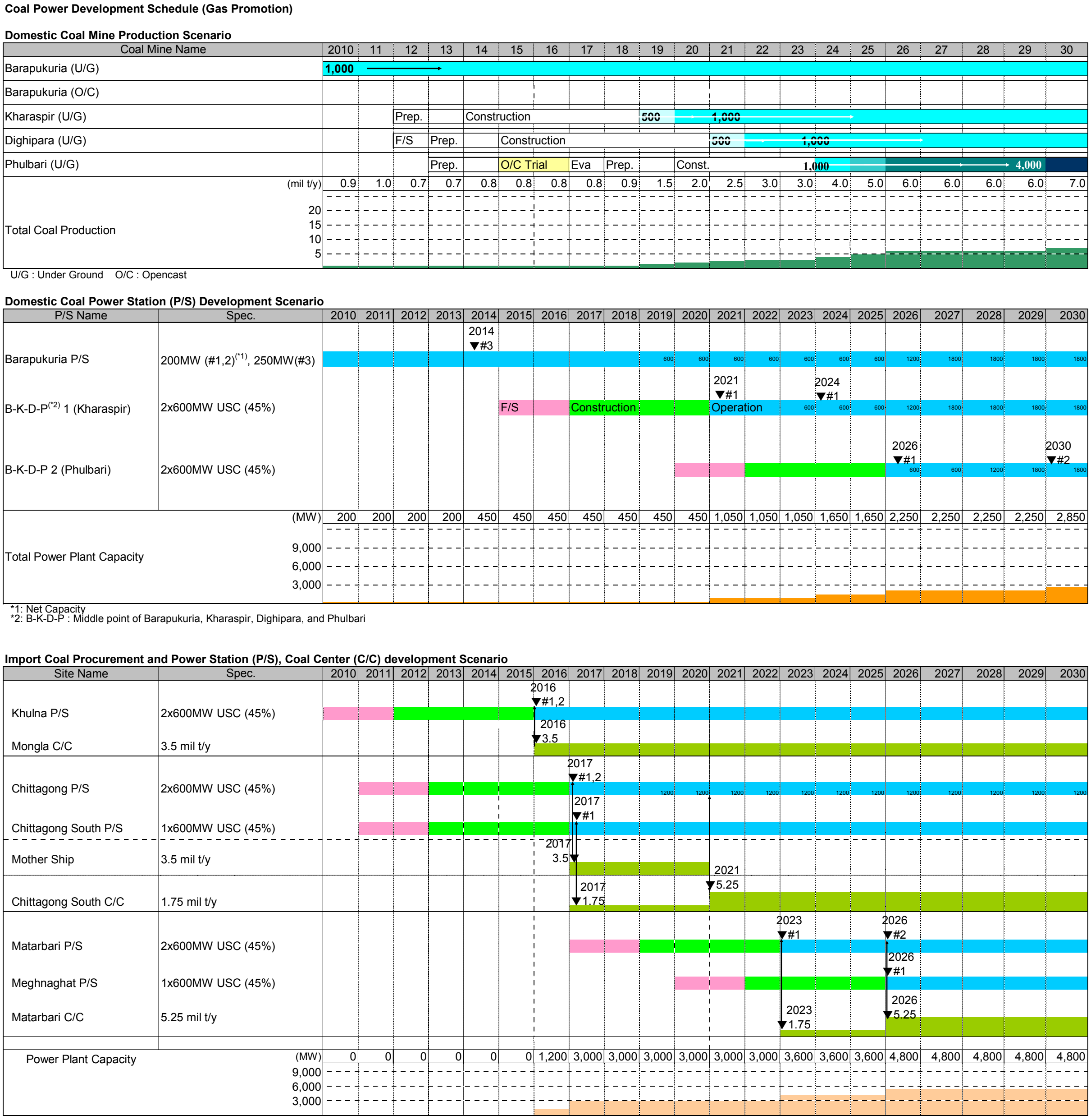
(3) Coal development and supply plan on Import Coal Promotion scenario



Source: PSMP Study Team

Fig. 8-29 Coal development and supply plan on Import Coal Promotion scenario

(4) Coal development and supply plan on Gas Promotion scenario



Source: PSMP Study Team

Fig. 8-30 Coal development and supply plan on Gas Promotion scenario

8.7.6 Determination of optimum power supply plan at each scenario

As indicated in the previous clause, a short-term power supply plan has been combined with the most economical power supply composition in the section for fiscal year 2030, having a fuel procurement restriction condition. Furthermore, the amount of fuel supply is fixed in consideration of the infrastructure necessary for fuel procurement such as coal mining development, the port facility, and the power supply composition for each year is determined as shown in the figure below. In particular, the power supply plan for both domestic and import coal-fired power stations is determined by the mining development schedule for domestic coal and the infrastructure plan such as the port facility and the coal center for import coal. Therefore, it is obviously difficult to attain a composition ratio of 70% coal dominantly under the circumstance of fuel procurement constraints. As a result, an optimum composition ratio of around 50% coal dominant is determined by linear programming and sticking to the upper limit, which was determined by fuel constraints.

Table 8-21 Case number of Power development scenarios

Scenario	Power Demand Forecast			Remarks
Scenario/Demand	Government Policy Scenario	Comparison 7% Scenario	Comparison 6% Scenario	Fuel composition rate at each scenario is different
Fuel Diversification	Case 1-1	Case 1-2	Case 1-3	
Domestic Coal Prom.	Case 2-1	-	-	
Import Coal Prom.	Case 3-1	-	-	
Gas Prom.	Case 4-1	-	-	
Remarks	Fuel composition rate is same on the same scenario with different power demand.			

Source: PSMP Study Team

(1) Fuel Diversification Scenario

To satisfy power demand via the government policy scenario, fuel diversification is promoted multifariously and considerable effort is required to attain domestic and import coal scenarios.

(2) Domestic Coal Promotion Scenario

Based on scenario (1), the risk of the unsuccessful development of import coal procurement will be considered. To make up for this shortage, oil will be increased. (Oil: 6% to 15%)

(3) Import Coal Promotion Scenario

Based on scenario (1), the risk of the unsuccessful development of domestic coal development will be considered. To make up for this shortage, oil will be increased. (Oil: 6% to 28%)

(4) Gas Promotion Scenario

Based on scenario (1), the risk of the unsuccessful development of both import and domestic coal development is considered. To make up for this shortage, gas will be increased. (Gas: 23% to 54%)

Fuel-wise composition at each scenario is shown as follows;

Table 8-22 Fuel-wise composition

Case	Dom. Coal	Imp.Coal	Gas	Oil	Nuclear	RE/Border
Fuel Diversification	29%	22%	23%	6%	10%	10%
Domestic Coal Prom.	29%	12%	23%	15%	10%	10%
Import Coal Prom.	7%	22%	23%	28%	10%	10%
Gas Prom.	7%	12%	54%	6%	10%	10%

Source: PSMP Study Team

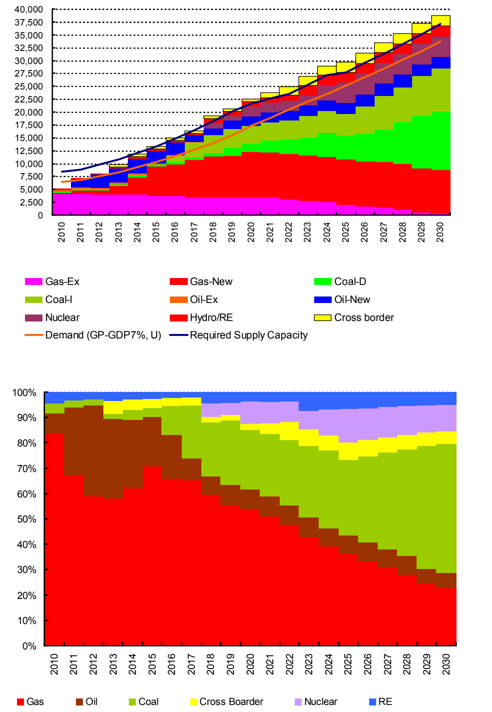


Fig. 8-31 CS1-1:Fuel Diversification

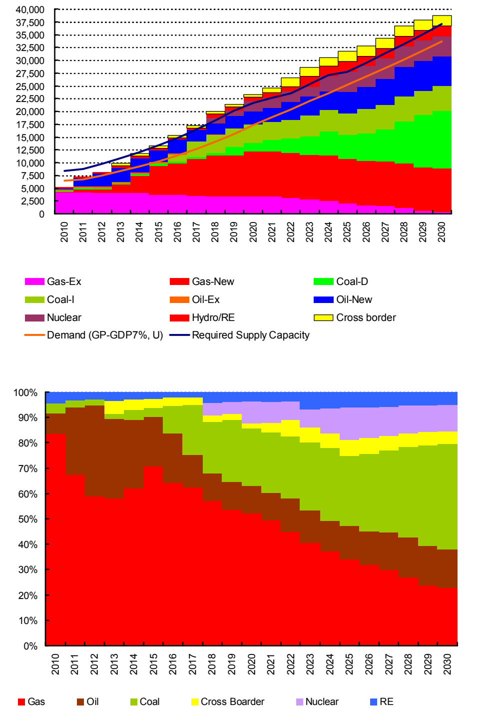


Fig. 8-32 CS2-1:Domestic Coal Prom.

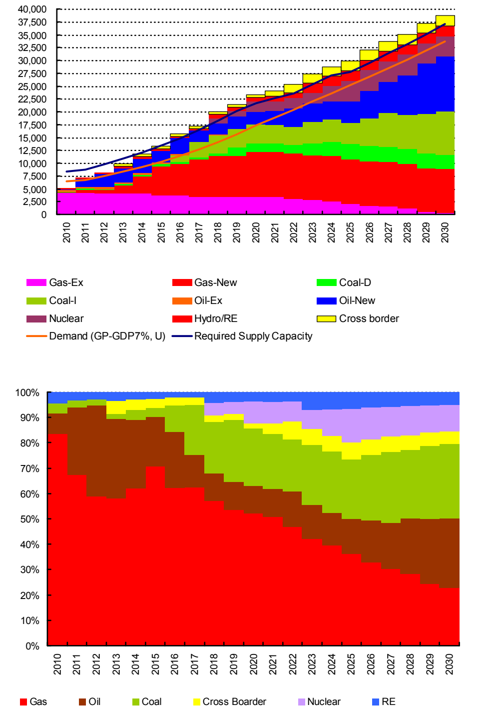


Fig. 8-33 CS3-1:Import Coal Prom.

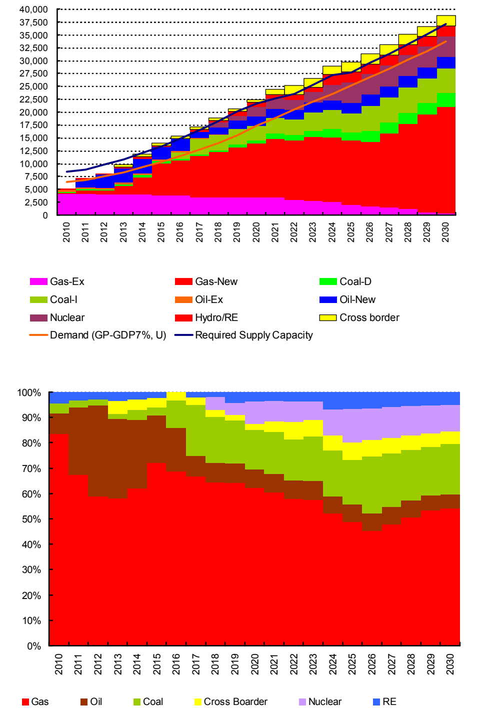


Fig. 8-34 CS4-1:Gas Prom.

Source: PSMP Study Team

Table 8-23 Characteristics of power plants

No.	Power Station	Thermal Parameters	Fuel	Net Unit Capacity (At Grid) [MW]	Auxiliary Power Including Main Transformer Loss	Heat Rate (LHV)				Design Efficiency	Construction Cost			O&M Cost			Others				
						(At Gen. Term Btu/ kWh)	(At Gen. Term kCal/ kWh)	(At Grid kCal/ kWh)	at Minimum Operation	(At Gen.LHV, 100% load)	Equipment Cost $/kW	Installation Cost $/kW (Include utility)	Total Project Cost $/kW	Fixed ($/kW/Year)	Fixed ($/kW/ Month)	Variable ($/MWh)	Fuel Cost ($//MWh)	Time required for Construction	Forced outage Rate	Schedule Maintenance Required (Weeks/year)	Life Time
1	750MW CC (Gas)	1300 degree C class	Gas	750	2.0%	6,206	1,564	1,596	1,877	55.00%	US$429	US$231	US$660	13.2	1.10	0.8	55.6	36	6%	6	25
2	450MW CC (Gas)	1300 degree C class	Gas	450	2.0%	6,206	1,564	1,596	1,877	55.00%	US$600	US$330	US$860	17.2	1.43	1.0	55.6	36	6%	6	25
3	360MW CC (Gas)	1300 degree C class	Gas	360	2.0%	6,206	1,564	1,596	1,877	55.00%	US$618	US$333	US$950	19.0	1.58	1.1	55.6	36	6%	6	25
4	150MW CC (Gas)	1300 degree C class	Gas	150	2.0%	6,206	1,564	1,596	1,877	55.00%	US$761	US$410	US$1,170	23.4	1.95	1.3	55.6	36	6%	6	25
5	300MW ST (Gas)	SubC(16.6MPa,566/566deg)	Gas	300	3.0%	8,031	2,024	2,086	2,196	42.50%	US$832	US$208	US$1,040	20.8	1.73	1.2	72.7	36	6%	6	30
6	150MW CT (Gas)	-	Gas	150	6.0%	9,481	2,389	2,542	3,177	36.00%	US$312	US$315	US$500	10.0	0.83	0.6	88.6	24	4%	4	20
7	120MW CT (Gas)	-	Gas	120	6.0%	10,038	2,530	2,691	3,364	34.00%	US$338	US$286	US$530	10.6	0.88	0.6	93.8	24	4%	4	20
8	Gas Engine (Gas)	GE	Gas	16.5	5.0%	7,230	1,822	1,918	2,019	47.27%	US$800	US$200	US$1,000	20.0	2.6	1.1	66.8	24	4%	2	15
9	1000MW ST USC (Coal)	USC(24.5MPa,600/600deg)	Coal	1000	7.0%	7,585	1,911	2,055	2,163	45.00%	US$1,080	US$270	US$1,350	45.0	3.75	2.6	31.4	48	8%	8	30
10	600MW ST USC (Coal) Domestic	USC(24.5MPa,600/600deg)	Coal	600	5.0%	7,585	1,911	2,012	2,118	45.00%	US$1,200	US$300	US$1,500	50.0	4.17	2.9	30.7	48	8%	8	30
11	600MW ST USC (Coal) Import	USC(24.5MPa,600/600deg)	Coal	600	5.0%	7,585	1,911	2,012	2,118	45.00%	US$1,280	US$320	US$1,600	53.3	4.44	3.0	30.7	48	8%	8	30
12	300MW ST (FO)	SubC(16.6MPa,566/566deg)	F.oil	300	6.0%	8,031	2,024	2,153	2,266	42.50%	US$944	US$236	US$1,180	31.5	2.62	1.8	100.0	36	6%	6	30
13	Gas Engine (FO)	GE	F.oil	16.5	5.0%	7,780	1,961	2,064	2,172	43.93%	US$904	US$226	US$1,130	30.1	2.51	1.7	95.9	24	4%	2	15
14	120MW CT (HSD)	-	HSD	120	6.0%	10,038	2,530	2,691	3,364	34.00%	US$338	US$286	US$600	16.0	1.33	0.9	191.7	24	4%	4	20
15	Gas Engine (HSD)	GE	HSD	16.5	5.0%	7,230	1,822	1,918	2,019	47.27%	US$904	US$226	US$1,130	30.1	2.51	1.7	136.7	24	4%	2	15
16	1000MW Nuclear	Light Water		1000	6.0%	10,343	2,606	2,773	2,919	33.00%			US$2,400					60	6%	8	40

Source: PSMP Study Team

8.8 Quantitative evaluation of 3E (Economy, Environment, Energy Security)

A quantitative evaluation has been examined to find the optimum power development plan in terms of the economy, environment, and energy security risks.

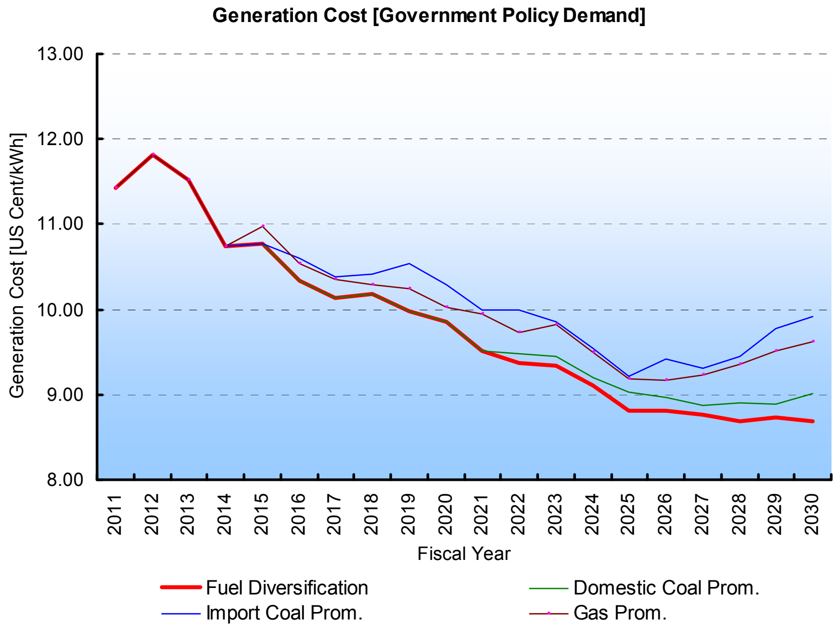
8.8.1 Economic evaluation

(1) Index

Generation cost (US Cent/kWh) of the grid average is adopted as an index for the economic evaluation.

(2) Time-series data

The power generation cost in the base case is as shown in the figure below. The generation cost becomes about 8TK/kWh in the section in fiscal year 2030 afterwards, though the power generation cost faces a peak of about 12TK/kWh in 2013 when the price of fuel becomes an international price value.



Source: PSMP Study Team

Fig. 8-35 Trend of Generation Cost

(3) Quantitative analysis result

Evaluation criteria and results are shown as follows.

Table 8-24 Evaluation criteria

Range (USCent/kWh)	Point
10 ～	1
9.5 ～ 10	2
9.0 ～ 9.5	3
8.5 ～ 9.0	4
～ 8.5	5

Source : PSMP Study Team

Table 8-25 Evaluation Result

Scenario	Index (USCent/kWh)	Point (Economy)
Fuel Diversification	8.68	4
Domestic Coal Prom.	9.01	3
Import Coal Prom.	9.92	2
Gas Prom.	9.62	2

Source : PSMP Study Team

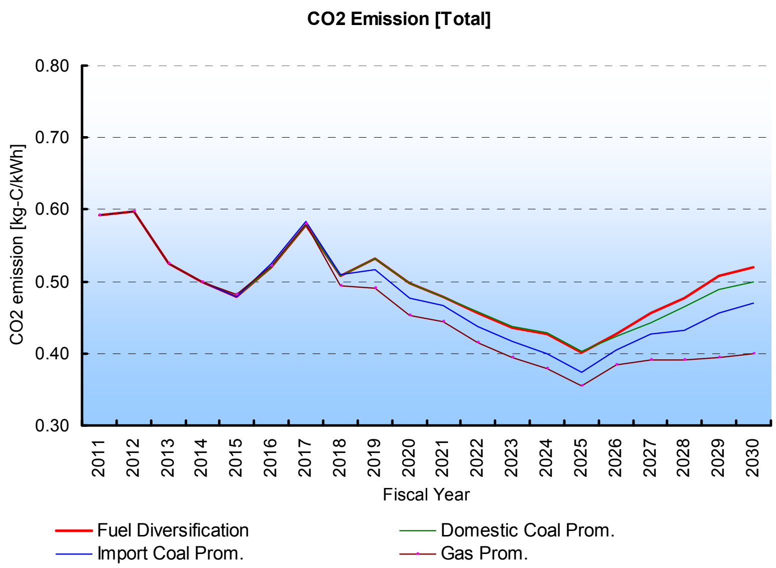
8.8.2 Environmental evaluation

(1) Index

CO2 Emissions (kg-C/kWh) on the grid average has been adopted as an index for the environmental evaluation.

(2) Time-series data

The introduction of a more efficient generation facility such as USC and the abolishment of an existing lower efficient facility, CO2 emissions somewhat increase within the limit range even for coal power generation which has a higher rate of CO2 emissions.



Source: PSMP Study Team

Fig. 8-36 Trend of CO2 Emission Source: PSMP Study Team

(3) Quantitative analysis result

The evaluation criteria and results are shown as follows.

Table 8-26 Evaluation criteria

Range (kg-CO2/kWh)	Point
0.55 ～	1
0.50 ～ 0.55	2
0.45 ～ 0.50	3
0.40 ～ 0.45	4
～ 0.40	5

Source: PSMP Study Team

Table 8-27 Evaluation Result

Scenario	Index (kg-CO2/kWh)	Point (Environment)
Fuel Diversification	0.52	2
Domestic Coal Prom.	0.50	3
Import Coal Prom.	0.47	3
Gas Prom.	0.40	4

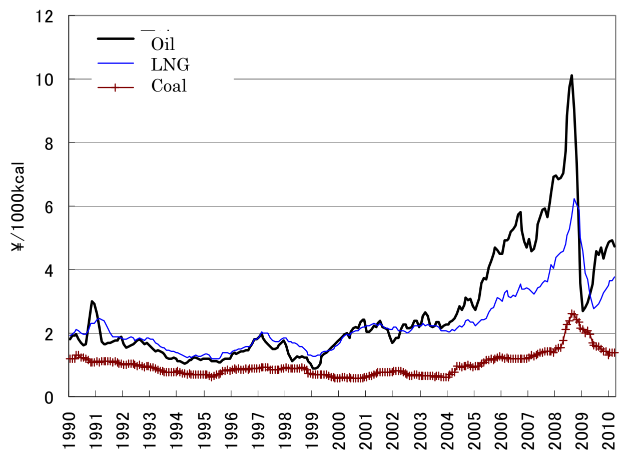
Source: PSMP Study Team

8.8.3 Energy security evaluation

(1) Index

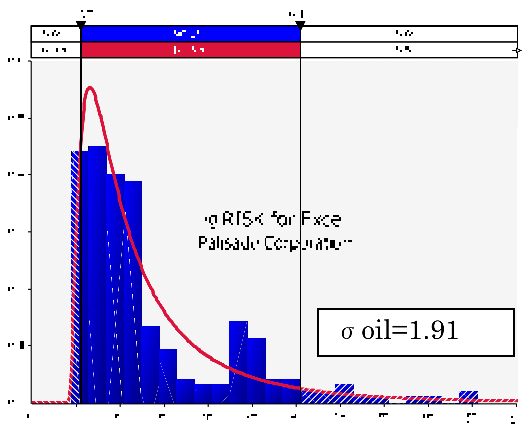
The figure below shows the price of oil, gas, and coal over the past 20 years in the time series. The change level is different as described in the preceding chapter. In this paragraph, it pays attention to such a fluctuation band, the Monte Carlo simulation model via a lognormal distribution was constructed, and the quantitative evaluation of the risk flexibility to the price of the fuel has been examined as follows.

$$\text{Energy Security Index} = (\text{Coal rate}) \times \text{Standard Deviation(Coal)} + (\text{Gas rate}) \times \text{Standard Deviation (Gas)} + (\text{Oil rate}) \times \text{Standard Deviation (Oil)}$$



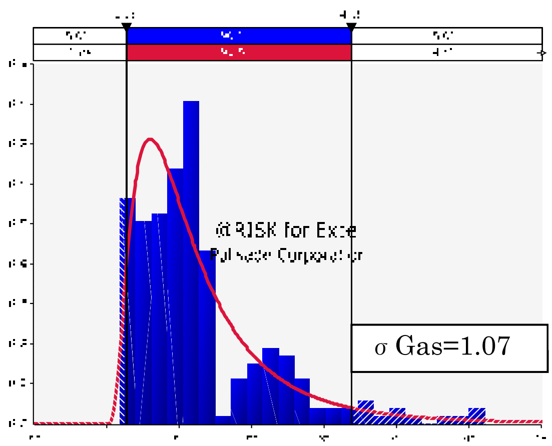
Source: PSMP Study Team

Fig. 8-37 Fuel Price Fluctuation



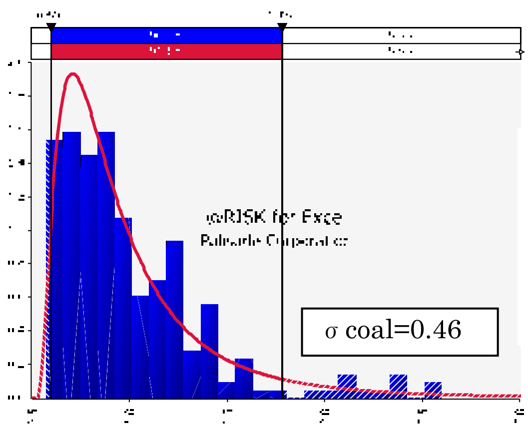
Source: PSMP Study Team

Fig. 8-38 Oil Price Lognormal Distribution



Source: PSMP Study Team

Fig. 8-39 Gas Price Lognormal Distribution

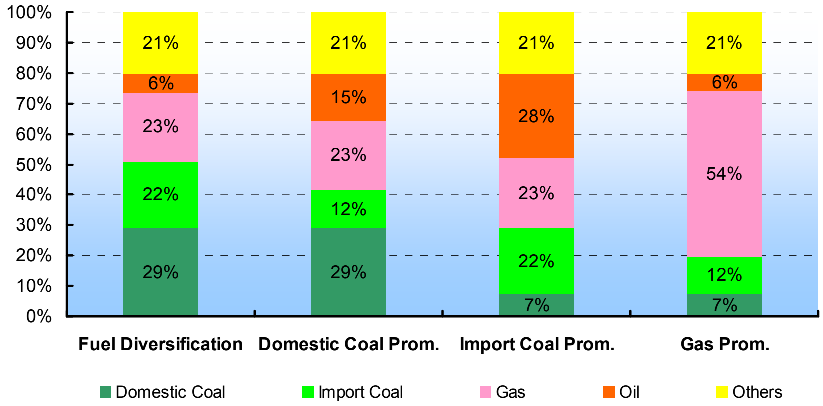


Source: PSMP Study Team

Fig. 8-40 Coal Price Lognormal Distribution

(2) Fuel-wise composition

Fuel-wise composition in FY 2030 is shown as follows.



Case	Domestic Coal	Import Coal	Gas	Oil	Others	Total	Energy Security Index
Risk Index	-	0.46	1.07	1.91	-		-
Fuel Diversification	29%	22%	23%	6%	21%	100%	0.46
Domestic Coal Prom.	19%	12%	23%	15%	21%	100%	0.59
Import Coal Prom.	7%	22%	23%	28%	21%	100%	0.87
Gas Prom.	7%	12%	54%	6%	21%	100%	0.74

Source: PSMP Study Team

Fig. 8-41 Fuel-wise composition

(3) Quantitative analysis result

Evaluation criteria and results are shown as follows.

Table 8-28 Evaluation criteria

Range (Risk index)	Point
0.80 ～	1
0.70 ～ 0.80	2
0.60 ～ 0.70	3
0.50 ～ 0.60	4
～ 0.50	5

Source: PSMP Study Team

Table 8-29 Evaluation Result

Case	Risk Index	Point (Security)
Fuel Diversification	0.46	5
Domestic Coal Prom.	0.59	4
Import Coal Prom.	0.87	1
Gas Prom.	0.74	2

Source: PSMP Study Team

8.8.4 Priority of evaluation item is given weight according to the AHP method

When it undertook a quantitative evaluation of 3E, the weight putting of the evaluation item was conducted utilizing the AHP method. Each scenario was evaluated from the viewpoint of the economy, environment, and overall risk flexibility, and the validity of the diversification base scenario was finally verified. The results are shown as follows.

Table 8-30 Priority of evaluation item is put weight according to the AHP method

Index	1	2	3	Average	Priority
Economy	1	5	4	2.714	0.7
Environment	1/5	1	1/4	0.368	0.1
Energy Security	1/4	4	1	1.000	0.2

Source: PSMP Study Team

Based on the above conditions, the fuel diversification scenario has been selected as the most optimum scenario, maximizing 3E value.

Table 8-31 3E Quantitative evaluation result

Scenario	Economy	Environment	Energy Security	Total Point	Priority
	0.7	0.1	0.2		
Fuel Diversification	4	2	5	4.064	1
Domestic Coal Prom.	3	3	4	3.245	2
Import Coal Prom.	2	3	1	1.845	4
Gas Promotion	2	4	2	2.180	3

Source: PSMP Study Team

8.9 Proposal of mid to long-term power development plan

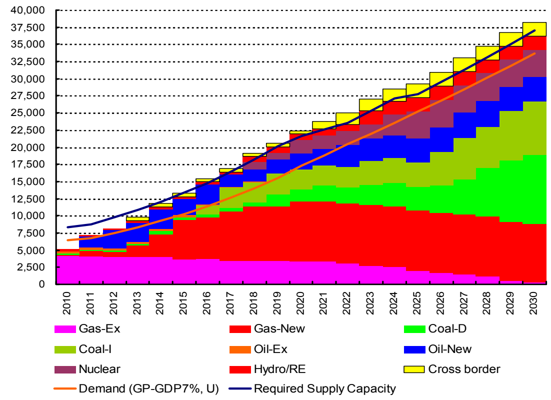
8.9.1 Optimum composition

The component ratio that becomes the maximization of the most optimum power supply composition in the section in fiscal year 2030, that is, 3E is about 50% coal, and becomes about 25% of unifying oil, nuclear power, cross border trade, and renewable energy, though accounting for over 80% and most of the gas in the section in fiscal year 2010. As a result, the optimum fuel-wise composition will shift from the exclusive devotion to gas, to a fuel diversification scenario. On the following page, an optimum scenario is shown at each power demand scenario.

8.9.2 Characteristics of operation condition for optimum power development planning

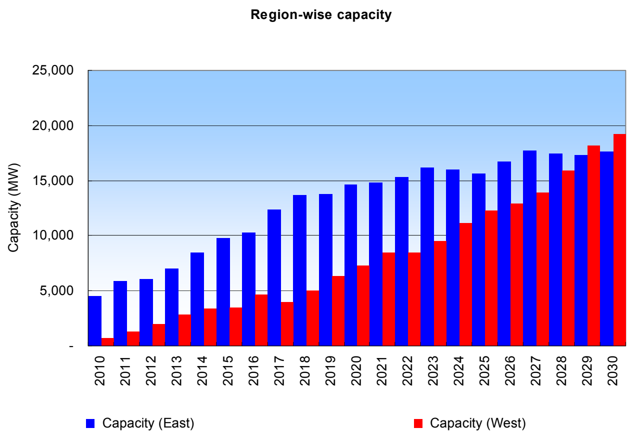
Fig.8-48 ～ 49indicates the characteristics of operating conditions for the optimum power development planning. The recommended focal points are shown as follows.

- Fuel diversification shift from Gas to Coal.
- Gas is shifted from base to middle to peak generation.
- For a higher load period, cheaper coal and other generations are to be for the base load.
- Coal generation with load following capability for even low load period is introduced.



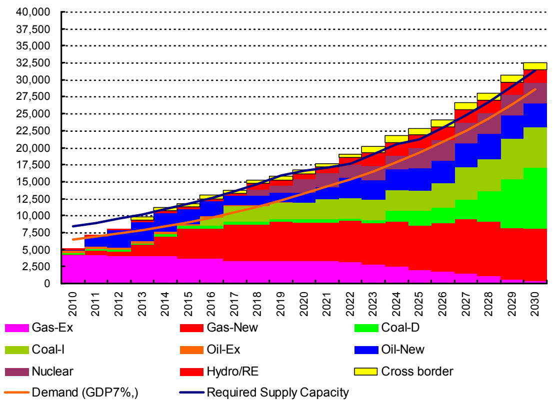
Source: PSMP Study Team

Fig. 8-42 Power development plan by 2030 (Demand: Government policy)



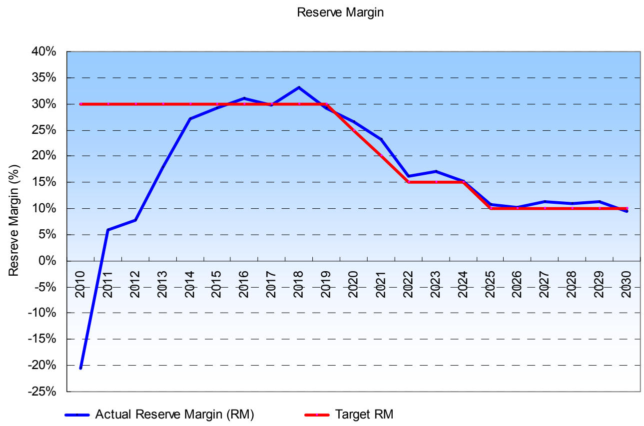
Source: PSMP Study Team

Fig. 8-43 East-West wise Generation capacity



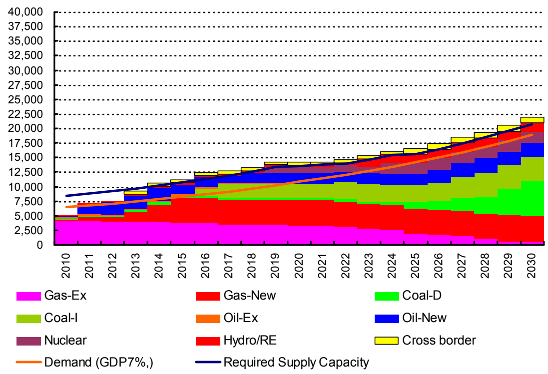
Source: PSMP Study Team

Fig. 8-44 Power development plan by 2030 (Demand: Comparison 7%)



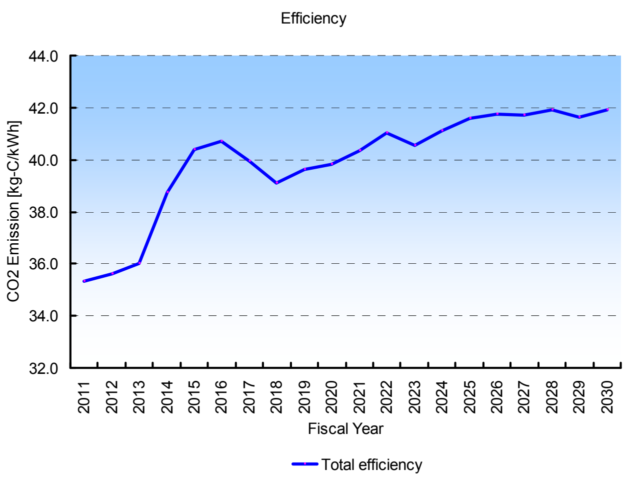
Source: PSMP Study Team

Fig. 8-45 Reliability level and reserve margin



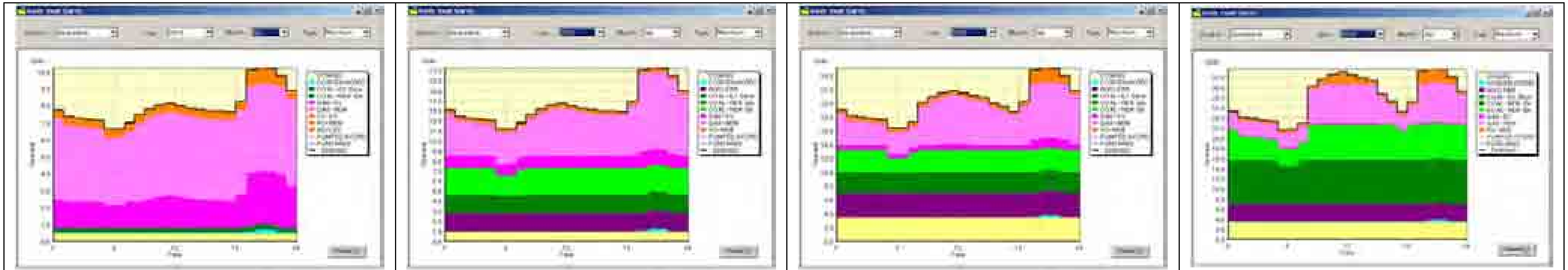
Source: PSMP Study Team

Fig. 8-46 Power development plan by 2030 (Demand: Comparison 6%)



Source: PSMP Study Team

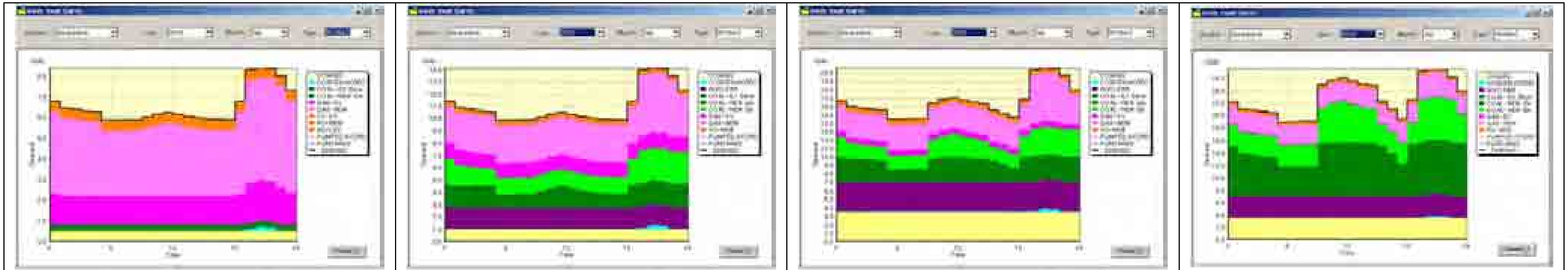
Fig. 8-47 Efficiency



FY2015 FY2020 FY2025 FY2030

Source: PSMP Study Team

Fig. 8-48 Daily Operation Model (Peak-month, Maximum)



FY2015 FY2020 FY2025 FY2030

Source: PSMP Study Team

Fig. 8-49 Daily Operation Model (Peak-month, Minimum)

Table 8-32 Power Development Plan (Fuel Diversification Scenario 2011-2030)

Station Name	Type	Fuel Type	Min Unit Net Capacity (MW)	Max Unit Net Capacity (MW)	In Service FY	Retirement FY	Net Heat Rate (kCal/kWh) Min. Load	Net Heat Rate (KCal/KWh) Incremental	Sping Resv (%)	Forced Outage (%)	Maint. Req'd D/yr	Maint. Class Size (MW)	Fuel Cost (Cents/10^6 KCal) Domst	Foreign	Fixed O&M ($/KW-mon)	Variable O&M ($/MWh)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total																	11191	12127	13865	15810	17323	18975	20433	23285	24687	26549	27851	29005	31000	33014	33767	35440	37567	39309	41321	42745
Barapukuria 2x125 MW ST	ST	Coal-Ex	50	100	2009	2036	2800	2350	5	10	60	100	1527	0	5.95	5.20	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Barapukuria 250MW (3rd unit)	ST	Coal-New-D	58	250	2014	2044	2670	2295	5	10	60	125	1527	0	4.69	3.22				250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
B-K-D-P 1 600MW #1	ST	Coal-New-D	180	600	2019	2049	2118	1966	5	8	60	600	1527	0	4.17	2.85									600	600	600	600	600	600	600	600	600	600	600	600
B-K-D-P 1 600MW #2	ST	Coal-New-D	180	600	2019	2049	2118	1966	5	8	60	600	1527	0	4.17	2.85									600	600	600	600	600	600	600	600	600	600	600	600
B-K-D-P 1 600MW #3	ST	Coal-New-D	180	600	2020	2050	2118	1966	5	8	60	600	1527	0	4.17	2.85											600	600	600	600	600	600	600	600	600	600
B-K-D-P 2 600MW #1	ST	Coal-New-D	180	600	2022	2052	2118	1966	5	8	60	600	1527	0	4.17	2.85												600	600	600	600	600	600	600	600	600
B-K-D-P 2 600MW #2	ST	Coal-New-D	180	600	2024	2054	2118	1966	5	8	60	600	1527	0	4.17	2.85														600	600	600	600	600	600	600
B-K-D-P 3 600MW #1	ST	Coal-New-D	180	600	2023	2053	2118	1966	5	8	60	600	1527	0	4.17	2.85													600	600	600	600	600	600	600	600
B-K-D-P 3 600MW #2	ST	Coal-New-D	180	600	2024	2054	2118	1966	5	8	60	600	1527	0	4.17	2.85														600	600	600	600	600	600	600
B-K-D-P 3 600MW #3	ST	Coal-New-D	180	600	2026	2056	2118	1966	5	8	60	600	1527	0	4.17	2.85																600	600	600	600	600
B-K-D-P 4 1000 MW #1	ST	Coal-New-D	300	1000	2027	2057	2118	1966	5	8	56	600	1527	0	3.75	2.57																	1000	1000	1000	1000
B-K-D-P 4 1000 MW #2	ST	Coal-New-D	300	1000	2028	2058	2118	1966	5	8	56	600	1527	0	3.75	2.57																		1000	1000	1000
B-K-D-P 5 1000 MW #1	ST	Coal-New-D	300	1000	2028	2058	2118	1966	5	8	56	600	1527	0	3.75	2.57																		1000	1000	1000
B-K-D-P 5 1000 MW #2	ST	Coal-New-D	300	1000	2029	2059	2118	1966	5	8	56	600	1527	0	3.75	2.57																			1000	1000
B-K-D-P 6 1000 MW #1	ST	Coal-New-D	300	1000	2029	2059	2118	1966	5	8	56	600	1527	0	3.75	2.57																			1000	1000
B-K-D-P 6 1000 MW #2	ST	Coal-New-D	300	1000	2030	2060	2118	1966	5	8	56	600	1527	0	3.75	2.57																				1000
Khulna South 600 MW ST #1	ST	Coal-New-I	180	600	2016	2045	2118	1966	5	8	60	600	0	1640	4.44	3.04						600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Khulna South 600 MW ST #2	ST	Coal-New-I	180	600	2016	2046	2118	1966	5	8	60	600	0	1640	4.44	3.04						600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Chittagong 600 MW ST #1	ST	Coal-New-I	180	600	2017	2045	2118	1966	5	8	60	600	0	1640	4.44	3.04							600	600	600	600	600	600	600	600	600	600	600	600	600	600
Chittagong 600 MW ST #2	ST	Coal-New-I	180	600	2017	2046	2118	1966	5	8	60	600	0	1640	4.44	3.04							600	600	600	600	600	600	600	600	600	600	600	600	600	600
Chittagong South 600MW #1	ST	Coal-New-I	180	600	2017	2047	2118	1966	5	8	56	600	0	1640	4.44	3.04							600	600	600	600	600	600	600	600	600	600	600	600	600	600
Matarbari 600MW #1	ST	Coal-New-I	180	600	2023	2053	2118	1966	5	8	56	600	0	1640	4.44	3.04													600	600	600	600	600	600	600	600
Matarbari 600MW #2	ST	Coal-New-I	180	600	2026	2056	2118	1966	5	8	56	600	0	1640	4.44	3.04																600	600	600	600	600
Matarbari 600MW #3	ST	Coal-New-I	180	600	2029	2059	2118	1966	5	8	56	600	0	1640	4.44	3.04																			600	600
Matarbari 600MW #4	ST	Coal-New-I	180	600	2030	2060	2118	1966	5	8	56	600	0	1640	4.44	3.04																				600
Megnagatt 600MW #1	ST	Coal-New-I	180	600	2018	2048	2118	1966	5	8	56	600	0	1640	4.44	3.04								600	600	600	600	600	600	600	600	600	600	600	600	600
Megnagatt 600MW #2	ST	Coal-New-I	180	600	2026	2056	2118	1966	5	8	56	600	0	1640	4.44	3.04																600	600	600	600	600
Mawa 600MW #1	ST	Coal-New-I	180	600	2027	2057	2118	1966	5	8	56	600	0	1640	4.44	3.04																	600	600	600	600
Mawa 600MW #2	ST	Coal-New-I	180	600	2027	2057	2118	1966	5	8	56	600	0	1640	4.44	3.04																	600	600	600	600
Zajira 600MW #1	ST	Coal-New-I	180	600	2029	2059	2118	1966	5	8	56	600	0	1640	4.44	3.04																			600	600
Siddhirgonj 210 MW ST #1	ST	Gas-Ex	89	177	2005	2034	2900	2400	5	8	60	210	3485	0	2.60	2.60	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177
Ghorasal 4x210 ST #6	ST	Gas-Ex	89	178	1999	2029	2947	2400	5	8	60	200	3485	0	2.60	2.60	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	
Ghorasal 4x210 ST #5	ST	Gas-Ex	89	178	1995	2025	2947	2400	5	8	60	200	3485	0	2.60	2.60	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178					
Ghorasal 4x210 ST #4	ST	Gas-Ex	89	178	1989	2024	2947	2400	5	8	60	200	3485	0	2.60	2.60	178	178	178	178	178	178	178	178	178	178	178	178	178	178						
Ghorasal 4x210 ST #3	ST	Gas-Ex	89	178	1987	2021	2947	2400	5	8	60	200	3485	0	2.60	2.60	178	178	178	178	178	178	178	178	178	178	178									
Ashuganj 3x150 MW ST #5	ST	Gas-Ex	60	120	1988	2023	2953	2400	5	4	60	150	3485	0	2.60	2.60	120	120	120	120	120	120	120	120	120	120	120	120	120							
Ashuganj 3x150 MW ST #4	ST	Gas-Ex	60	120	1987	2022	2953	2400	5	4	60	150	3485	0	2.60	2.60	120	120	120	120	120	120	120	120	120	120	120	120								
Ashuganj 3x150 MW ST #3	ST	Gas-Ex	60	120	1987	2021	2953	2400	5	4	60	150	3485	0	2.60	2.60	120	120	120	120	120	120	120	120	120	120	120									
Raozan 2X210 ST#2	ST	Gas-Ex	88	175	1998	2028	2990	2400	5	6	60	200	3485	0	2.60	2.60	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175		
Raozan 2X210 ST#1	ST	Gas-Ex	88	175	1993	2026	2990	2400	5	6	60	200	3485	0	2.60	2.60	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175				
Ghorasal 2x55 ST #1	ST	Gas-Ex	20	40	1974	2016	3232	2400	5	10	60	60	3485	0	2.60	2.60	50	50	50	50	50	50														
Ghorasal 2x55 ST #2	ST	Gas-Ex	20	40	1976	2016	3232	2400	5	10	60	60	3485	0	2.60	2.60	30	30	30	30	30	30														
Ashuganj 2x64 MW ST #2	ST	Gas-Ex	30	60	1971	2014	3500	2232	5	7	60	60	3485	0	2.60	2.60	60	60	60	60																
Ashuganj 2x64 MW ST #1	ST	Gas-Ex	30	60	1971	2014	3500	2232	5	7	60	60	3485	0	2.60	2.60	60	60	60	60																
Chittagon (Sikalbaha) 60 MW ST	ST	Gas-Ex	18	36	1984	2019	3540	2558	5	10	60	60	3485	0	2.60	2.60	36	36	36	36	36	36	36	36	36											
NEPC, Haripur BMPP	GE	Gas-Ex	22	110	1999	2016	2000	2000		7	30	100	3485	0	-	4.00	110	110	110	110	110	110														
Jangalia, comilla SIPP	GE	Gas-Ex	7	33	2009	2024	2249	2249		4	30	30	3485	0	1.30	3.25	33	33	33	33	33	33	33	33	33	33	33	33	33	33						
Tangail SIPP (22 MW)	GE	Gas-Ex	2	22	2009	2024	2249	2249		4	30	30	3485	0	1.30	3.25	22	22	22	22	22	22	22	22	22	22	22	22	22	22						
Feni SIPP	GE	Gas-Ex	4	22	2009	2024	2249	2249		4	30	30	3485	0	1.30	3.25	22	22	22	22	22	22	22	22	22	22	22	22	22	22						
Barobkundo SIPP	GE	Gas-Ex	4	22	2009	2024	2249	2249		4	30	30	3485	0	1.30	3.25	22	22	22	22	22	22	22	22	22	22	22	22	22	22						
Kumargao 10 MW (15 Years)	GE	Gas-Ex	2	10	2009	2024	2419	2419		4	30	10	3485	0	1.30	3.25	10	10	10	10	10	10	10	10	10	10	10	10	10	10						
Ullapara, SIPP, REB	GE	Gas-Ex	2	11	2009	2024	2500	2500		4	30	20	3485	0	1.30	3.25	121	121	121	121	121	121	121	121	121	121	121	121	121	121						
Chandina,Mahdabdi,AshuliaSummit , REB	GE	Gas-Ex	7	35	2007	2024	2500	2500		4	30	30	3485	0	1.30	3.25	105	105	105	105	105	105	105	105	105	105	105	105	105	105						
Kumargoan 48MW (3 Years)	GE	Gas-Ex	2	48	2009	2011	2512	2512		4	30	50	3485	0	1.30	3.25	48																			
West Mount Baghabari BMPP	GE	Gas-Ex	14	70	1999	2016	2921	1960		6	30	100	3485	0	-	3.09	70	70	70	70	70	70														
Sahzibazar RPP (3 Years)	GE	Gas-Ex	2	50	2009	2011	3028	3028		4	30	50	3485	0	1.30	3.25	50																			
Sahzibazar RPP (15 Years)	GE	Gas-Ex	2	86	2009	2024	3158	3158		4	30	100	3485	0	1.30	3.25	86	86	86	86	86	86	86	86	86	86	86	86	86	86						
Tongi 100 MW GT	CT	Gas-Ex	30	100	2005	2025	3064	2408		7	30	100	3485	0	1.30	3.25	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100					
Baghabari 100 MW CT	CT	Gas-Ex	30	99	2002	2022	3064	2408		4	30	100	3485	0	1.30	3.25	99	99	99	99	99	99	99	99	99	99	99	99								
Baghabari 71 MW CT	CT	Gas-Ex	21	70	1991	2016	3057	3057		4	30	100	3485	0	1.30	3.25	70	70	70	70	70	70														
Shahjibazar GT 7 units	CT	Gas-Ex	11	38	1968	2009	3062	3062		10	30	60	3485	0	1.30	3.25																				
Shahjibazar2x35 MW CT #2	CT	Gas-Ex	10	34	2001	2023	3062	3062		10	30	60	3485	0	1.30	3.25	34	34	34	34	34	34	34	34	34	34	34	34	34							
Shahjibazar2x35 MW CT #1	CT	Gas-Ex	10	34	2000	2023	3062	3062		10	30	60	3485	0	1.30	3.25	34	34	34	34	34	34	34	34	34	34	34	34	34							
Chittagon (Sikalbaha) BMGT	CT	Gas-Ex	10	10	1987	2019	3540	2558	5	10	60	60	3485	0	2.60	2.60																				
Haripur 3x33 CT #3	CT	Gas-Ex	9	31	1988	2014	3835	3835		5	30	30	3485	0	1.30	3.25	31	31	31	31																
Haripur 3x33 CT #2	CT	Gas-Ex	9	31	1988	2014	3835	3835		5	30	30	3485	0	1.30	3.25	31	31	31	31																
Haripur 3x33 CT #1	CT	Gas-Ex	9	31	1988	2014	3835	3835		5	30	30	3485	0	1.30	3.25	31	31	31	31																
Sylhet 20 MW CT	CT	Gas-Ex	6	19	1987	2014	3969	3969		8	30	20	3485	0	1.30	3.25	19	19	19	19																
Ashuganj CT 56 MW	CT	Gas-Ex	12	40	1986	2014	4258	4258		15	30	40	3485	0	1.30	3.25	40	40	40	40																

Station Name	Type	Fuel Type	Min Unit Net Capacity (MW)	Max Unit Net Capacity (MW)	In Service FY	Retirement FY	Net Heat Rate (kCal/kWh) Min. Load	Net Heat Rate (KCal/KWh) Incremental	Sping Resv (%)	Forced Outage (%)	Maint. Req'd D/yr	Maint. Class Size (MW)	Fuel Cost (Cents/10^6 KCal) Domst	Fuel Cost (Cents/10^6 KCal) Foreign	Fixed O&M ($/KW-mon	Variable O&M ($/MWh)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CDC, Haripur	CC	Gas-Ex	144	360	2002	2027	2027	1479	5	6	45	400	3485	0	1.85	1.43	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360			
CDC, Meghnaghat	CC	Gas-Ex	180	450	2003	2028	1900	1850	5	6	45	500	3485	0	0.70	1.34	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450		
Mymenshing (RPC) 210 MW CC	CC	Gas-Ex	70	175	2006	2031	2000	1900	5	6	45	200	3485	0	6.50	1.30	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175
Fenchuganj CC	CC	Gas-Ex	35	88	1994	2022	2090	1950	5	6	45	90	3485	0	1.63	1.69	88	88	88	88	88	88	88	88	88	88	88	88								
Ashuganj 90 MW CC	CC	Gas-Ex	23	56	1984	2014	3483	2400	5	15	45	60	3485	0	1.63	1.69	56	56	56	56																
Ghorasal, Dual Fuel, Peaking Plant	GE	Gas-New	40	290	2013	2033	2019	1902		6	40	200	3485	0	2.60	1.14			290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290
Kaliakair, Dual Fuel, Peaking Plant	GE	Gas-New	20	100	2014	2029	2019	1893		6	40	100	3485	0	2.60	1.14			0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
Savar, Dual Fuel, Peaking Plant	GE	Gas-New	20	100	2014	2029	2019	1893		6	40	100	3485	0	2.60	1.14			0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
Ashuganj – 3 yrs Rental, commissioned	GE	Gas-New	11	55	2010	2013	2019	1893		4	30	60	3485	0	2.60	1.14	55	55	55																	
Fenchuganj (15 Years), commissioned	GE	Gas-New	10	51	2010	2025	2019	1893		4	30	50	3485	0	2.60	1.14	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51					
Ashuganj 50	GE	Gas-New	10	52	2012	2032	2019	1894		4	30	50	3485	0	2.60	1.14		52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
Comilla Peaking, Dual Fuel, Peaking Plant	GE	Gas-New	10	50	2013	2028	2019	1893		6	40	50	3485	0	2.60	1.14			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50		
Fenchuganj – 3 Yrs rental, U/C	GE	Gas-New	10	50	2011	2014	2019	1893		4	30	50	3485	0	2.60	1.14	50	50	50	50																
Bhola (3 Years), Commissioned	GE	Gas-New	7	33	2010	2013	2019	1893		4	30	40	3485	0	2.60	1.14	33	33	33																	
Bogra –3 yrs rental, U/C	GE	Gas-New	4	20	2011	2014	2019	1893		4	30	20	3485	0	2.60	1.14	20	20	20	20																
Siddhirgonj 2X150 MW CT(450CC)	CC	Gas-New	180	450	2014	2039	1877	2984	5	5	45	500	3485	0	1.43	0.98			0	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
Ashuganj 150 MW (150CC)	CC	Gas-New	59	150	2015	2040	1877	2972	5	5	45	150	3485	0	1.95	1.34				0	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Khulna 150MW , Dual Fuel, Peaking Plant	CT	Gas-New	45	150	2013	2033	3177	2269		6	40	150	0	4647	0.73	0.50			150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Sikalbaha 150MW Peaking Plant, U/C	CT	Gas-New	45	149	2011	2031	3177	2269		4	30	150	3485	0	0.73	0.50	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149
Sirajganj 150MW , Dual Fuel, Peaking Plant	CT	Gas-New	45	150	2013	2033	3177	2269		6	40	150	0	4647	0.73	0.50			150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Siddhirgonj 2X120 MW Peaking Plant (U/C)	CT	Gas-New	31	104	2011	2031	3738	2670		4	30	100	3485	0	0.88	0.61	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208	208
Keraniganj, 750 MW, CC	CC	Gas-New	300	750	2018	2043	1877	1408	5	5	45	750	3485	0	0.92	0.63								750	750	750	750	750	750	750	750	750	750	750	750	750
Meghnaghat Large #1, 750 MW, CC	CC	Gas-New	300	750	2017	2042	1877	1408	5	5	45	750	3485	0	0.92	0.63						0	750	750	750	750	750	750	750	750	750	750	750	750	750	750
Meghnaghat Large #2, 750 MW, CC	CC	Gas-New	300	750	2020	2044	1877	1408	5	5	45	750	3485	0	0.92	0.63										750	750	750	750	750	750	750	750	750	750	750
Ashuganj 450 MW CCPP	CC	Gas-New	179	450	2017	2041	1877	1410	5	5	45	450	3485	0	1.43	0.98					0	0	450	450	450	450	450	450	450	450	450	450	450	450	450	450
Bibiana 450 MW CCPP(Ist Unit)	CC	Gas-New	180	450	2015	2040	1877	1408	5	5	45	500	3485	0	1.43	0.98				0	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
Bibiana 450 MW CCPP(2nd Unit)	CC	Gas-New	180	450	2015	2040	1877	1408	5	5	45	500	3485	0	1.43	0.98				0	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
Meghnaghat CCPP (2nd unit) Dual Fuel	CC	Gas-New	180	450	2015	2040	1877	1408	5	6	50	500	3485	0	2.18	1.49				0	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
North Dhaka 450MW CCPP	CC	Gas-New	179	450	2016	2040	1877	1410	5	5	45	450	3485	0	1.43	0.98					0	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
Serajganj 450 MW CCPP	CC	Gas-New	180	450	2015	2040	1877	1408	5	5	45	500	3485	0	1.43	0.98					450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
Bheramara 360 MW CCPP (NWPGC)	CC	Gas-New	143	360	2015	2040	1877	1410	5	5	45	400	3485	0	1.58	1.08					360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360
Haripur 360 MW CCPP (EGCB)	CC	Gas-New	143	360	2014	2039	1877	1410	5	5	45	400	3485	0	2	1.08				360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360
Bhola 150MW CCPP(Ist unit), BPDB	CC	Gas-New	59	150	2015	2040	1877	1413	5	5	45	150	3485	0	1.95	1.34				0	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Chandpur 150 MW CCPP (BPDB), U/C	CC	Gas-New	59	150	2013	2038	1877	1413	5	5	45	150	3485	0	1.95	1.34			150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Sylhet 150 MW CCPP (BPDB), U/C	CC	Gas-New	59	150	2013	2038	1877	1413	5	5	45	150	3485	0	1.95	1.34			150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Fenchuganj CC(2nd Phase), U/C	CC	Gas-New	43	108	2011	2036	1877	1629	5	5	45	100	3485	0	1.95	1.34	103	103	103	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108
Bhola CCPP(2nd unit)	CC	Gas-New	90	225	2014	2039	2086	1564	5	5	45	200	3485	0	1.95	1.34				225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Madanganj,Keraniganj CCPP Dual Fuel	CC	Gas-New	90	225	2014	2039	2086	1564	5	6	50	300	0	4647	1.95	1.34				225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Sikalbaha 225 MW Dual Fuel, CC	CC	Gas-New	90	225	2014	2039	2086	1564	5	6	50	400	0	4647	1.95	1.34				225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Khulna 60 MW ST	ST	FO-Ex	17	33	1973	2016	3540	2558	5	10	60	60	0	4647	2.60	3.00	33	33	33	33	33	33														
khulna 110 MW ST	ST	FO-Ex	27	54	1985	2019	3437	2487	5	10	60	100	0	4647	2.60	3.00	54	54	54	54	54	54	54	54	54											
Syedpur Peaking Plant	GE	FO-New	20	100	2012	2030	2172	2037		6	40	100	0	4647	2.51	1.72		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
Jamalpur Peaking Plant	GE	FO-New	20	100	2012	2030	2172	2037		6	40	100	0	4647	2.51	1.72		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
Chapai Nababgonj Peaking Plant	GE	FO-New	20	100	2012	2030	2172	2037		6	40	100	0	4647	2.51	1.72		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
Khulna Peaking Plant	GE	FO-New	20	100	2012	2030	2172	2037		6	40	100	0	4647	2.51	1.72		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
Dohazari Peaking Plant	GE	FO-New	20	100	2012	2032	2172	2037		6	40	100	0	4647	2.51	1.72		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Hathazari Peaking Plant	GE	FO-New	20	100	2012	2032	2172	2037		6	40	100	0	4647	2.51	1.72		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
FaridpurPeaking Plant	GE	FO-New	10	50	2012	2032	2172	2037		6	40	50	0	4647	2.51	1.72		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Baghabari Peaking Plant	GE	FO-New	10	50	2012	2032	2172	2037		6	40	50	0	4647	2.51	1.72		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Katakhali Peaking Plant	GE	FO-New	10	50	2012	2032	2172	2037		6	40	50	0	4647	2.51	1.72		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Santahar Peaking Plant	GE	FO-New	10	50	2012	2032	2172	2037		6	40	50	0	4647	2.51	1.72		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
BPDB & RPCL, 150MW	GE	FO-New	30	150	2014	2034	2172	2037		6	40	150	0	4647	2.51	1.72			0	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Khulna(quick rental)	GE	FO-New	23	115	2011	2017	2172	2037		4	40	115	0	4647	2.51	1.72	115	115	115	115	115	115														
Modanganj(quick rental)	GE	FO-New	20	102	2011	2017	2172	2037		4	40	102	0	4647	2.51	1.72	102	102	102	102	102	102														
Gopalgonj Peaking Plant	GE	FO-New	20	100	2012	2032	2172	2037		6	40	100	0	4647	2.51	1.72		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Julda(quick rental)	GE	FO-New	20	100	2011	2017	2172	2037		4	40	100	0	4647	2.51	1.72	100	100	100	100	100	100														
Kadda, Meghna(quick rental)	GE	FO-New	20	100	2011	2017	2172	2037		4	40	100	0	4647	2.51	1.72	100	100	100	100	100	100														
Kadda, Sidhirganj(quick rental)	GE	FO-New	20	100	2011	2017	2172	2037		4	40	100	0	4647	2.51	1.72	100	100	100	100	100	100														
Keranigong(quick rental)	GE	FO-New	20	100	2011	2017	2172	2037		4	40	100	0	4647	2.51	1.72	100	100	100	100	100	100														
Meghnagat(quick rental)	GE	FO-New	20	100	2011	2017	2172	2037		4	40	100	0	4647	2.51	1.72	100	100	100	100	100	100														
Noapara, Jessore, Rental, U/C	GE	FO-New	20	100	2011	2017	2172	2037		4	40	100	0	4647	2.51	1.72	100	100	100	100	100	100														
Bera, Pabna, Peaking Plant	GE	FO-New	14	70	2012	2032	2172	2037		6	40	100	0	4647	2.51	1.72		70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
Shikalbaha – 3 yrs rental, commissioned	GE	FO-New	11	55	2010	2013	2172	2037		4	40	60	0	4647	2.51	1.72	55	55	55																	
Barisal, Rental,U/C	GE	FO-New	10	50	2011	2017	2172	2037		4	40	50	0	4647	2.51	1.72	50	50	50	50	50	50														
Chapai Nawabgonj(quick rental)	GE	FO-New	10	50	2011	2017	2172	2037		4	40	50	0	4647	2.51	1.72	50	50	50	50	50	50														
Doudkandi	GE	FO-New	10	50	2012	2032	2172	2037		6	40	50	0	4647	2.51	1.72		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Gazipur 50 MW	GE	FO-New	10	50	2013	2033	2172	2037		6	40	50	0	4647	2.51	1.72			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Katakhali(quick rental)	GE	FO-New	10	50	2011	2017	2172	2037		4	40	50	0	4647	2.51	1.72	50	50	50	50	50	50														
Katakhali, Rajshahi, Peaking Plant	GE	FO-New	10	50	2013	2028	2172	2037		6	40	50	0	4647	2.51	1.72			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50		
Noapara(quick rental)	GE	FO-New	8	40	2011	2017	2172	2037		4	40	40	0	4647	2.51	1.72	40	40	40	40	40	40														
Raujan 20 MW	GE	FO-New	4	20	2013	2033	2172	2038		6	40	20	0	4647	2.51	1.72			20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

Station Name	Type	Fuel Type	Min Unit Net Capacity (MW)	Max Unit Net Capacity (MW)	In Service FY	Retirement FY	Net Heat Rate (kCal/kWh) Min. Load	Net Heat Rate (KCal/KWh) Incremental	Sping Resv (%)	Forced Outage (%)	Maint. Req'd D/yr	Maint. Class Size (MW)	Fuel Cost (Cents/10^6 KCal) Domst /	Foreign	Fixed O&M ($/KW-mon	Variable O&M ($/MWh)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Tangail 20 MW	GE	FO-New	4	20	2013	2028	2172	2037		6	40	20	0	4647	2.51	1.72			20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20		
Chandpur 15 MW	GE	FO-New	3	15	2013	2028	2172	2037		6	40	20	0	4647	2.51	1.72			15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15		
Narayanganj 30MW	GE	FO-New	3	30	2013	2028	2172	2052		6	40	20	0	4647	2.51	1.72			30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30		
Keraniganj Peaking	GE	FO-New	20	100	2026	2041	2172	2037		4	45	100	0	4647	2.51	1.72																200	200	200	200	200
Bogra Peaking	GE	FO-New	20	100	2025	2040	2172	2037		4	45	100	0	4647	2.51	1.72															100	100	100	100	100	100
Comilla Peaking	GE	FO-New	20	100	2019	2033	2172	2037		4	45	100	0	4647	2.51	1.72								-	100	100	100	100	100	100	100	100	100	100	100	100
Daudkandi Peaking	GE	FO-New	20	100	2028	2043	2172	2037		4	45	100	0	4647	2.51	1.72																		100	100	100
Jessore Peaking	GE	FO-New	20	100	2019	2034	2172	2037		4	45	100	0	4647	2.51	1.72									100	100	100	100	100	100	100	100	100	100	100	100
Jhenaidah Peaking	GE	FO-New	20	100	2023	2038	2172	2037		4	45	100	0	4647	2.51	1.72													100	100	100	100	100	100	100	100
Halishahar Peaking	GE	FO-New	20	100	2022	2037	2172	2037		4	45	100	0	4647	2.51	1.72												100	100	100	100	100	100	100	100	100
Khulna Center Peaking	GE	FO-New	20	100	2021	2036	2172	2037		4	45	100	0	4647	2.51	1.72											100	100	100	100	100	100	100	100	100	100
Ashuganj Peaking	GE	FO-New	20	100	2020	2035	2172	2037		4	45	100	0	4647	2.51	1.72										200	200	200	200	200	200	200	200	200	200	200
Mymensingh Peaking	GE	FO-New	20	100	2029	2044	2172	2037		4	45	100	0	4647	2.51	1.72																			100	100
Rajshahi Peaking	GE	FO-New	20	100	2027	2042	2172	2037		4	45	100	0	4647	2.51	1.72																	100	100	100	100
Rangpur Peaking	GE	FO-New	20	100	2029	2044	2172	2037		4	45	100	0	4647	2.51	1.72																			100	100
Khulna Rental (3 Years)	GE	HSD-Ex	8	40	2008	2011	1972	1972		4	30	40	0	7125	1.50	4.00	40																			
KPCL, Khulna BMPP	GE	HSD-Ex	21	106	1999	2016	2205	2205		6	40	100	0	7125		4.50	106	106	106	106	106	106														
Rangpur 20MW CT	CT	HSD-Ex	5.7	19	1989	2016	4000	4000		8	30	20	0	7125	1.50	4.00	19	19	19	19	19	19														
Saidpur 20MW CT	CT	HSD-Ex	5.7	19	1988	2016	4000	4000		8	30	20	0	7125	1.50	4.00	19	19	19	19	19	19														
Barisal 2x20MW CT #1	CT	HSD-Ex	4.5	15	1985	2016	4000	4000		8	30	20	0	7125	1.50	4.00	15	15	15	15	15	15														
Barisal 2x20MW CT #2	CT	HSD-Ex	4.5	15	1988	2016	4000	4000		8	30	20	0	7125	1.50	4.00	15	15	15	15	15	15														
Bheramara 3x20 MW CT #1	CT	HSD-Ex	5	17	1977	2014	3772	3772		6	30	20	0	7125	1.50	4.00	17	17	17	17																
Bheramara 3x20 MW CT #2	CT	HSD-Ex	5	17	1976	2014	3772	3772		6	30	20	0	7125	1.50	4.00	17	17	17	17																
Bheramara 3x20 MW CT #3	CT	HSD-Ex	5	17	1980	2014	3772	3772		6	30	20	0	7125	1.50	4.00	17	17	17	17																
Barisal Diesel (9 units)	GE	HSD-Ex			1975	2009							0	7125	1.50	4.00																				
Bhola Diesel	GE	HSD-Ex		2	1989	2013							0	7125	1.50	4.00	2	2	2																	
Bhola Diesel (New)	GE	HSD-Ex		2	1989	2013							0	7125	1.50	4.00	2	2	2																	
Ghorashal (quick rental)	GE	HSD-New	29	145	2011	2014	2172	2037		4	30	145	0	7125	2.51	1.72	145	145	145	145																
Bheramara, Rental , U/C	GE	HSD-New	20	100	2011	2014	2172	2037		4	30	100	0	7125	2.51	1.72	100	100	100	100																
Siddirganj(quick rental)	GE	HSD-New	20	100	2011	2014	2172	2037		4	30	100	0	7125	2.51	1.72	100	100	100	100																
Khulna(quick rental)	GE	HSD-New	11	55	2011	2014	2172	2037		4	30	55	0	7125	2.51	1.72	55	55	55	55																
Pagla, Narayaganj(quick rental)	GE	HSD-New	10	50	2011	2014	2172	2037		4	30	50	0	7125	2.51	1.72	50	50	50	50																
Thakurgao, Rental, U/C	GE	HSD-New	10	50	2011	2014	2172	2037		4	30	50	0	7125	2.51	1.72	50	50	50	50																
Karnafuli hydro power plant #1	HY	Hydro/RE-Ex	25	40	1962	2040	-	-	-	-	-	230	-	-	2.60	-	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Karnafuli hydro power plant #2	HY	Hydro/RE-Ex	25	40	1963	2040	-	-	-	-	-	230	-	-	2.60	-	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Karnafuli hydro power plant #3	HY	Hydro/RE-Ex	25	50	1983	2040	-	-	-	-	-	230	-	-	2.60	-	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Karnafuli hydro power plant #4	HY	Hydro/RE-Ex	25	50	1989	2040	-	-	-	-	-	230	-	-	2.60	-	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Karnafuli hydro power plant #5	HY	Hydro/RE-Ex	25	50	1989	2040	-	-	-	-	-	230	-	-	2.60	-	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Karnafuli Hydro (#6&7, 2x50 MW)	HY	Hydro/RE-New	20	100	2016	2066									2.60	-	-	-	-	-	-	-	-	-	-	-	100	100	100	100	100	100	100	100	100	100
Sarishabari, Jamalpur(Solar)	SP	Hydro/RE-New	0	3	2013	2063													3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Rajabarihat Goat Development Firm(Solar)	SP	Hydro/RE-New	0	3	2013	2063													3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Kaptai Power Plant(Solar)	SP	Hydro/RE-New	0	5	2013	2063													5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Patenga Offshore, Chittagong(Wind)	WP	Hydro/RE-New	0	100	2013	2063													100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Rooppur Nuclear # 1, 1000 MW	Nuclear	Nuclear	500	1000	2018	2058	2300	2896	5	8	60	1000											0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Rooppur Nuclear # 2, 1000 MW	Nuclear	Nuclear	500	1000	2020	2061	2300	2896	5	8	60	1000														1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Rooppur Nuclear # 3, 1000 MW	Nuclear	Nuclear	500	1000	2024	2064	2300	2896	5	8	60	1000																	0	1000	1000	1000	1000	1000	1000	1000
Rooppur Nuclear # 4, 1000 MW	Nuclear	Nuclear	500	1000	2025	2065	2300	2896	5	8	60	1000																			1000	1000	1000	1000	1000	1000
PALLATANA to COMILLA	IC	Int-conect		250	2025	2075																	-	-	-	-	-	-	-	-	250	250	250	250	250	250
SILCHAR to FENCHUGANJ 1	IC	Int-conect		750	2022	2072																						750	750	750	750	750	750	750	750	750
BAHARAMPUR to BHERAMARA Phase-1	IC	Int-conect		500	2013	2063													500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
BAHARAMPUR to BHERAMARA Phase-2	IC	Int-conect		500	2021	2071																				-	500	500	500	500	500	500	500	500	500	500
Hydro from Nepal (Kishanganj (PURNIA) to Bogra	IC	Hydro/RE-New		500	2023	2073																				-	-	-	500	500	500	500	500	500	500	500
Hydro from Bhutan (Alipurduar to Bogra)	IC	Hydro/RE-New		500	2023	2073																				-	-	-	500	500	500	500	500	500	500	500
Myanmmer to Bangladesh (should refer from PGC	IC	Hydro/RE-New		500	2018	2068																		500	500	500	500	500	500	500	500	500	500	500	500	500

Source: PSMP Study Team

Chapter 9 Power System Analysis

In this chapter, the study of a long-term transmission network expansion plan is carried out based on the power demand forecast and the optimum power development plan by 2030 in Bangladesh, taking into account potential interconnection with neighboring countries. The required system analysis is carried out by utilizing the system analysis software PSS/E.

9.1 Basic concept for the optimum transmission network development plan

9.1.1 Conditions for implementation of the optimum transmission network development plan planning criteria

The BPDB developed the Bangladesh Power System Master Plan in 1995, and updated it in 2006 to the year 2025 under support of Asian Development Bank (ADB). The PSMP Study Team will review the 2006 Power System Master Plan and implement the optimum transmission network development plan according to the Study for power demand forecasts and the power supply development plan.

Moreover, the adequacy of the power supply capability of the present transmission system in light of future power demand increases will be studied. Therefore, it is necessary to establish an optimal transmission network development plan including the provision of a power system interconnected with neighboring countries from the viewpoint of securing long-term stability in power supply capability.

As for the implementation of the transmission network plan, the horizon year 2030 plan and the near future year 2015 plan will be implemented first, followed by the year 2020 and 2025, taking into account the following factors:

(1) Power demand forecast
(2) Linkage with the amount of power and energy available at the time, i.e., power supply development plan,
(3) Effective utilization and expansion of the existing transmission network, and transmission network development plan,
(4) Satisfaction of facilities expansion criteria,
(5) Provision of the power system interconnected with the neighboring countries,
(6) Facilities to be developed on a least cost basis, and
(7) Environmental situation

9.1.2 Planning criteria

This Study formulates a power system expansion plan, which satisfies the reliability criteria based on the PSMP 2006.

A power system expansion plan, which satisfies the reliability criteria under normal conditions and outage contingencies of facilities, should be formulated for the formation of power system facilities, taking into account the frequency and effect of the facilities failure.

The reliability criteria used in this Study is defined as the target level for system reliability in single outage contingencies of facilities, according to the “BANGLADESH GRID CODE DRAFT” dated 18/10/2000.

Practical reliability criteria under normal conditions and the outage contingencies of facilities are shown in Table 9-1.

Table 9-1 Reliability criteria in normal conditions and outage contingencies of facilities

Normal conditions of facilities	- Facilities loading <100% - Steady-state voltage range: ±5%
Single outage contingencies of facilities (N-1)	- Facilities loading < 100% - Steady-state voltage range: ±10% - Transiently stable to 3-phase to ground fault with normal clearing

Source: BANGDALESH GRID CODE DRAFT (October 18, 2000)

In order to formulate the power system expansion plan, it is necessary to evaluate properly whether it satisfies the reliability criteria as shown in Table 9-2.

Table 9-2 Evaluation method of reliability criteria

Item	Evaluation Method
Normal capacity and overload capacity of facilities	It is necessary that the power flow does not exceed the normal capacity and overload capacity of the facilities in order to prevent damage such as potential harm to the transmission line and substation.
System reliability	In the AC power system, it is necessary to secure system reliability because if such trustworthiness cannot be maintained the generator will be out-of-phase resulting in adverse effects to the power system. Specifically, the steadiness of the power system is necessary in terms of the transient stability. If the system reliability is not secured, appropriate countermeasures such as the multi-route transmission line and the installation of an intermediate switching station should be taken.
Voltage stability	In the power system, the effect of the controls such as effective reactive power compensation facilities and transformer taps for the voltage control becomes insufficient starting with the power system disturbance due to rapid increasing load and outage contingencies of the transmission line etc. during the heavy load period. Finally, it is necessary to secure voltage stability because the system voltage decreases to an abnormal level and is likely to arrive at a wide-ranging power supply outage, when it becomes impossible to maintain the voltage stability. When the voltage stability cannot be secured, appropriate countermeasures such as the installation of the reactive power compensation facilities should be taken.

Source: PSMP Study Team

9.1.3 Improvement in quality of electricity

In establishing the transmission network development plan, supplying high quality electricity is the main purpose of The PSMP Study Team. To this end, the following elements are to be secured:

(1) Electric power shall be supplied continually at an optimum level that ensures as much as possible less power outages and periods under normal operating conditions as well as having safeguards in place in the event of an accident. (Power Supply Reliability).

(2) For the prevention of load increases, accidents and an imbalance of reactive power of long-distance transmission lines (Voltage Maintenance), system voltages shall be maintained within an appropriate level by installing voltage regulators such as an AVR, on-load tap changing equipment, etc. and phase modifiers such as static capacitors, shunt reactors etc.

9.1.4 Efficient, stable and economic plans & designs

In order to transmit electric power efficiently and stably, the transmission lines and substation facilities will be planned and designed in consideration of both the “Electrical Performance” such as the transmission capacity, voltage maintenance and failure prevention, and the “Mechanical Performance”. Effect of the reduction of transmission losses shall also be extensively considered.

Technical measures for reduction of transmission losses to raise economic efficiency are:

(1) Application of a thicker conductor size and additional circuits

(2) Application of an upper system voltage

(3) Adjustment of reactive power by installing static capacitors and shunt reactors.

In designing transmission lines and substation facilities in the optimum transmission system, the aforementioned countermeasures coupled with economic efficiency are to be considered.

9.1.5 Environmental and social consideration

The impact of transmission lines and substations to the environment and society is usually moderate compared with hydroelectric and thermal power projects. Routes of new transmission lines and locations of new substations will be examined in cooperation with environmental management and social consideration experts in reference to the terms stipulated in the environmental law and legislation of Bangladesh. In addition, the following elements will be examined in selecting the line routes and locations of substations through the map study and site investigation:

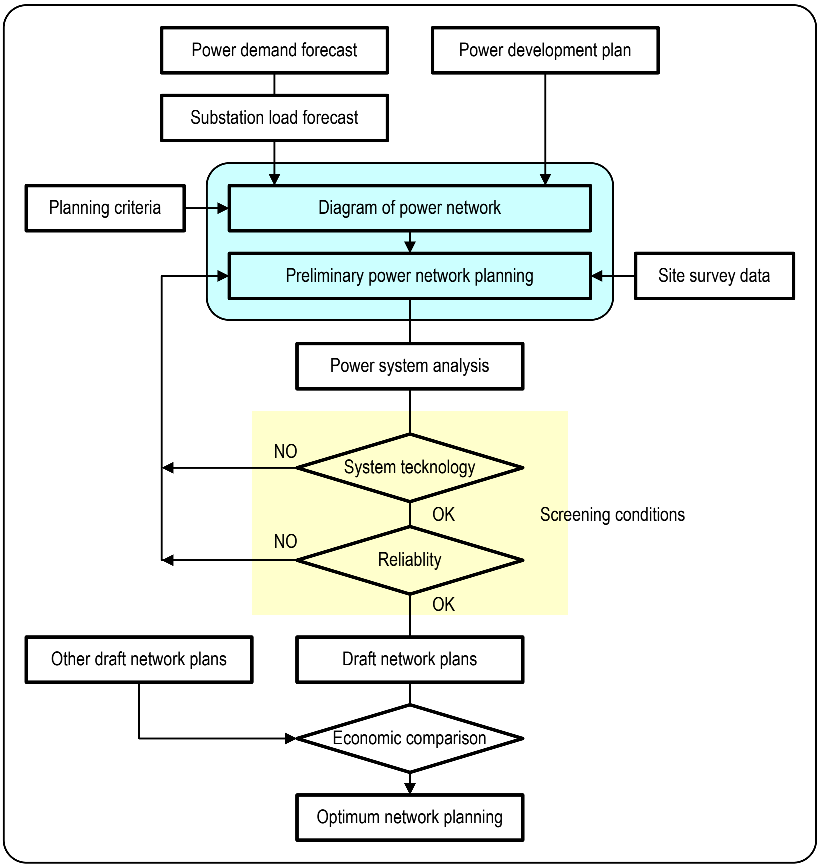
(1) To minimize interference with the existing infrastructures
(2) To minimize the clearing of trees
(3) To avoid historic spots and cultural heritages
(4) To avoid National Bio-diversity and Conservation Areas and scenic areas
(5) To avoid foreseeable natural disaster zones and geologically peculiar areas
(6) To avoid military zones, airport zones and public facilities
(7) To minimize the resettlement of people and the disturbance to habitats

9.2 Establishment procedures of the optimum transmission development plan

9.2.1 Selection of the optimum transmission development plan

The establishment procedure of the optimum transmission development plan is assumed based on the following steps, as shown in Fig. 9-1:

(1) Review of the existing plan
(2) Status confirmation of existing equipment and information gathering
(3) Data confirmation of power system and generator
(4) Confirmation of a power demand forecast and an optimum power supply development plan
(5) Preliminary establishment of a transmission network development plan
(6) Power System analysis (power flow/system voltage, fault current, system stability calculation)
(7) Establishment of an optimum transmission network development plan



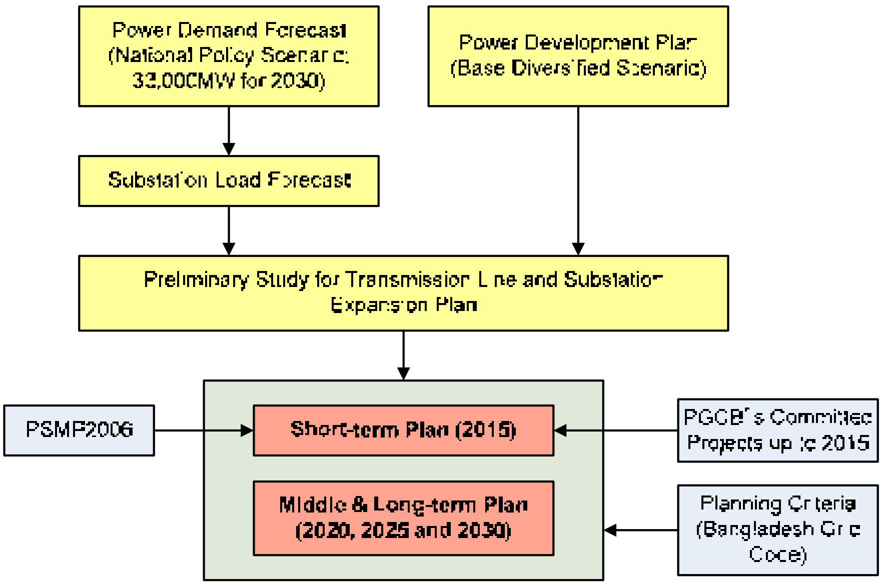
Source: PSMP Study Team

Fig. 9-1 Establishment procedure of an optimum transmission development plan flow

(1) First, according to the assumed power development plan and power demand forecast, a power supply diagram will be made. This is a power system diagram that includes the power source and demand location (existing and planning substation location) with the transmission line, based on the power system diagram of the existing power system. In addition, the preliminary design of the transmission and substation equipment in the short-term, middle-term and long-term phases will be carried out based on the basic conditions and considerations for plan implementation and electrical data will be set up.
(2) Based on the above data, power system analysis will be carried out as described later.
(3) In case the results do not meet the screening conditions of the facilities expansion criteria such as the technical requirements and the power supply reliability, “planning” and “analysis” will be repeated until the results fulfill the conditions with modifying parameters such as voltage, transmission construction, conductors (the number of conductor or circuits) and transformers (capacity or the number of transformers).
(4) Similar analysis will be also repeatedly carried out for the route option between the power station and the substation, and the system plan will be established to fulfill the criteria and condition.
(5) The overall costs of the power facilities including the power supply costs will be compared with various transmission network development plans. The relation between the effect of the forecast and the investment will be established, and the highest efficient optimum transmission network development plan will be selected from various plans.

9.2.2 Power system analysis

Based on the power demand forecast in Chapter 7 and the power development plan in Chapter 8, an optimum power system plan that satisfies the system planning criteria has been formulated taking into account the PSMP2006 and the PGCB’s committed projects up to 2015, as shown in Fig. 9-2. Power flow, voltage regulation, fault current and stability in the power system are technical basic elements that a power system will be properly and appropriately operated.



Source: PSMP Study Team

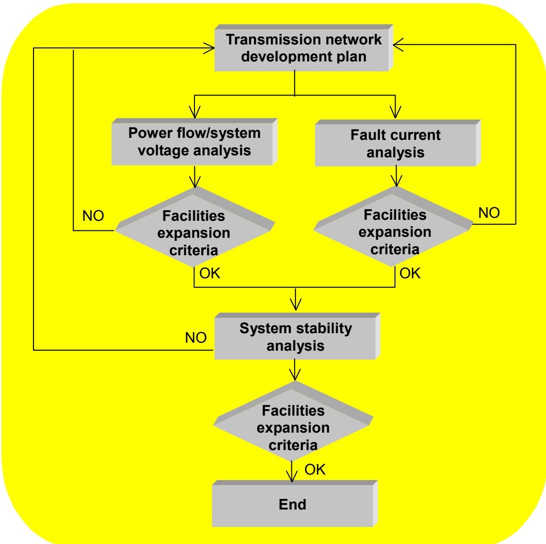
Fig. 9-2 Items to be taken into account power system analysis

Power system analysis is an integral part of verifying the transmission network development plan. The flow of the power system analysis is shown in Fig. 9-3. An evaluation will be carried out taking into account the following points:

- Power flow/System voltage analysis: Check whether or not an overload and/or an abnormal voltage condition will occur
- Fault (short circuit) current analysis: Check for an extremely large fault current occurrence
- System stability analysis: Check if generators can maintain stable operations

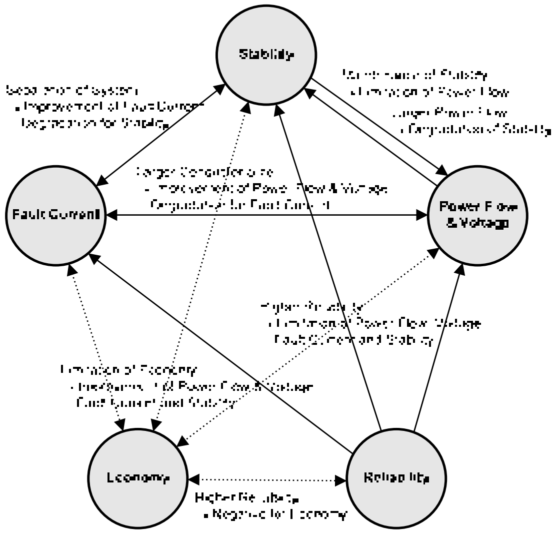
The PSMP Study Team will use the software such as a PSS/E for the power system analysis.

The aforementioned technical basic elements interact among them, as seen in Fig. 9-4. For example, the larger conductor size might resolve an overload condition of a transmission line but increase the fault current. Therefore, a “revision of the system planning” and a “system analysis for the technical basic elements” were repeatedly examined until the planned system satisfies the system planning criteria for all the technical basic elements.



Source: PSMP Study Team

Fig. 9-3 Power system analysis flow



Source: PSMP Study Team

Fig. 9-4 Relations among elements for power system analysis

9.2.3 Items to be taken into account system planning

(1) Scope of the study for facilities expansion

Since the 132kV system analysis is impractical and the volume of all system analysis is huge, the scope of the study for facilities expansion is proposed to PGCB. The agreed scope of study is shown in Table 9-3.

Table 9-3 Scope of study for facilities expansion (○: necessary study)

		Short-term plan	Middle and long-term plan		
		2015	2020	2025	2030
Transmission line	400kV	O	O	O	O
	230kV	O	O	O	O
	132kV	O	–	–	–
Substation	400/230kV	O	O	O	O
	230/132kV	O	O	O	O
	132/33kV	O	–	–	–

Source: PSMP Study Team

(2) Substation load forecast

Based on the methodology for power demand forecast (Chapter 7), each substation load for system analysis by 2030 is shown in AP Table 9-1.

(3) Basic concept of substation expansion

Based on the discussion with PGCB, the maximum power flow through the 230kV and 132kV substation is shown in Table 9-4. If the power flow exceeds this value, the substation expansion will be basically studied.

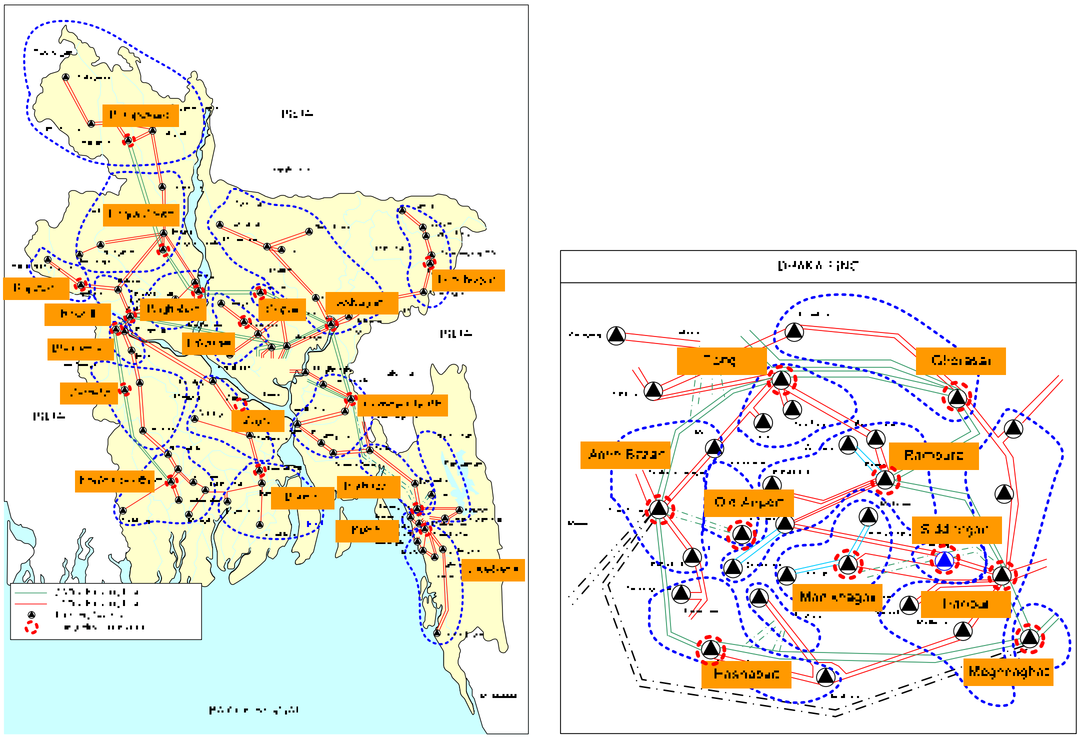
Table 9-4 Scope of study for facilities expansion

		Maximum passing power flow
230kV substation	Urban area	500MW
	Rural area	300MW
132kV substation		100MW

Source: PGCB

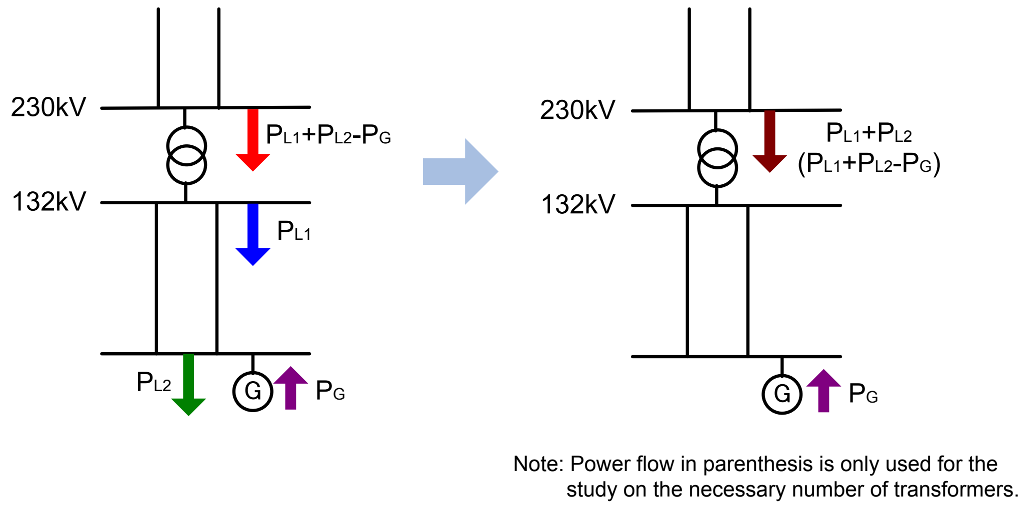
(4) System simulation method of study for middle and long-term plan

For the simulation method of study for the middle and long-term plan, the 132kV substation load is summarized in the 230kV substation bus as shown in Fig. 9-5 and Fig. 9-6.



Source: PSMP Study Team

Fig. 9-5 Summarization of 132kV substation load



Source: PSMP Study Team

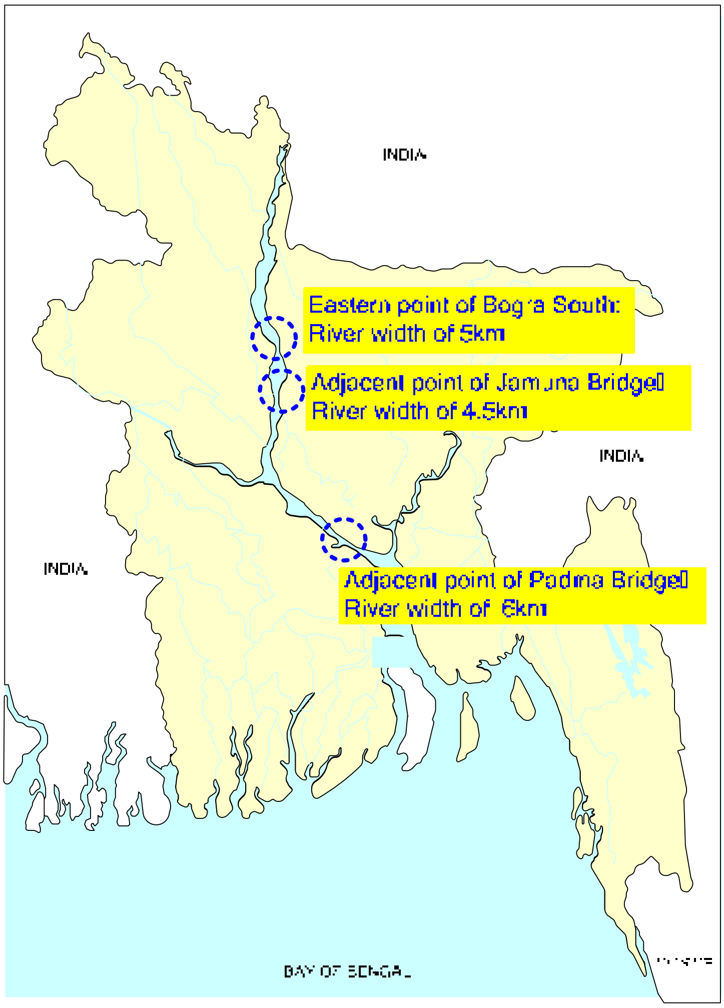
Fig. 9-6 Summarization method of 132kV substation load

(5) Items to be taken into account expansion of transmission line across the river

Based on the discussion with BPDB and PGCB, the following items have been taken into account in the expansion of the transmission line across the Jamuna and Padma River.

(a) Candidate site point

Three site points across the Jamuna and Padma River where the width of a river is relatively narrow have been made a candidate, as shown in Fig. 9-7.



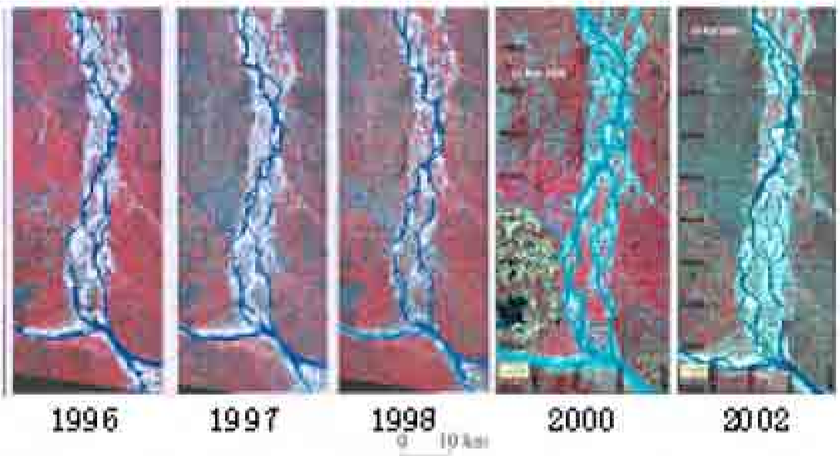
Source: BPDB, PGCB, PSMP Study Team

Fig. 9-7 Candidate site point across the Jamuna and Padma River

(b) Availability of submarine cable adoption

The adoption of the submarine cable is considered to be difficult for the following reasons. Therefore, the proven overhead transmission line across the river in Bangladesh should be essentially adopted.

- The river concerned is known as one of the leading rage rivers in the world. The light and fine-grained sand carried from the Himalayas repeats the deposition and the movement. Further the flow channel geometry of the braided river always changes as shown in Fig. 9-8. Moreover, the position of the river might move at as much as 5km due to a flood. Therefore it is inappropriate for the construction of the submarine cable.
- If the submarine cable is adopted, it should be laid on the riverbed so that the unexpected power is not applied by the flow of the river. In addition, it is necessary to lay the underground deeply so as to not allow the cable to erode by exposure. As a result, the construction cost becomes expensive.
- Moreover, repairing cable trouble if the depth of the burial cable becomes deep by deposition becomes extremely difficult.

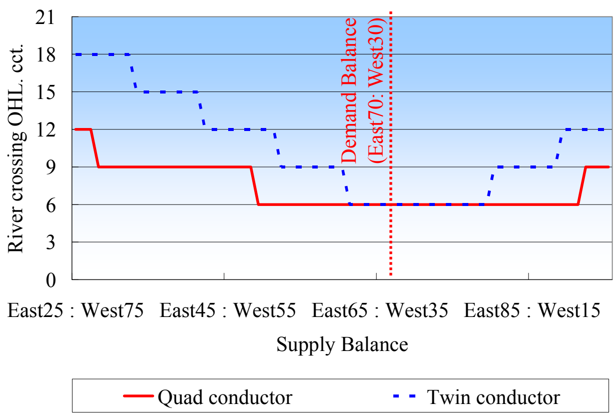


Source: Y. Tamakoshi, "Fundamental study on of the bank erosion along the braided river and its control", Master's thesis mid-term presentation for Master Civil Engineering Division, Graduate School of Engineering, Gifu University (September, 2005)

Fig. 9-8 Year-on-year configuration of flow channel geometry of Jamuna River

(c) Larger capacity of transmission line

The construction of the transmission line across the Jamuna River requires a tremendous of expense. Therefore, it is possible to cut costs by reducing the number of circuits across the river. The preliminary study for the number of circuits across the Jamuna River has been carried out when the supply balance between the east and west and the transmission line type (number of conductors) has been changed, as shown in Fig. 9-9. The following measures against the reduction of the number of circuits across the river are effective.



Source: PSMP Study Team

Fig. 9-9 Study results of the number of circuits across the Jamuna River

- Formulation of the power development plan corresponding to the power demand balance between east and west
- Larger capacity of the transmission line

Therefore, in order to deal with the interconnection power flow from the west to the east that increases over the mid to long-term, the adoption of a 400kV larger capacity transmission line (quad conductor) will be basically adopted.

The quad conductor has the following features compared to the single conductor which has an equivalent cross-section.

- The critical corona inception voltage shows a nearly 15-20% rise, which results in decreased corona loss and noise.
- The inductance of the transmission line decreases by nearly 20-30%, while the capacitance of that increases by nearly 20-30%. As a result, the surge impedance decreases, and the surge impedance loading increases by nearly 20%.

- The high current capacity can be ensured and the transmission capacity increases due to the less skin effect.

(d) Possibility of installation of cables along the Padma multipurpose bridge

The currently-projected Padma multipurpose bridge with a length of 6.15km has been designed to have the 400kV double circuit 3000mm^2 XLPE cable with a duct system installed. [1], [2]

The following items should be considered for the installation of cables along the bridge.

- There are two kinds of methods such as the installation to the ladder or the trough and the installation to the duct. For the installation to the ladder or the trough, it is easy to construct an intermediate joint comparatively because it is possible to construct utilizing the installation method similar to the standard installation to the tunnel.
- On the other hand, the span length of the cables is limited from the point of the pulling tension of the long distance for the duct system as well as a standard underground cable. It is necessary to prepare the intermediate joint space including the construction space.
- It is necessary to consider the expansion and contraction of the bridge (the heat expansion and contraction, and the deflection of the bridge to the vertical direction according to the pass of the super-heavy load such as and the railroad trains), the vibrations depending on the car and the train, etc., and the downward slip of the cable (especially for the duct system, transition section from the bridge to the underground) because it differs from the construction of a standard underground cable.
- The measures against expansion and contraction are the pantograph type expansion and contraction absorbers and the installation of the long offset. Moreover, measures against the deflection of the bridge are the installation of angular bend absorbers and the prevention of a downward slip of the cable.
- In addition, it is necessary to evaluate the influence of the impact on the intermediate joint work from the vibration of the bridge and the vibration to the cable after installation.

The installation of 400kV class cable along the bridge has a cost advantage compared to the overhead transmission line across the river because the construction cost of installing a 400kV class cable along the bridge is almost the same as that of a standard underground cable except for the aforementioned special equipment such as the expansion and contraction absorbers. However, there is no country that has adopted the installation of a 400kV class cable along the bridge, and it is considered to be difficult for the following reasons. Therefore, the proven overhead transmission line across the river in Bangladesh should be essentially adopted in this Study. Incidentally, two anchor towers on either side of the line will be installed on the bank with the terminal arrangement.[2]

Table 9-5 Comparison of the river crossing method

Options	Advantages	Disadvantages
Overhead transmission line	• Experience with 230kV • Easy and quick to repair	• Higher construction cost
Cable on the bridge	• Lower construction cost	• No experience in Bangladesh • Measures for behavior bridge • Constrained work in the case of construction and maintenance due to other utilities such as roads and railways • Significant decrease in supply reliability to restore the cable fault etc. for a long time

Source: PSMP Study Team

[1] ADB: "Proposed Technical Assistance Loan People's Republic of Bangladesh: Padma Multipurpose Bridge Design Project", November 2007

[2] Bangladesh Bridge Authority: "Environmental Assessment, Report: Padma Multipurpose Bridge Project", July 2010

Incidentally, the number of circuits necessary for the river crossing at the point concerned is four circuits as described later in the 2030 plan for the 400kV overhead transmission line (quad-conductor), and it becomes necessary by approximately four circuits for the 400kV double circuit 3000mm^2 XLPE cable.

9.3 Existing transmission network and its expansion plan

9.3.1 Existing transmission network

The existing Bangladesh transmission facilities incorporate two main voltage levels, 230kV and 132kV. The circuit length of the 230kV transmission line is 2,644.5km, and that of the 132kV transmission line is 5,818km (as of the end of June 2010).

A 230kV bulk power system consists of an all double-circuit transmission line and the loop network is additionally formed with a 132kV system around the Dhaka region. Currently, there is a 230kV transmission line that interconnects the eastern and western part of the country. A 230kV line planned between Meghnaghat and Aminbazar in the Dhaka region will be upgraded to 400kV in the future. The number of the 230kV/132kV substation is 15 (6,850MVA), and that of the 132kV/33kV substation is 93 (9,899MVA), as shown in Table 9-6 and Table 9-7 (as of the end of June 2010). The representative 230kV transmission and substation facilities are shown in Fig. 9-10 and Fig. 9-11 . The power system diagram (132kV and above) in Bangladesh is shown in Fig. 9-12.

Table 9-6 Existing 230kV/132kV substation facilities (as of the end of June 2010)

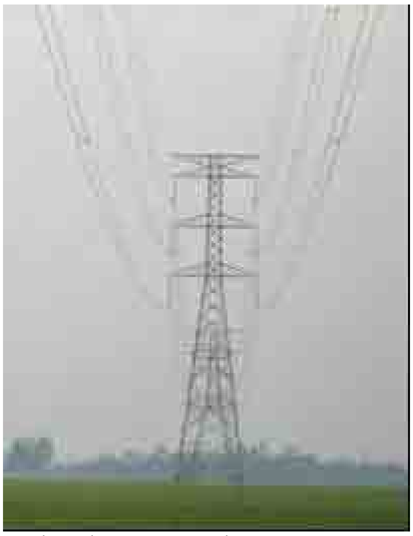
	PGCB		BPDB		DPDC	
	No. of S/S	Total (MVA)	No. of S/S	Total (MVA)	No. of S/S	Total (MVA)
Chittagong	1	450				
Comilla	1	225	1	300		
Dhaka	5	3,375	1	250		
Khulna	1	450				
Bogra	4+1 (Switching)	1,800				
Total	**13**	**6,300**	**2**	**550**		
Grand Total (MVA)	**6,850**					

Source: PGCB Special Annual Bulletin (2010.7)

Table 9-7 Existing 132kV/33kV substation facilities (as of the end of June 2010)

	PGCB		BPDB		DPDC	
	No. of S/S	Total (MVA)	No. of S/S	Total (MVA)	No. of S/S	Total (MVA)
Chittagong	11	1,317	2	103	1	30
Comilla	9	837	2	157		
Dhaka	21	2,973	1	100	12	1645
Khulna	17	1,367			Bheramara GKP	20
Bogra	17	1,350				
Total	**75**	**7,844**	**5**	**360**	**13**	**1,695**
Grand Total (MVA)	**9,899**					

Source: PGCB Special Annual Bulletin (2010.7)



Source: Photo by PSMP Study Team
(November 2009)

Fig. 9-10 230kV Barapukuria -Bogra South transmission line

Source: Photo by PSMP Study Team
(November 2009)

Fig. 9-11 230kV/132kV Bogra South substation

Source: PGCB System Planning Division

Fig. 9-12 Power system diagram (132kV and above; as of June 2010)

9.3.2 Existing transmission network expansion plan

(1) PGCB's expansion plan

PGCB expects implementation of the 400kV and 230kV transmission line expansion plan by 2015, as shown in Fig. 9-8.

Table 9-8 PGCB's transmission line expansion plan

Section	Voltage	Length	No. of circuits	Region	Completion year
1, Meghnaghat – Aminbazar	400kV	50km	2	Dhaka	2010-11 (on-going)
2. Bibiyana – Kaliakoir	400kV	168km	2	Central	2011-12
3. Bheramara – Baharampur (India)	400kV	30km	2	Western	2012-13
4. Aminbazar – Maowa – Mongla	400kV	192km	2	Central Western	2014-15
5. Anowara – Meghnaghat	400kV	260km	2	Southern Dhaka	2014-15
6. Aminbazar – Old Airport	230kV	10km (6km U/G)	2	Dhaka	2010-11 (on-going)
7. Siddhirganj – Maniknagar	230kV	11km	2	Dhaka	2011-12 (on-going)
8. Fenchuganj – Bibiyana	230kV	32km	2	Central	2011-12
9. Bibiyana – Comilla North	230kV	160km	2	Central	2011-12
10. Barisal – Bhola – Burhanuddin	230kV	60km	2	Western	2012-13
11. Ishurdi – Rajshahi	230kV	70km	2	Northern	2012-13
12. Raozan – Sikalbaha – Anowara Hathazari – Khulshi	230kV	60km	2	Southern	2012-13
13. Comilla North – Tripura (India)	230kV	13km	2	Central	2012-13
14, Mongla – Khulna South	230kV	40km	2	Western	2014-15

Source: PGCB System Planning Division (December 2010)

(2) Expansion plan in PSMP 2006

PSMP 2006 recommended construction of the transmission lines by 2025 in PSMP 2006, as shown in Table 9-9.

Table 9-9 Transmission network expansion plan in PSMP 2006

Section	Voltage	Length	No. of circuits	Region
1. Meghnaghat – Aminbazar	400kV [1]	48km	2	Dhaka
2. Maowa – Aminbazar	230kV	40km	3	Dhaka
3. Haripur – Meghnaghat	230kV	11.6km	2	Dhaka
4. Aminbazar – Old Airport	230kV	10km	3	Dhaka
5. Sikalbaha – Madunaghat/New Sikalbaha	230kV	20km	4	Southern
6. Madanganji – Sitalakhya	230kV	4.5km	4	Dhaka
7. Bhandaria – Barisal	230kV	40km	2	Western
8. Mawa – Hasnabad	230kV	30km	5	Dhaka
9. Hathazari – Madunaghat	230kV	9km	3	Southern
10. Tongi – Uttara	230kV	9km	1	Dhaka
11. Milpur – Aminbazar	230kV	10km	3	Dhaka
12. Hathazari – Baraulia	230kV	12km	2	Southern
13. Madunaghat – Sitalakhya	230kV	12km	2	Southern

1 230kV operation at initial stage

Section	Voltage	Length	No. of circuits	Region
14. Hasnabad – Kulshi	230kV	12.7km	2	Dhaka
15. Uttara – Milpur	230kV	13km	2	Dhaka
16. Kulshi – Baraulia	230kV	12.9km	2	Southern
17. Madunaghat – Madunaghat/New Sikalbaha	230kV	12.9km	2	Southern
18. Maniknagar – Siddhirganj	230kV	11km	2	Dhaka
19. Tongi – Kasimpur	230kV	15km	2	Dhaka
20. Kasimpur – Kabirpur	230kV	15km	2	Dhaka

Source: PGCB System Planning Division (June 2010)

9.4 Transmission network development plan

9.4.1 Analysis condition

(1) Generation patterns

The list of generators for system analysis is shown in AP Table 9-2. The power flow and voltage analysis will be carried out to confirm to the power flow criteria explained in 9.1.1 is satisfied. In this study, the overloading will be checked for the two generation patterns, as shown in Table 9-10, in consideration of the output of the spinning service.

Table 9-10 Studied generation patterns

Generators	West-side	East-side
Pattern East	Reduced to match demand-supply balance	Full output
Pattern West	Full output	Reduced to match demand-supply balance

Source: PSMP Study Team

(2) Short-circuit and ground-fault current

A short-circuit and a ground-fault current maximum value at each point in the system increases as the system scale expands. They are especially easily greatly increased in the bulk power system that is directly susceptible to the newly installed generator. Therefore, the short-circuit and the ground-fault current will aim to remain below the value indicated in Table 9-11.

Table 9-11 Maximum value of short-circuit and ground-fault current in system

Votage Class	Short-circuit and ground fault current
400kV	63kA
230kV	63kA
132kV	63kA

Source: PGCB

When the short-circuit and the ground-fault current exceeds the value as shown in Table 9-11, appropriate reduction measures for the short-circuit and the ground-fault current as shown below will be adopted after comprehensively taking into account system stability, voltage stability and economic efficiency.

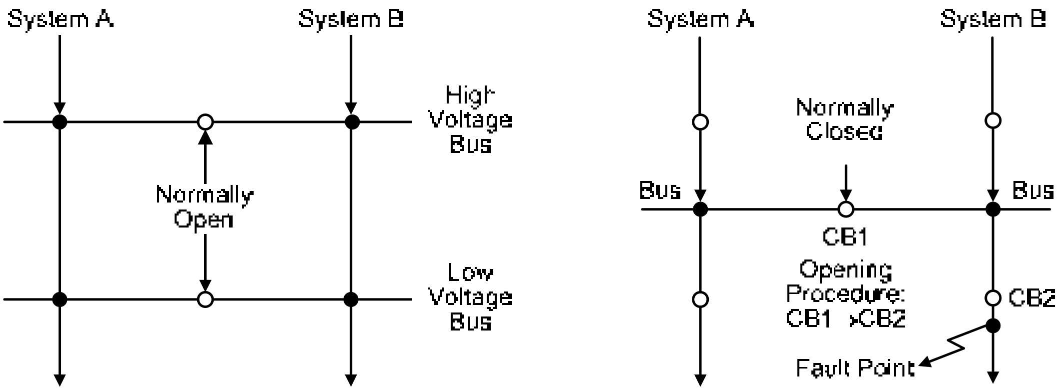
- System decomposition and generation dispersion
- Bus splitting of a power station and a substation under normal operations
- Bus separation of a power station and a substation in case of a fault
- Adoption of a high impedance transformer
- Adoption of a series reactor
- Adoption of an asynchronous method such as a DC transmission and a DC interconnection

There are two methods of the bus splitting of a power station and a substation to reduce the fault current as follows.

(a) Method of bus splitting under normal operations
The bus will be split with the normally-opened operations by installing the automatic bus tie circuit breaker.

(b) Method of bus splitting in the case of a fault
The bus will be interconnected under normal operations and the circuit breaker at the fault point after opening the bus in the case of a fault.

The method (a) is disadvantageous in that the advantage of the system interconnection is significantly damaged in spite of the most effective method. Meanwhile, the method (b) has disadvantages such as the unbalanced bank load and the fault clearing delay.



(a) Method of bus splitting under normal operations

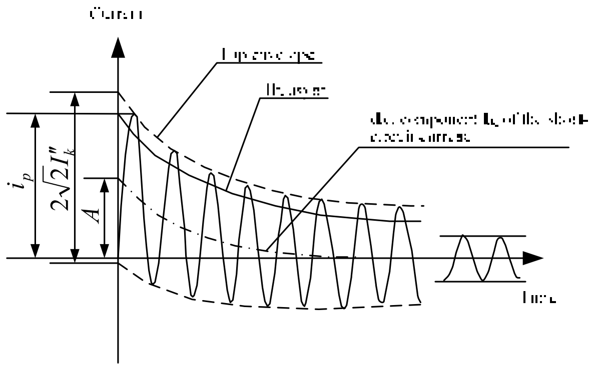
(b) Method of bus splitting in case of fault

Source: PSMP Study Team

Fig. 9-13 Bus splitting method

This study has been carried out based on method (a). In addition, the replacement of the high impedance transformer and the installation of the series reactor will be effective as the measures for facilities.

As for the bus design of the power station and substation, its planning is necessary so as not to cause an interruption in system operations and maintenance by adopting an automatic bus tie circuit breaker method if necessary even when the bus is spitted by the aforementioned measures etc.
In the study of the short-circuit and the ground-fault current, the RMS asymmetrical short-circuit breaking current ($I_{b\ asym}$), defined in the IEC 60909 standard (Short-circuit calculation in three-phase ac systems), as shown in Fig. 9-14 will be calculated at a minimum time delay.



I''_k Initial symmetrical short-circuit current

i_p Peak short-circuit current

A Initial value of the d.c. component $i_{d.c.}$

$i_{d.c.}$ d.c. component of short-circuit current

Source: IEC60909 etc.

Fig. 9-14 Fault current defined by IEC60909

(3) Transient stability

Transient stability will be carefully analyzed from the viewpoint of the overall power system in studying transmission planning according to power supply development. Various measures for stability improvement from the generator to the transmission line and substation facilities will also be studied, if necessary. After that, the necessary transmission capacity will be secured by effective measures.

Therefore, the transient stability analysis will be carried out according to the following conditions. The supply reliability will be secured without the limitations of significant generator output at the fault of a transmission line, as described in Table 9-1.

(a) Type of contingency

Three phase to the ground normally opened of a single-circuit transmission line at the same point for the system with a parallel double-circuit operation and the above transmission line

(b) Protection device and circuit breaker operations

The case of tripping the transmission lines by main protection and without reclosing will be studied. The fault clearing time by main protection is shown in Table 9-12.

Table 9-12 Maximum value of short-circuit and ground-fault current in system

Voltage class	Fault clearing time
400kV	160ms
230kV	160ms
132kV	160ms

Source: BANGDALESH GRID CODE DRAFT (October 18, 2000)

(4) Light load condition

As for the light load condition study, whether the proper voltage shown in 9.1.2 under the following condition was able to be maintained has been studied.

- Load of each substation: Setting for 45% of the load (heavy load condition) in case of the power flow and voltage study
- Generator: Stopping an inefficient generator until it corresponds to demand

The generator for the study is listed in AP Table 9-2.

(5) Existing facilities

Since there is some inadequate generator data, an analysis is carried out with the following standard data. (Table 9-13 - Table 9-15)

Table 9-13 Machine

Machine	Power factor	R Source (pu)	X Source (pu)	RG-Pos (pu)	XG-Pos (pu)	RG-Neg (pu)	XG-Neg (pu)	RG-Zero (pu)	XG-Zero (pu)
Hydro plant	0.85	0.00009	0.25	0.00009	0.25	0.00009	0.25	0.00009	0.25
Thermal plant	0.85	0.00009	0.2	0.00009	0.2	0.00009	0.2	0.00009	0.2

Source: PSMP Study Team

Machine	Model	T'd0	T"d0	T'q0	T"q0	H	D	Xd	Xq	X'd	X'q	X"d	X1	S(1.0)	S(1.2)
Hydro plant	GENSAL	5	0.05	-	0.06	5.084	1	1.5	1.2	0.4		0.25	0.12	0.03	0.25
Thermal plant	GENROU	6	0.05	1	0.05	3	0	1.4	1.35	0.3	0.6	0.2	0.1	0.03	0.4

Source: PSMP Study Team

Table 9-14 Excitation system

Machine	Model	TA/TB	TB	K	TE	EMIN	EMAX
Hydro plant	SEXS	0.1	10	100	0.1	0	5
Thermal plant	SEXS	0.1	10	100	0.1	0	5

Source: PSMP Study Team

Table 9-15 Governor

Machine	Model	R	r	Tr	Tf	Tg	VELM	Gmax	Gmin	TW	At	Dturb	qNl
Hydro plant	'HYGOV'	0.05	0.5	10	0.05	0.5	0.17	1	0	2	1.2	0.5	0.08
Machine	Model	R	T1	VMAX	VMIN	T2	T3	Dt					
Thermal plant	'TGOV1'	0.05	0.5	1.5	0	1.8	6	0					

Source: PSMP Study Team

(6) Newly installed transmission line and submission facilities

(a) Transmission line

The following are the standard parameters of the newly installed transmission line. The detailed data is shown in AP Table 9-3.

- Quad conductor for 400kV
- Bangladesh specification based on the existing facilities for 132kV and 230kV

(b) Generator

Analyses are carried out with standard data. (Table 9-13 - Table 9-15)

(c) Step-up transformer

The parameters of existing facilities similar to the capacity have been used. Otherwise the standard parameters have been used.

(d) Ttransformer

The parameters of the 230kV/132kV transformer are based on existing facilities. In addition, the standard parameters of the 400kV/230kV transformer are shown in AP Table 9-4.

(7) Construction cost

The construction cost for the power system expansion plan is based on the unit costs provided by PGCB, as shown in Table 9-16. In addition, for the construction cost of the transmission line across the river, it is assumed to be 40 times the standard cost based on information from Japanese concerned parties really involved in the 230kV transmission line construction of the river crossing part in Bangladesh thirty years ago.

Table 9-16 Unit cost for construction of transmission line and substation

		Unit Cost	
Overhead Line	132kV	0.1786	mil. US$/km/2cct
	230kV	0.357	mil. US$/km/2cct
	400kV	0.643	mil. US$/km/2cct
Underground Cable	132kV	0.893	mil. US$/km/2cct
	230kV	1.785	mil. US$/km/1cct
	400kV	3.215	mil. US$/km/1cct
River Crossing OHL[1]	400kV North 10km	257.2	mil. US$/2cct
	400kV Middle 4.5km	115.74	mil. US$/2cct
	400kV South 6km	154.32	mil. US$/2cct
Substation[2]	132/33kV(2x100MW, AIS)	5	mil. US$/station
	132/33kV(2x100MW, GIS)	5.714	mil. US$/station
	230/132kV(2x500MW, AIS)	23.3	mil. US$/station
	230/132kV(2x500MW, GIS)	26.7	mil. US$/station
	230/132kV(2x300MW, AIS)	14.0	mil. US$/station
	230/132kV(2x300MW, GIS)	16.0	mil. US$/station
	400/230kV(4x500MW, AIS)	81.2	mil. US$/station
	400/230kV(3x500MW, AIS)	60.9	mil. US$/station
	400/230kV(2x500MW, AIS)	40.6	mil. US$/station
	400/230kV(1x500MW, AIS)	20.3	mil. US$/station
Switching Station	400kV	20.3	mil. US$/station
BTB	230kV, 400kV	80.0	mil. US$/station
Static Capacitor	132kV	0.017	mil. US$/Mvar
	230kV	0.029	mil. US$/Mvar
	400kV	0.051	mil. US$/Mvar

Source: PGCB, PSMP Study Team

(8) Basic concept of cross border trading

The interconnection transmission line should be designed during the stage of the newly-constructed facilities to adjust the future reinforcement plan and the neighboring power system.

In order to construct such a reasonable interconnection transmission line, not only the immediate necessity of the construction but also the future plan concerning the overall power system should be thoroughly discussed at the stage of the construction plan study by all concerned nations.

In addition, the Back to Back (BTB) system is currently attracting a great deal of attention as an interconnection method. The BTB system has the advantage of being able to ease the power flow

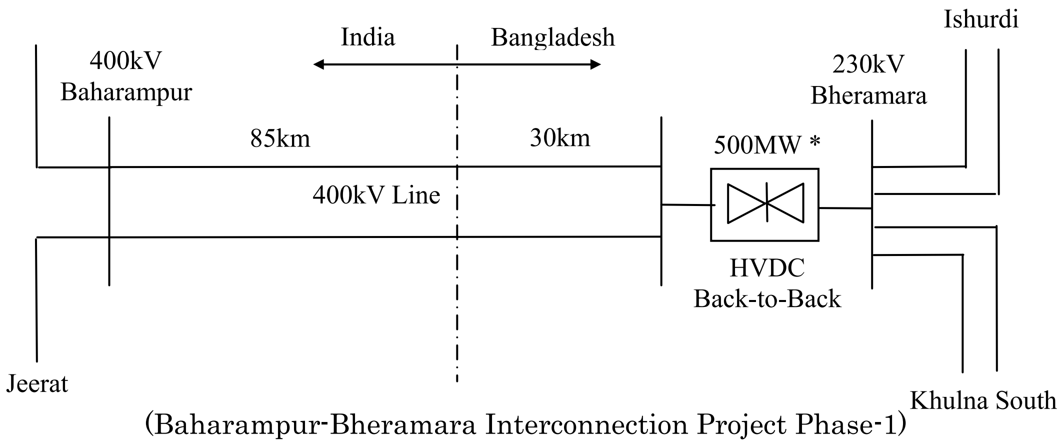
[1] Based on information from the Japanese concerned parties involved in the 230kV transmission line construction of the river crossing part in Bangladesh nearly thirty years ago

[2] The unit cost of the 400/232kV substation will be estimated assuming that the proportion to the number of the banks, the capacity of the single-unit capacity, and the voltage based on that of the 230/132kV substation (2×300MVA, GIS), which is the 16 mil. US$/ station.

control, grasp the solution to a problem concerning power system stability and the short circuit capacity via a large-scale AC power system, and an increase of the transmission capacity between the AC power systems.

(a) Planned project

The cross border trading between Baharampur (India) and Bheramara has been already planned by adopting the BTB system as shown in Fig. 9-15.



Source: BPDB

Fig. 9-15 Power system diagram of Asynchronous interconnection

(b) Other potential projects

For the cross border trading with the neighboring countries, the following candidate points have been considered at present.

- Indian Meghalaya state
  The hilly area of the 2,000m class extends to the Indian Meghalaya state which is adjacent to the northeast of Bangladesh. It is considered that the new transmission line for the interconnection will be difficult due to geographical factors, though there is existing hydro-power potential.

- Pallatana, Indian Tripura state
  Recently the burial of large-scale natural gas has been discovered in the Indian Tripura state which is adjacent to the east of Bangladesh, Pallatana gas power generation project (726.6MW) is planned. It is considered that the majority of the power generation will be consumed by the home country as the solution to power shortages.

- Indian Assam state
  There is potential of coal and hydro-power in the Indian northeastern Assam state. The reinforcement of the power system in India will be necessary because it is far from Bangladesh.

- Bhutan and Nepal
  It is necessary to import the electric power via India as there is large-scale hydro-power potential in Bhutan and Nepal.

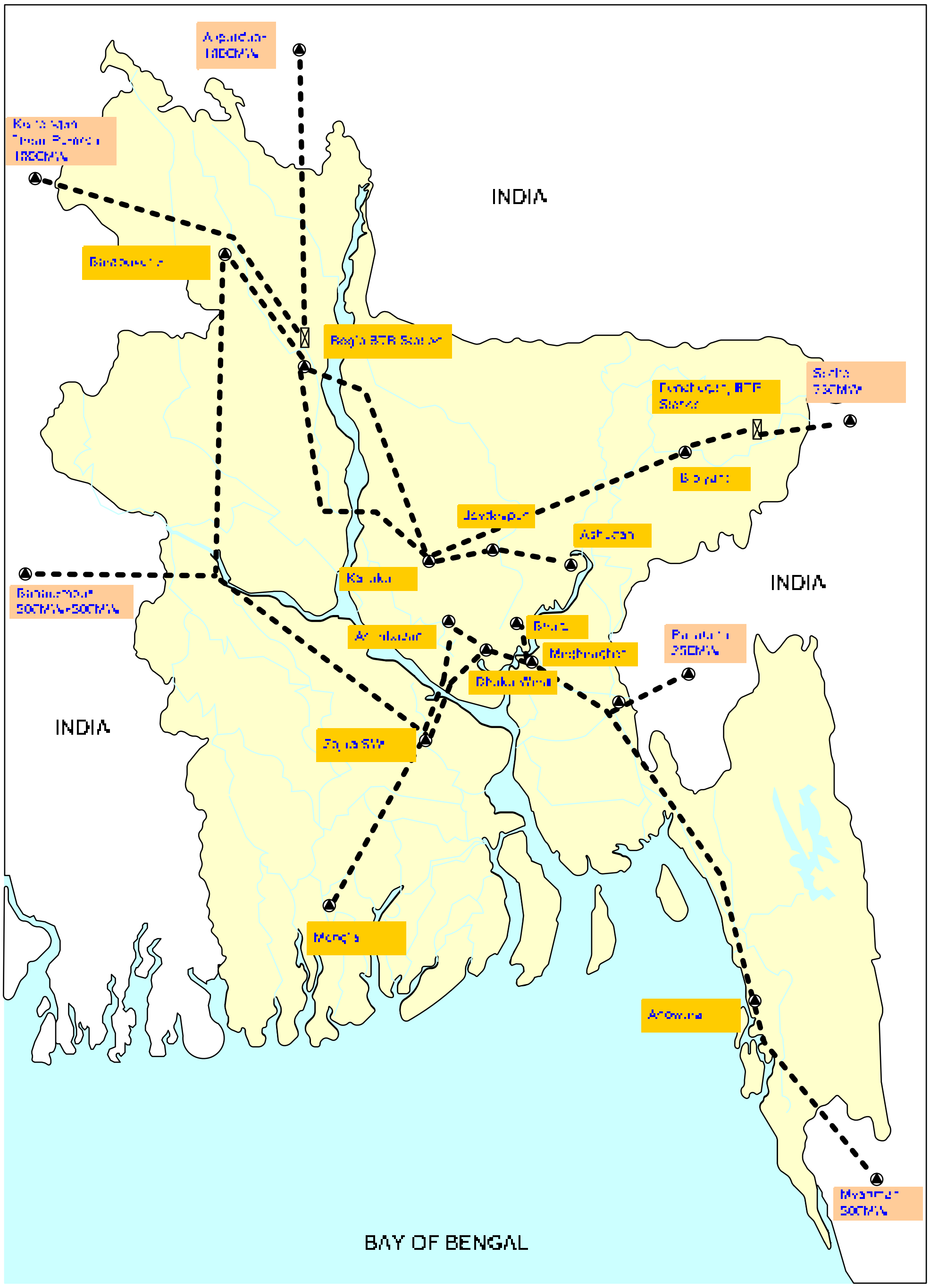
- Myanmar
  Discussion between Bangladesh and Myanmar Governments is advancing for power import by Bangladesh from hydro power plant to be developed in Lemro site in Myanmar's Rakhine State.

- Other
  Although, it is possible to connect a part of the small demand in South – West Bangladesh to India, it is not considered in this MP.

As for the interconnection in the northwestern region, increasing power flow from the northwest to the Dhaka region together with a rapidly advanced coal power development in the same region in the future should be considered. The number of circuits for the transmission line across the Jamuna River is increased as mentioned in 9.2.3(5)(c). Therefore, it is recommended to reduce the amount of interconnection in the northwestern region from the perspective of minimizing costs.
Moreover, neighboring countries such as India, Nepal, Bhutan, and Myanmar positively focusing on developing large-scale hydro power as renewable energy, and strengthening the wide area interconnection system contribute to power supply reliability improvements and measures for controlling global warming in each country. In conclusion, the interconnection with the neighboring countries was planned including the following two candidate site points with a current possibility as shown in Fig. 9-16.

- Indian Tripura state
  There is the possibility of further gas field development around Pallatana.
- Indian northeastern region
  It is possible to correspond with the system reinforcement in India though it is in a remote place from Bangladesh.

The voltage class for interconnection voltages (400kV or 230kV) will be individually studied, taking into account the amount of interconnection and the power flow conditions in the surrounding area, etc.



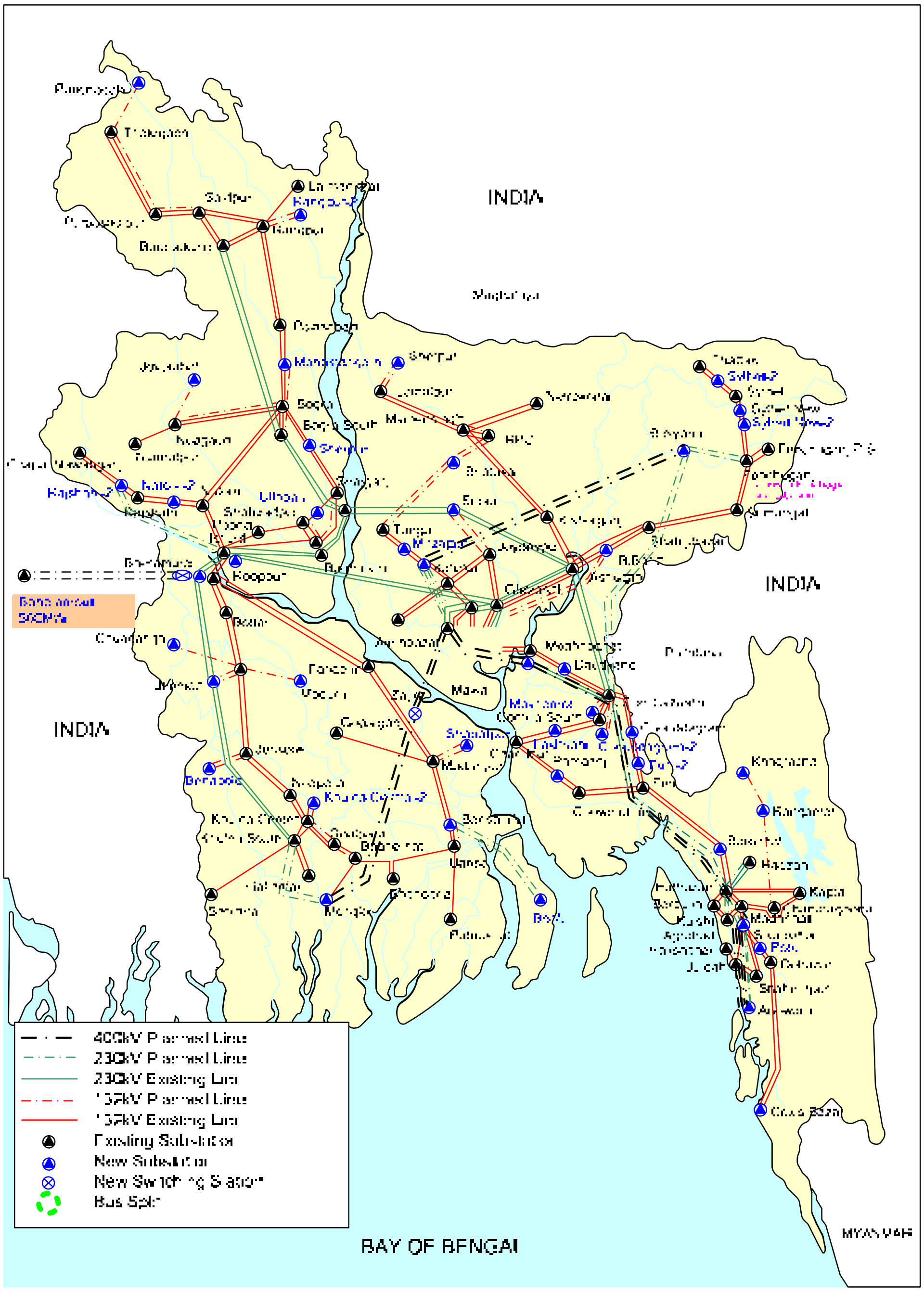
Source: PSMP Study Team

Fig. 9-16 Summary of potential interconnections (2030)

9.4.2 2015 plan

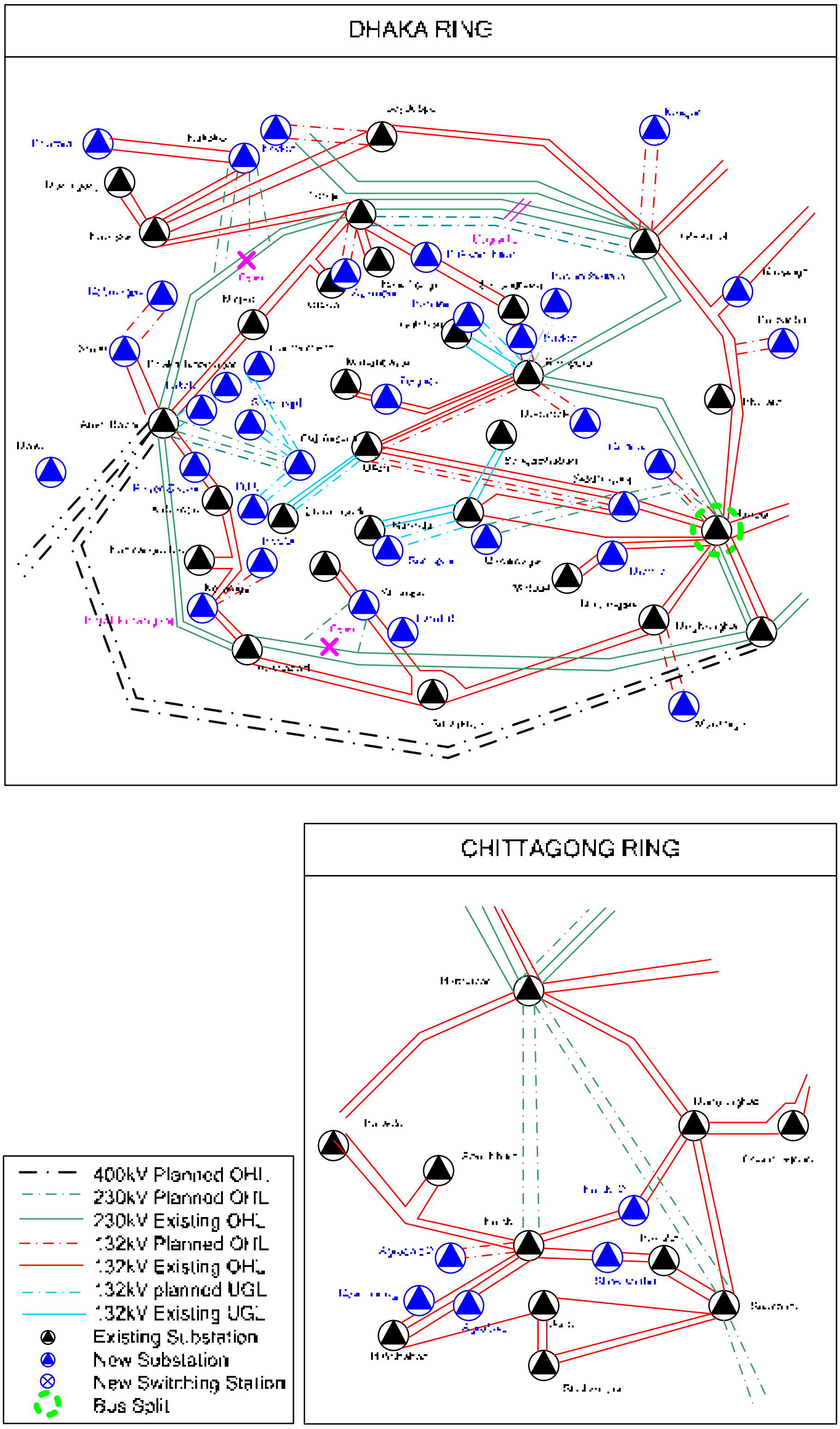
The 2015 power system expansion plan, which satisfies the planning criteria as mentioned in 9.4.1 , are shown in Fig. 9-17 and Fig. 9-18. The power flow is shown in APFig. 9-1 – APFig. 9-12.

System Configuration at 2015 (Grid Demand:10GW)



Source: PSMP Study Team

Fig. 9-17 Power system expansion plan at 2015 (overall system)



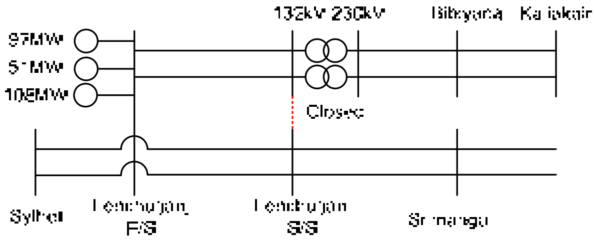
Source: PSMP Study Team

Fig. 9-18 Power system expansion plan at 2015 (Dhaka and Chittagong ring)

(1) Results of power flow and voltage analysis

Special instructions for the results of the power flow and voltage analysis are as follows.

- 230kV Fenchuganj substation
  According to the PGCB's plan, the bus of Fenchuganj 132kV substation will be split, and the power from the Fenchuganj power station will be transmitted to the 230kV Bibiyana substation through the 230kV transmission line, as shown in Fig. 9-19. However, the bus of the 132kV Fenchuganj substation will not be split due to a large voltage drop occurrence around the Fenchuganj substation.



Source: PSMP Study Team

Fig. 9-19 Power system around Fenchuganj substation

- 400kV Mongla-Aminbazar transmission line
  According to the PGCB's plan concerning the 400kV Mongla-Aminbazar transmission line, the transmission capacity will be insufficient in the future, and the amount of the investment for the river crossing where vast funds will be necessary will grow. Therefore, the 400kV switching station will be needs to be constructed at Zajira and a 400kV large capacity (quad-conductor) transmission line will be required.

- 400kV Meghnaghat-Anowara transmission line
  The 400kV large capacity (quad-conductor) transmission line will also be required between Meghnaghat and Anowara.

- 400kVAminbazar – Zajira transmission line
  The 400kV large capacity (quad-conductor) transmission line will also be required between Aminbazar and Zajira.

- 230kV Raozan-Hathazari transmission line
  An additional 230kV Raozan-Hathazari transmission line will not be necessary for the near term due to the 100MW operation of the Raozan power station. After the operation condition of the Raozan power station in the future is ascertained, it will be necessary to study additional line construction.

- Bhola power station
  A large voltage drop occurs when the two generators of the Bhola power station are stopped simultaneously. Therefore, the two generators of the Bhola power station will not be stopped simultaneously under heavy load conditions.

- 230kV Barisal (N)-Bhola transmission line
  The 230kV Barisal (N)-Bhola transmission line will be connected with the Barisal (N) substation without being connected with the Barisal substation because there is a restriction in surplus bay in the Barisal substation.

- 132kV Goalpara-Bagherhat transmission line
  Regarding the N-1 overload condition for the 132kV Bagherhat-Bandaria transmission line, it will be possible to evade it by opening those lines.

- 132kV Barisal-Patuakhali transmission line
  In case of the N-1 fault for the 132kV Barisal-Patuakhali single-circuit transmission line, it will be possible to evade it by opening the 132kV Bagherhat-Bandaria transmission line.

- 230kV Tongi-Ghorasal transmission line
  The construction of an additional 230kV Tongi-Ghorasal transmission line is impossible. Therefore, it will be required to be replaced with a 230kV large capacity transmission line.

(2) Results of the short-circuit and ground-fault current analysis

The bus 132kV splitting in the Haripur power station will be necessary because a large-capacity generator is connected to the 132kV bus of the Haripur power station. It was confirmed that the short-circuit and ground-fault current of all substations became less than 63kA via the aforementioned measures, as shown in the AP Table 9-5.

(3) Results of the system stability analysis

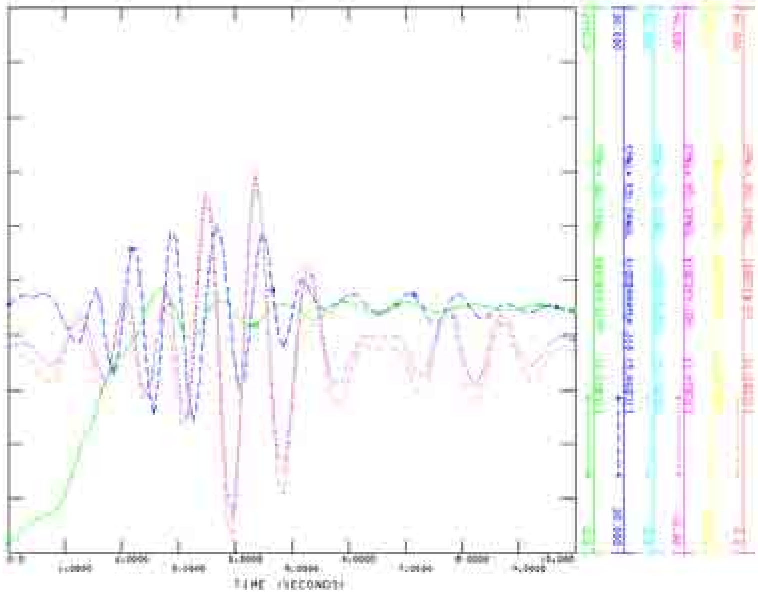
It has been confirmed that the system is unstable in case of the 230kV Bhola – Barisal(N) transmission line contingency. This will be improved by measure such as additional two circuits, 230kV Bhola – Barisal(N) transmission line or connection of two circuits 230kV Barisal (N) - Mongla. The result is shown in Fig. 9-20, Fig. 9-21. Since there exists some inadequate generator data for transient stability, an analysis is carried out with standard data. It is considered that the system stability analysis will be carried out again after data is maintained, and necessary measures are studied. The measures for improving system stability are considered as follows.

- Measures by system configuration
  Multi-route transmission line, system voltage upgrading, and the installation of an intermediate switching station

- Measures by generator and turbine control
  High initial response excitation, PSS (Power System Stabilizer), and turbine high-speed valve

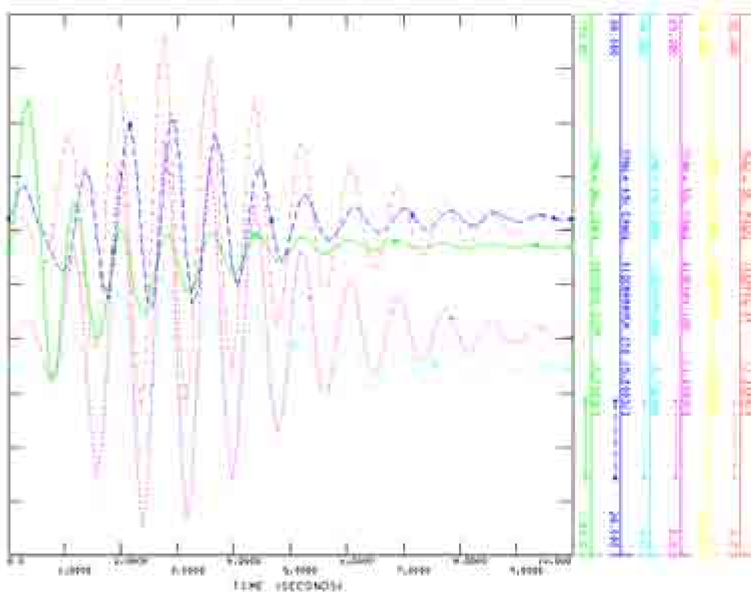
- Measures by relay and control system
  High speed fault clearing, high speed reclosing, and a predictive out-of-phase protection system

- Measures by special equipment
  SVC (Static Var Compensator), series capacitor, and damping resistor



Source: PSMP Study Team

Fig. 9-20 Results of the system stability analysis without measures



Source: PSMP Study Team

Fig. 9-21 Results of the system stability analysis with measures

(4) Light load study condition

The light load condition study has been also carried out. It was confirmed that the bus voltage of all substations remains within the stipulated range. The power flow is shown in APFig. 9-13 - APFig 9-18.

(5) Amount of facilities expansion

(a) Transmission line

The transmission line for which construction is necessary by 2015 is shown in AP Table 9-6. Summary is shown in Table 9-17 The 400kV and 230kV transmission line for which construction is necessary from 2010 to 2015 is shown in Table 9-18 and Table 9-19.

Table 9-17 Summary of transmission line required by 2015

Voltage (kV)	2010		2015		Additional (2015-2010)	
	Length (km)	cct.	Length (km)	cct.	Length (km)	cct.
132	6116.7	194	7384.8	339	1268.1	146
230	2644.8	40	3676.3	73	1031.5	33
400	0	0	1340	10	1340	12

Source: PSMP Study Team

Table 9-18 230kV transmission line required from 2010 to 2015[1]

From Substation	To Substation	CCT.	Length(km)
AMINBZ	KALIAKAIR	2	50.5
AMINBZ	OLDAIRPORT	3	30
ANOWARA	SIKALBAHA	2	40
BARISAL	BHOLA	2	120
BIBIYANA	COMIN	2	320
BIBIYANA	FENCHUGANJ	2	64
HARIPR	SIDDHIRGANJ	2	4
HATHZR	KULSHI	2	40
HATHZR	RAOZN	1	22.5
HATHZR	SIKALBAHA	2	50
ISHRDI	RAJSHAHI	2	140
KALIAKAIR	TONGI	2	50.5
KHULN	MONGLA	2	80
MANIKNAGAR	SIDDHIRGANJ	2	20
		Total	1031.5

Source: PSMP Study Team

Table 9-19 400 kV transmission line required from 2010 to 2015

From Substation	To Substation	cct.	Length(km)
AMINBAZAR	MEGHNAGHAT	2	100
AMINBAZAR	ZAJIRA	2	112.5
ANOWARA	MEGHNAGHAT	2	520
BIBIYANA	KALIAKAIR	2	336
MONGLA	ZAJIRA	2	272
		Total	1340.5

Source: PSMP Study Team

[1] 230kV GHRSL – TONG transmission line upgrade is not included.

(b) Substation

The substation for which construction is necessary by 2015 is shown in AP Table 9-7. Summary is shown in Table 9-20. The 230/132kV and 400/230kV substation for which construction is necessary from 2010 to 2015 is shown in .Table 9-21 and Table 9-22

Table 9-20 Summary of substation required by 2015

<table>
<tr><th>Voltage</th><th>East or West</th><th>Region</th><th colspan="3">Additional Number of Substation</th></tr>
<tr><td rowspan="5">132/33kV</td><td rowspan="3">East</td><td>Central</td><td>6</td><td rowspan="3">51</td><td rowspan="5">65</td></tr>
<tr><td>Dhaka</td><td>29</td></tr>
<tr><td>Southern</td><td>16</td></tr>
<tr><td rowspan="2">West</td><td>Northern</td><td>8</td><td rowspan="2">14</td></tr>
<tr><td>Western</td><td>6</td></tr>
<tr><td rowspan="5">230/132kV</td><td rowspan="3">East</td><td>Central</td><td>1</td><td rowspan="3">8</td><td rowspan="5">12</td></tr>
<tr><td>Dhaka</td><td>5</td></tr>
<tr><td>Southern</td><td>2</td></tr>
<tr><td rowspan="2">West</td><td>Northern</td><td>1</td><td rowspan="2">4</td></tr>
<tr><td>Western</td><td>3</td></tr>
<tr><td rowspan="4">400/230kV</td><td rowspan="3">East</td><td>Central</td><td>1</td><td rowspan="3">5</td><td rowspan="4">6</td></tr>
<tr><td>Dhaka</td><td>3</td></tr>
<tr><td>Southern</td><td>1</td></tr>
<tr><td>West</td><td>Western</td><td>1</td><td>1</td></tr>
</table>

Source: PSMP Study Team

Table 9-21 230/132kV Substation required from 2010 to 2015

Voltage	East or West	Region	Substation
230/132kV	East	Southern	KULSHI
230/132kV	East	Southern	SIKALBAHA
230/132kV	East	Dhaka	KALIAKAIR
230/132kV	East	Dhaka	OLDAIRPORT
230/132kV	East	Dhaka	SHAMPUR
230/132kV	East	Dhaka	SIDDHIRGANJ
230/132kV	East	Dhaka	SRIPUR
230/132kV	East	Central	FENCHUGANJ
230/132kV	West	Western	BARISAL
230/132kV	West	Western	BHERAMARA
230/132kV	West	Western	JHENIDA
230/132kV	West	Northern	RAJSHAHI

Source: PSMP Study Team

Table 9-22 400/230kV Substation required from 2010 to 2015)

Voltage	East or West	Region	Substation
400/230kV	East	Southern	ANOWARA
400/230kV	East	Dhaka	AMINBAZAR
400/230kV	East	Dhaka	MEGHNAGHAT2
400/230kV	East	Dhaka	KALIAKAIR
400/230kV	East	Central	BIBIYANA
400/230kV	West	Western	MONGLA

Source: PSMP Study Team

(c) Switching station

The switching station for which construction is necessary by 2015 is shown in Table 9-23.

Table 9-23 Summary of switching station required by 2015

Voltage	East or West	Region	New Switching Station
400kV	West	Western	Zajira

Source: PSMP Study Team

(d) Capacitor

The capacitor for which construction is necessary by 2015 is shown in Table 9-24.

Table 9-24 Summary of capacitor required by 2015

East or West	Region	Voltage	Substation	Capacity (Mvar)
East	Southern	132kV	HATHAZARI	45
East	Southern	132kV	DOHAZARI	45
East	Southern	132kV	BAKULIA	45
East	Southern	132kV	KHAGRACHARI	45
East	Dhaka	132kV	RAMPURA	90
East	Dhaka	132kV	AMINBAZAR	90
East	Central	132kV	JAMALPUR	25
East	Central	132kV	NETRAKONA	12.5
East	Central	132kV	CHHATAK	12.5
East	Southern	33kV	FENI	25
East	Southern	33kV	CHOWMUHANI	25
East	Southern	33kV	COMILLA (S)	50
East	Dhaka	33kV	HASNABAD	25
East	Dhaka	33kV	KALYANPUR	50
East	Dhaka	33kV	KABIRPUR	25
East	Dhaka	33kV	TANGAIL	25
East	Dhaka	33kV	JOYDEBPUR	37.5
East	Dhaka	33kV	BHULTA	25
East	Dhaka	33kV	MANIKGANJ	25
West	Western	132kV	CHUADANGA	12.5
West	Western	132kV	JESSORE	45
West	Western	132kV	JHENAIDAH	12.5
West	Western	132kV	KUSHTIA (BOT	25
West	Western	132kV	MAGURA	12.5
West	Western	132kV	GOPALGANJ	45
West	Western	132kV	MADARIPUR	45
West	Western	132kV	BARISAL	45
West	Western	132kV	BAGHERHAT	25
West	Western	132kV	MONGLA	25

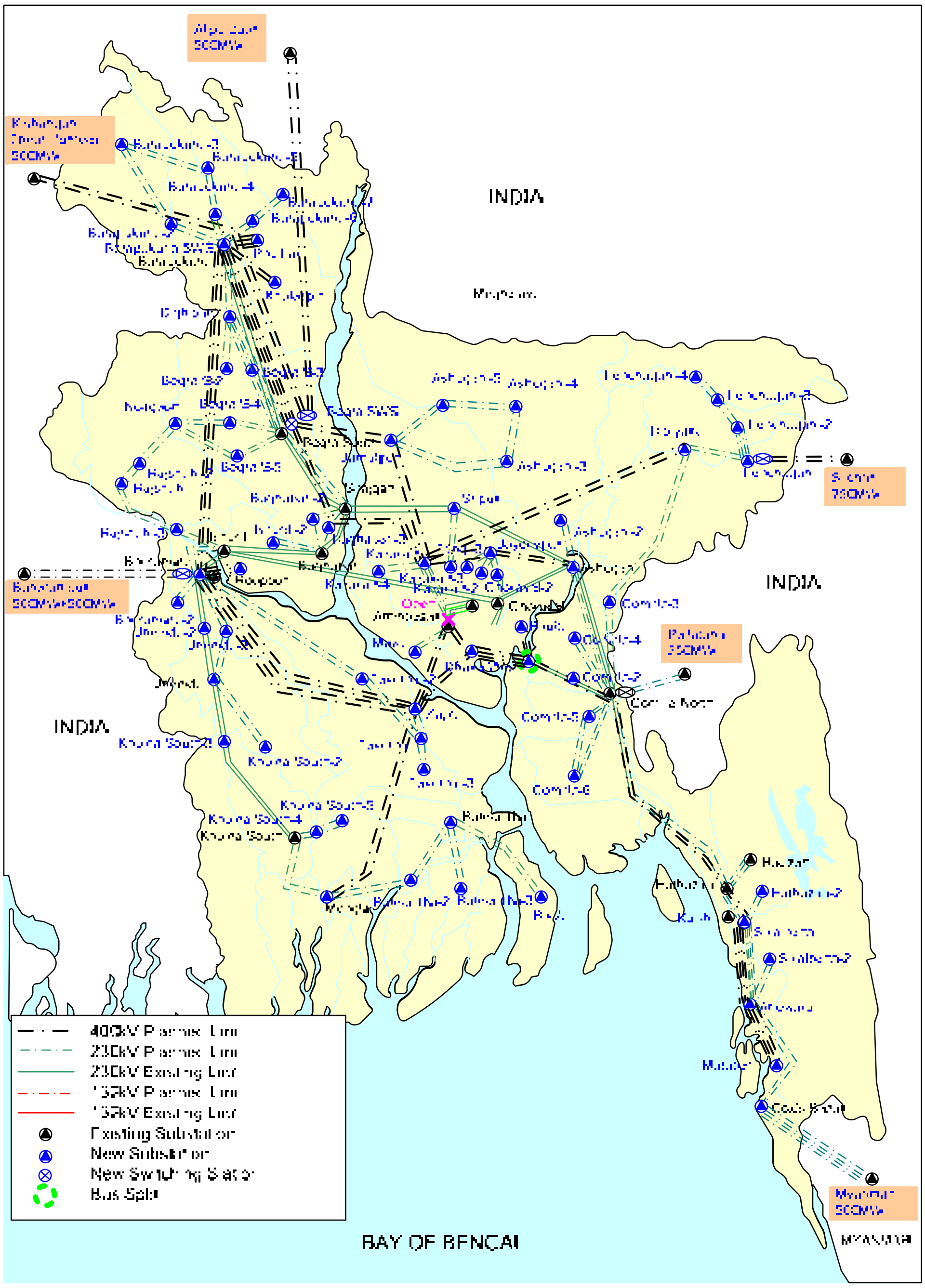
East or West	Region	Voltage	Substation	Capacity (Mvar)
West	Western	132kV	GOLLAMARI	12.5
West	Western	132kV	PATUAKHALI	25
West	Northern	132kV	NIAMATPUR	62.5
West	Northern	132kV	JOYPURHAT	30
West	Northern	132kV	LALMONIRHAT	62.5
West	Northern	132kV	PANCHAGAR	30
West	Northern	132kV	THAKURGAON	45
West	Northern	132kV	RANGPUR-2	45
West	Northern	132kV	BOGRA-3	12.5
West	Western	33kV	SATKHIRA	12.5
West	Northern	33kV	NATORE	25
West	Northern	33kV	RAJSHAHI	25
West	Northern	33kV	CHAPAI NOWAB	25
West	Northern	33kV	SIRAJGANJ	12.5
West	Northern	33kV	NOAGAON	25
West	Northern	33kV	PALASHBARI	12.5
West	Northern	33kV	PURBASHADIPU	50

Source: PSMP Study Team

9.4.3 2030 plan

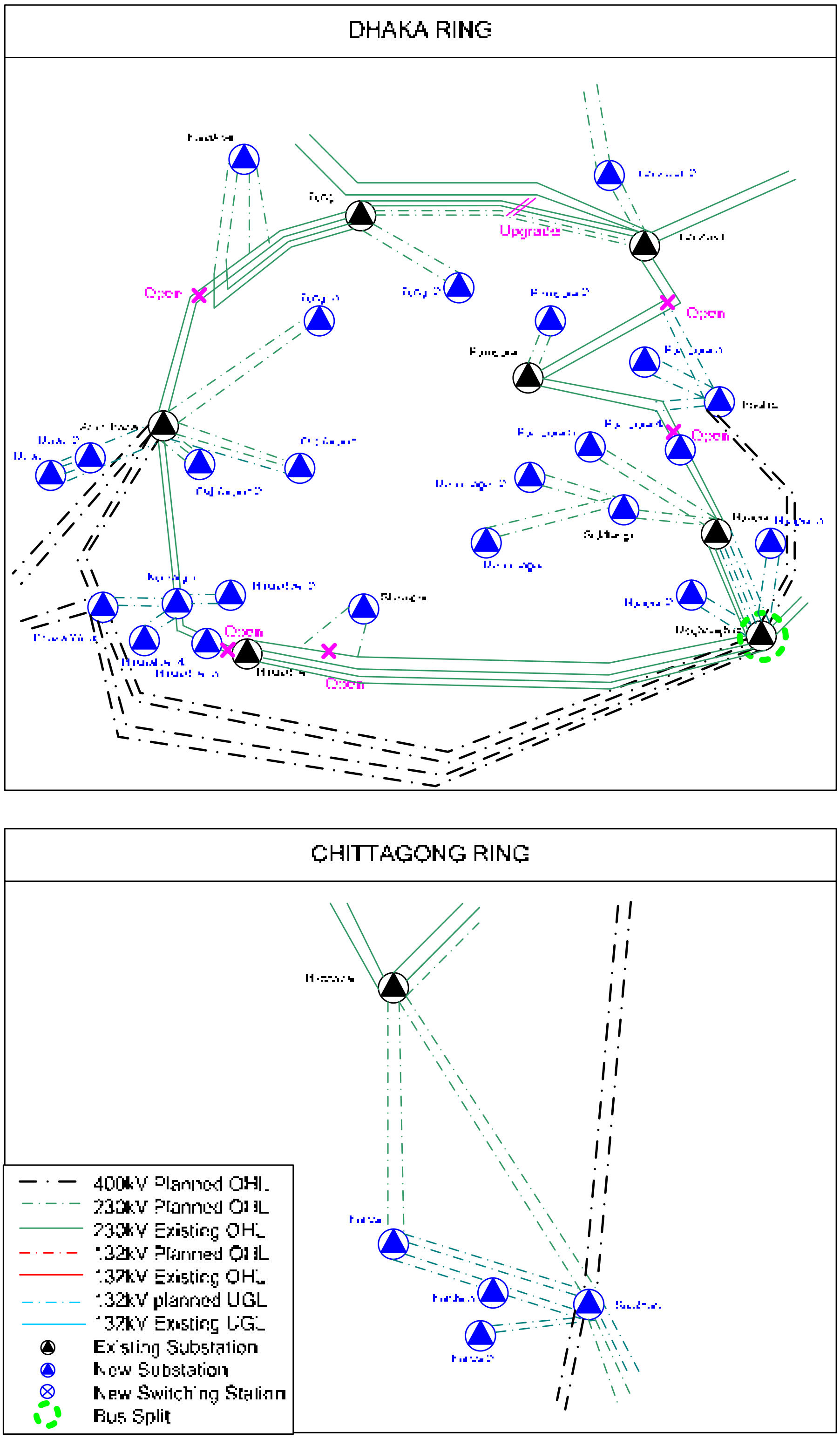
The 2030 power system expansion plan, which satisfies the planning criteria as mentioned in 9.4.1 is shown in Fig. 9-22 and Fig. 9-23. The power flow is shown in APFig. 9-19 and APFig. 9-20.

System Configuration (2030) (Grid Demand: 33GW)



Source: PSMP Study Team

Fig. 9-22 Power system expansion plan at 2030 (overall system)



Source: PSMP Study Team

Fig. 9-23 Power system expansion plan at 2030 (Dhaka and Chittagong ring)

(1) Results of power flow and voltage analysis

Special instructions for the results of the power flow and voltage analysis are as follows.

- 400kV Bogra switching station
  For the purpose of reducing the short-circuit and the ground-fault current and the system stability, the switching station is constructed at Bogra. In addition, the Bogra switching station contributes to system stability.

- 400kV Bogra switching station-Kaliakair transmission line
  As for the 400kV Bogra switching station-Kaliakair four circuit transmission line, each two circuit is crossing the river at a different point taking into account system security.

- 400kV Aminbazar-Kaliakair transmission line
  Although The connection of the 400kV Aminbazar-Kaliakair transmission line results in an increase of the short-circuit and the ground-fault current around the Dhaka area, .the connection of 400kV Aminbazar-Kaliakai is recommended in the future for reliability and stability improvement.

- Interconnection transmission line connection
  If the interconnection transmission line is connected with the 400kV bus of the 400/230kV substation (Bogra, Bheramara), an additional 400kV/230kV transformer will be necessary because power is supplied to the adjacent demand. Therefore, it is connected with the 230kV bus of substation.

- Myanmar interconnection transmission line
  The construction of the switching station or the substation at Cox's Bazar, the measure by the series capacitor is required for the stability improvement. Detailed planning should be required in FS.

- 230kV Sirajganj – Siripur transmission line
  Although the 230kV Sirajganj – Siripur transmission line is over current (101.5%) when the east plant is maximum, it will be reacted by the operation.

- Installation of the series capacitor
  Although the series capacitor is effective for the improvement of the heavy load voltage drop and the system stabilization of the long transmission lines, it may cause the Sub-synchronous resonance (SSR). Therefore, it has not been adopted in this Study. Recently, the Thyristor Controlled Series Capacitor (TCSC) is being adapted to the worldwide actual system in USA, Brazil, China, India, etc. to prevent the SSR.

(2) Results of short-circuit and ground-fault current analysis

Moreover, for the 400kV Meghnaghat substation, the measures of bus splitting are also necessary. It has been confirmed that the short-circuit and the ground-fault current of all substations becomes less than 63kA via the aforementioned measures, as shown in AP Table 9-8..

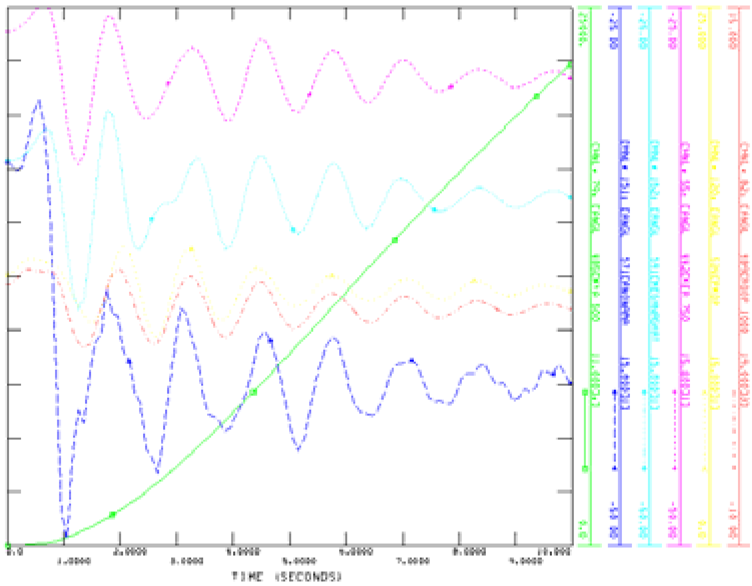
(3) Results of system stability analysis

The result is shown in Fig. 9-24, Fig. 9-25 and Fig. 9-26.

- 400kV Barapukuria – Bheramara 2cct
  400kV Barapukuria - Bheramara reinforce to 4cct.

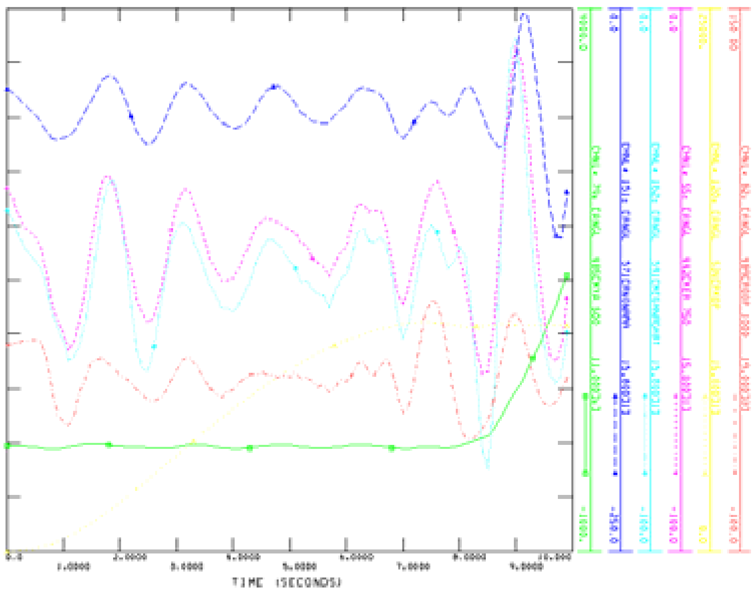
- 230kV Myanmar-Cox's Bazar 2cct
  230kV Myanmar-Cox's Bazar reinforce to 4cct.

Although the system stability improves by adding transmission lines, there are other measures. After data is adjusted, a detailed study will be required.



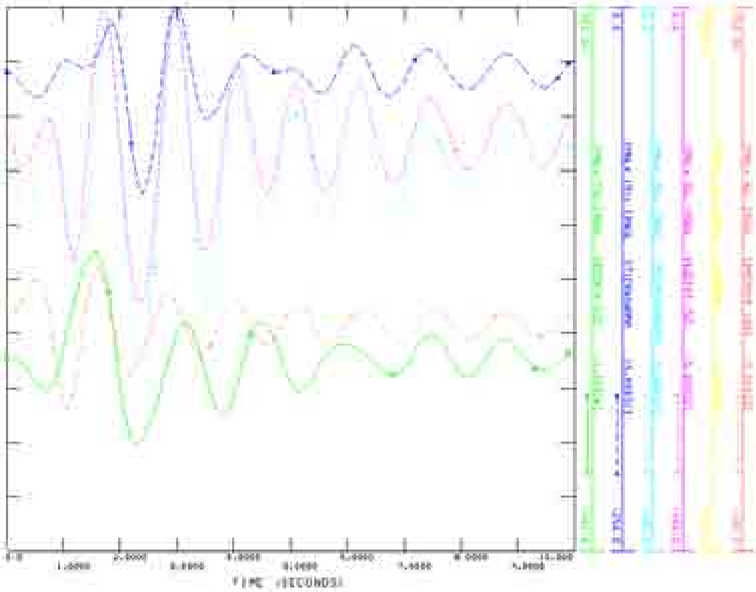
Source: PSMP Study Team

Fig. 9-24 Results of system stability analysis without measures (Myanmar)



Source: PSMP Study Team

Fig. 9-25 Results of system stability analysis with measures (Khalaspir)



Source: PSMP Study Team

Fig. 9-26 Results of system stability analysis after countermeasure

(4) Light load condition

The light load condition study has been also carried out. It has been confirmed that the bus voltage of all substations remains within the stipulated range. The power flow is shown in APFig. 9-21.

(5) Amount of facilities expansion

(a) Transmission line

The transmission line for which construction is necessary by 2030 is shown in AP Table 9-9. A summary is shown in Table 9-25. The 400kV transmission line for which construction is necessary from 2025 to 2030 is shown in Table 9-26.

Table 9-25 Summary of transmission line required by 2030

Voltage	2010		2030		Additional (2030-2010)	
	Length(km)	cct.	Length(km)	cct.	Length(km)	cct.
230	2644.8	40	9360.2	251	6715.4	211
400			4479.3	58	4479.3	58

Source: PSMP Study Team

Table 9-26 400kV transmission line required from 2025 to 2030

From Substation	To Substation	cct.	Length(km)
AMINBAZAR	DHAKA WEST	2	7.5
ANOWARA	MATARBARI	2	90
ANOWARA	SIKALBAHA	2	40
BHERAMARA	PKDP	4	810
BHERAMARA	ZAJIRA	2	337.5
BOGRA	KALIAKAIR	2	270
BOGRA	PKDP	2	225
DHAKA WEST	MEGHNAGHAT	4	59
DHAKA WEST	ZAJIRA	2	81
PHULBARI	PKDP	4	40
		Total	1960

Source: PSMP Study Team

(b) Substation

The substation for which construction is necessary by 2030 is shown in AP Table 9-10. A summary is shown in Table 9-27. The 400/230kV substation for which construction is necessary from 2025 to 2030 is shown in Table 9-28.

Table 9-27 Summary of substation required by 2030

Voltage	East or West	Region	Additional Number of Substation		
230/132kV	East	Southern	23	46	78
		Dhaka	25		
		Central	8		
	West	Western	15	43	
		Northern	17		
400/230kV	East	Southern	2	11	14
		Dhaka	6		
		Central	3		
	West	Western	3	3	

Source: PSMP Study Team

Table 9-28 400/230kV substation required from 2025 to 2030

Voltage	East or West	Region	Substation
400/230kV	East	Southern	SIKALBAHA
400/230kV	East	Dhaka	DHAKA WEST

Source: PSMP Study Team

(c) Switching station

The switching station for which construction is necessary by 2030 is shown in Table 9-29.

Table 9-29 Summary of switching station required by 2030

Voltage	East or West	Region	New Switching Station
400kV	West	Northern	Bogra
400kV	West	Northern	Barapukuria

Source: PSMP Study Team

(d) Capacitor

The capacitor for which construction is necessary by 2030 is shown in Table 9-30.

Table 9-30 Summary of capacitor required by 2030

East or West	Region	Voltage	Substation	Capacity (Mvar)
East	Southern	230kV	HATHZR	100
East	Southern	230kV	COMIN	400
East	Southern	230kV	KULSHI	400
East	Southern	230kV	COXS BAZAR	100
East	Southern	230kV	HATHZR-2	200
East	Southern	230kV	KULSHI-2	200
East	Southern	230kV	COMIN-2	300
East	Southern	230kV	COMIN-3	200

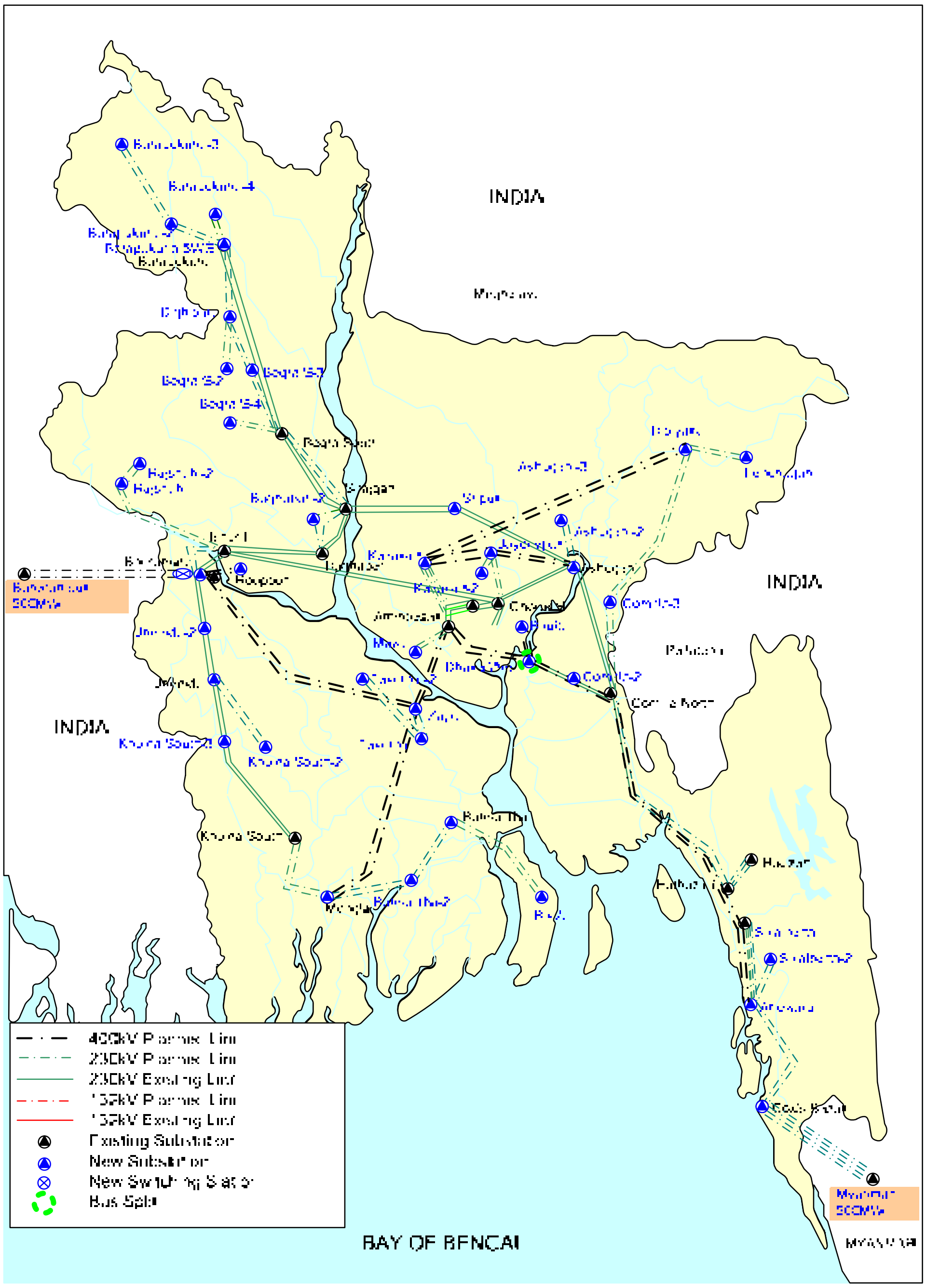
East or West	Region	Voltage	Substation	Capacity (Mvar)
East	Southern	230kV	COMIN-6	200
East	Dhaka	230kV	MANIKNAGAR	500
East	Dhaka	230kV	GHRSL	300
East	Dhaka	230kV	TONGI	100
East	Dhaka	230kV	HARIPR	200
East	Dhaka	230kV	HASNBD	500
East	Dhaka	230kV	OLDAIRPORT	500
East	Dhaka	230kV	SRIPUR	100
East	Dhaka	230kV	HARIPR2	200
East	Dhaka	230kV	RAMPR2	500
East	Dhaka	230kV	TONGI-2	300
East	Dhaka	230kV	TONGI-3	300
East	Dhaka	230kV	HASNBD-2	200
East	Dhaka	230kV	HASNBD-3	200
East	Dhaka	230kV	HASNBD-4	200
East	Dhaka	230kV	OLDAIRPORT-2	500
East	Dhaka	230kV	KALIAKAIR-2	300
East	Dhaka	230kV	KALIAKAIR-3	300
East	Dhaka	230kV	KALIAKAIR-4	300
East	Dhaka	230kV	RAMPR-2	300
East	Dhaka	230kV	RAMPR-3	200
East	Dhaka	230kV	RAMPR-5	200
East	Dhaka	230kV	GHRSL-2	300
East	Central	230kV	FENCHUGANJ	100
East	Central	230kV	ASHUGNJ-2	300
East	Central	230kV	ASHUGNJ-3	200
East	Central	230kV	ASHUGNJ-4	200
East	Central	230kV	ASHUGNJ-5	100
East	Central	231kV	FENCHUGANJ-3	100
East	Central	232kV	FENCHUGANJ-4	200
West	Western	230kV	KHULN	200
West	Western	230kV	JHENIDA	200
West	Western	230kV	KHULN-2	200
West	Western	230kV	KHULN-5	100
West	Western	230kV	BARISAL-3	200
West	Western	233kV	TAKERHAT-2	200
West	Western	234kV	TAKERHAT-3	200
West	Northern	230kV	RAJSHAHI	200
West	Northern	230kV	BAGHA	200
West	Northern	230kV	BOGRS	500
West	Northern	230kV	NOAGAON	200
West	Northern	230kV	BOGRS-3	100
West	Northern	230kV	BOGRS-2	100
West	Northern	230kV	ISHRDI-2	200
West	Northern	230kV	RAJSHAHI-2	100
West	Northern	230kV	BRPUK-3	200
West	Northern	230kV	BRPUK-5	200
West	Northern	230kV	BRPUK-7	200

Source: PSMP Study Team

9.4.4 2020 plan

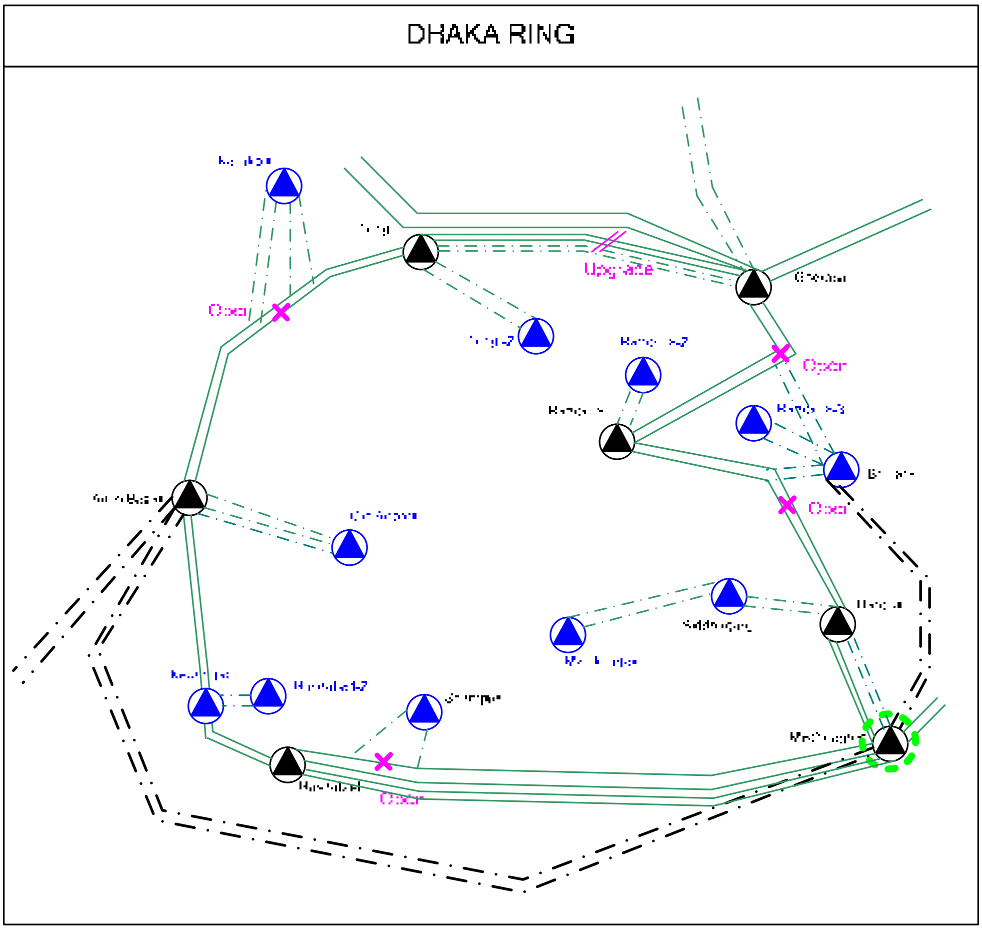
For the 2020 power system expansion plan, the power flow, the voltage, the short-circuit and the ground-fault current have been only confirmed, and the system configuration is shown in Fig. 9-27 and Fig. 9-28. The power flow is shown in APFig. 9-22 and APFig. 9-23. The 400kV transmission line for which construction is necessary from 2015 to 2020 is shown in Table 9-31 The 400/230kV substation for which construction is necessary from 2015 to 2020 is shown in Table 9-32.

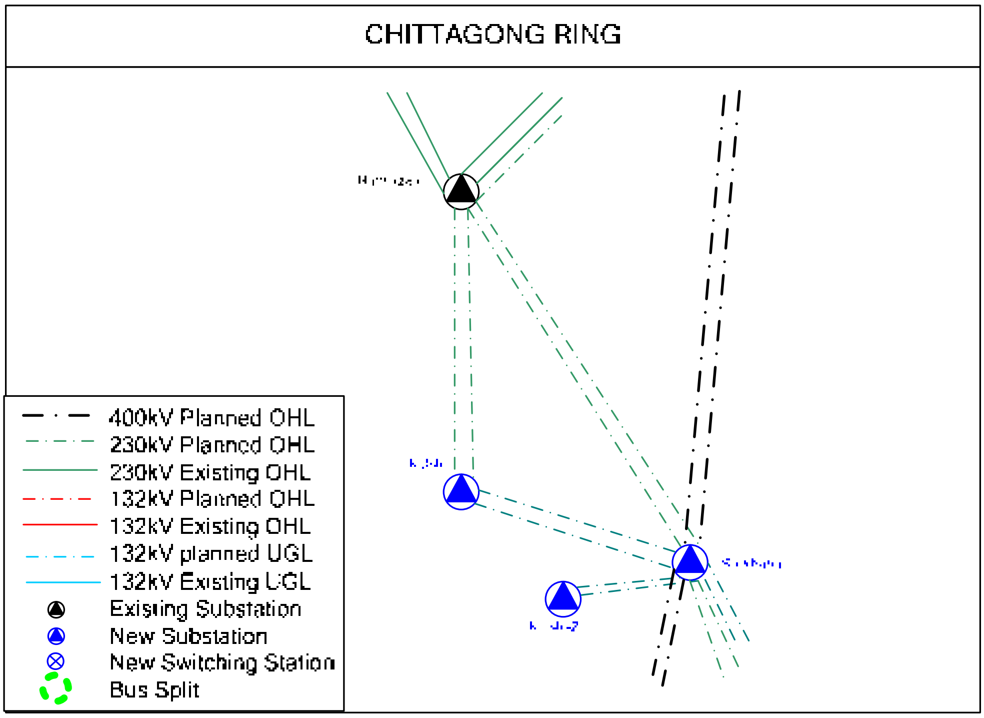
System Configuration (2020) (Grid Demand: 18GW)



Source: PSMP Study Team

Fig. 9-27 Power system expansion plan at 2020 (overall system)





Source: PSMP Study Team

Fig. 9-28 Power system expansion plan at 2020 (Dhaka and Chittagong ring)

Table 9-31 400kV transmission line required from 2015 to 2020

From Substation	To Substation	cct.	Length(km)
JOYDEBPUR	ASHUGANJ	2	56.25
MEGHNAGHAT	BHULTA	2	51.75
KALIAKAIR	JOYDEBPUR	2	56.25
ROOPPUR	BHERAMARA	2	24.75
ZAJIRA	BHERAMARA	2	337.5
		Total	526.5

Source: PSMP Study Team

Table 9-32 400/230kV substation required from 2015 to 2020

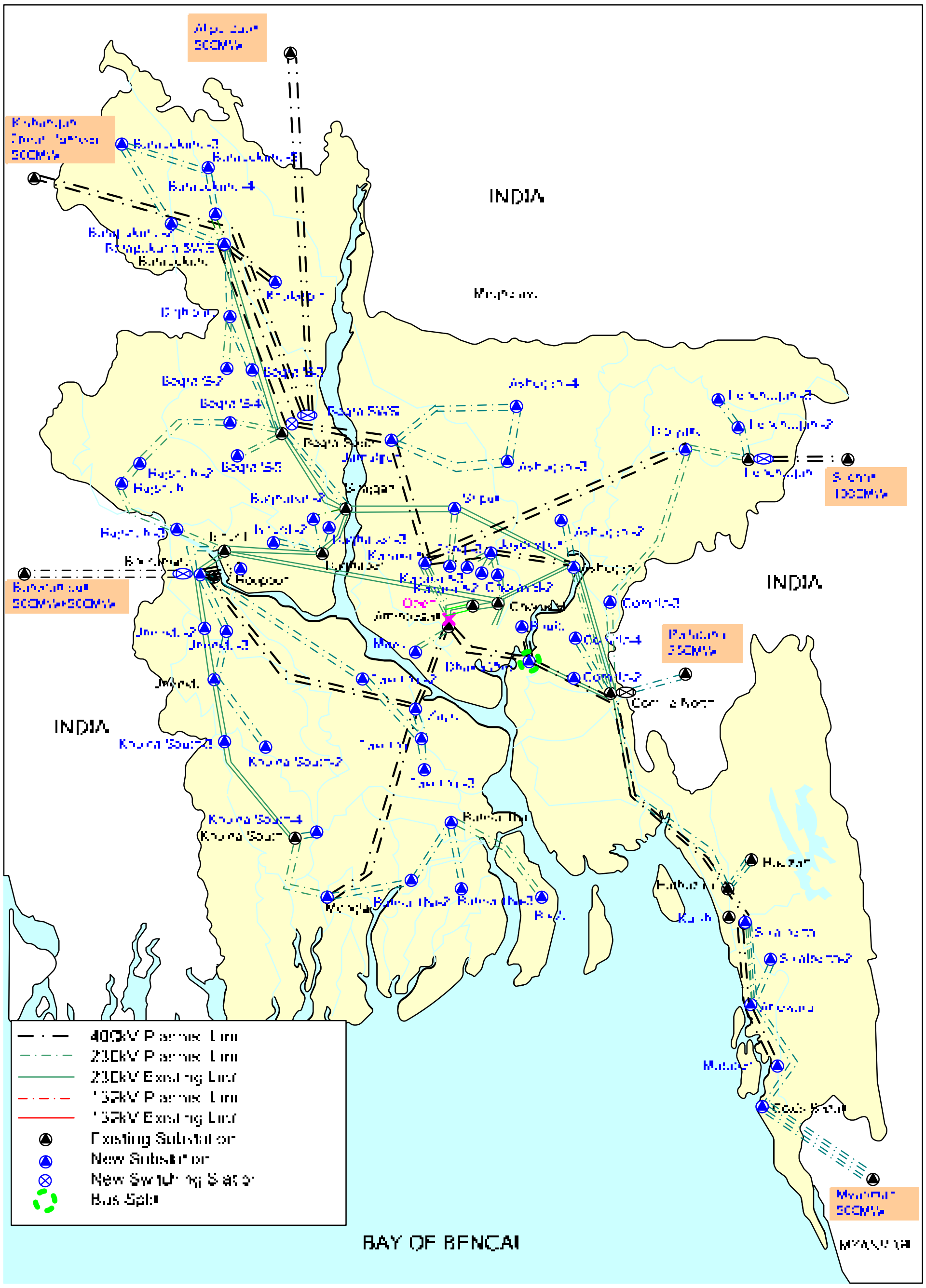
Voltage	East or West	Region	Substation
400/230kV	East	Dhaka	BHULTA
400/230kV	East	Dhaka	JOYDEBPUR
400/230kV	East	Central	ASHUGANJ
400/230kV	West	Western	ZAJIRA
400/230kV	West	Western	BHERAMARA

Source: PSMP Study Team

9.4.5 2025 plan

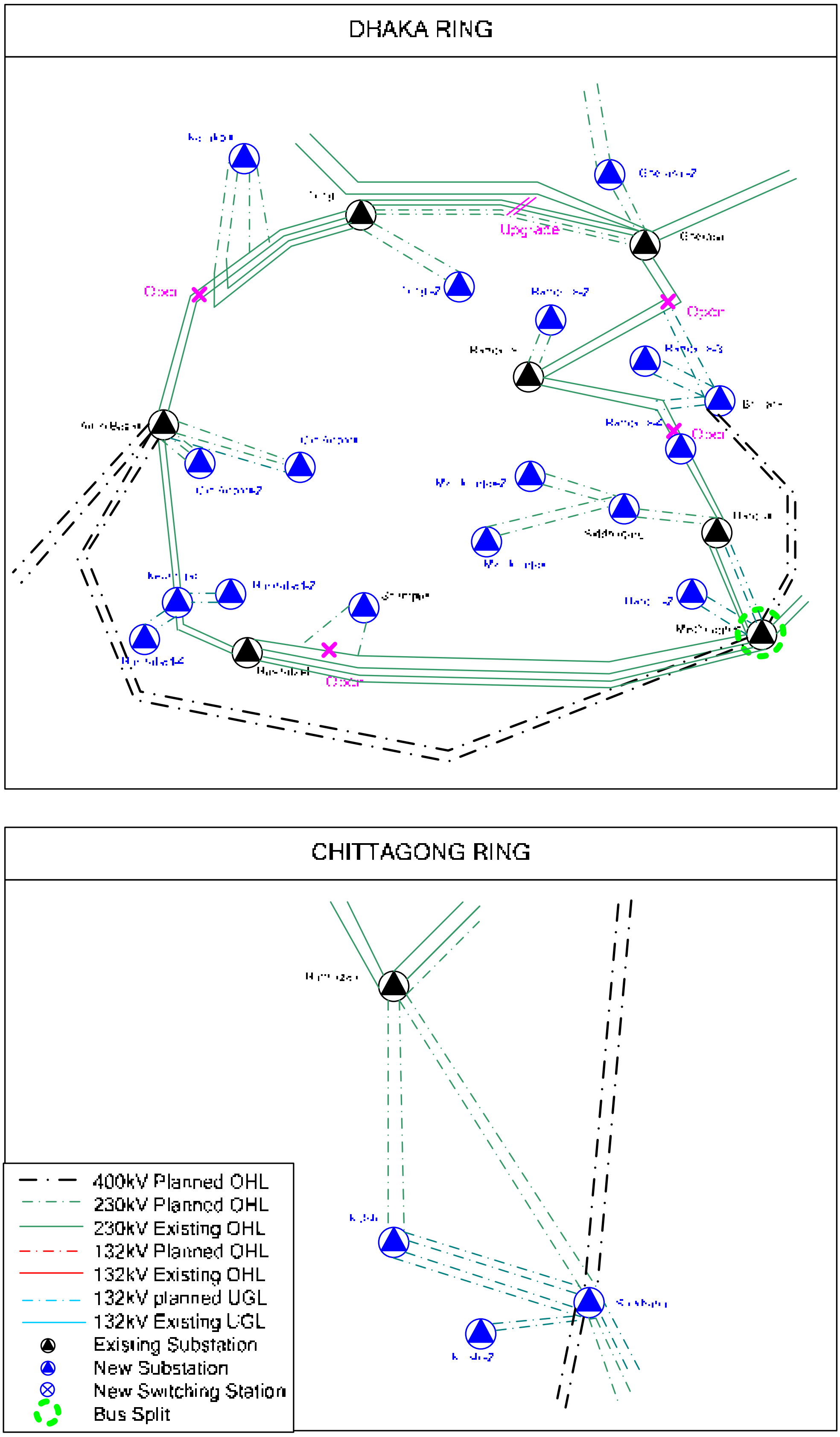
For the 2025 power system expansion plan, the power flow, the voltage, the short-circuit and the ground-fault current have been only confirmed, and the system configuration is shown in Fig. 9-29 and Fig. 9-30. The power flow is shown in APFig. 9-24 and APFig. 9-25. The 400kV transmission line for which construction is necessary from 2020 to 2025 is shown in Table 9-33. The 400/230kV substation for which construction is necessary from 2020 to 2025 is shown in Table 9-34.

System Configuration (2025) (Grid Demand: 25GW)



Source: PSMP Study Team

Fig. 9-29 Power system expansion plan at 2025 (overall system)



Source: PSMP Study Team

Fig. 9-30 Power system expansion plan at 2025 (Dhaka and Chittagong ring)

Table 9-33 400kV transmission line required from 2020 to 2025

From Substation	To Substation	cct.	Length(km)
ANOWARA	MATARBARI	2	90
BHERAMARA	ROOPPUR	2	24.75
BOGRA	JAMALPUR	2	130.5
BOGRA	PKDP	2	225
JAMALPUR	KALIAKAIR	2	162
KHARASPIR	PKDP	2	20
		Total	652.25

Source: PSMP Study Team

Table 9-34 400/230kV substation required from 2020 to 2025

Voltage	East or West	Region	Substation
400/230kV	East	Central	JAMALPUR

Source: PSMP Study Team

9.4.6 Construction cost

The construction cost based on the analysis results is shown in Table 9-35 and Table 9-36.

Table 9-35 Construction cost for facilities expansion (2010-2015)[1]

		Unit Cost		Required amount	Required Cost	
Overhead Line	132kV	0.1786	mil. US$/km/2cct	606.9	108.4	mil. US$
	230kV	0.357	mil. US$/km/2cct	500.8	178.8	mil. US$
	400kV	0.643	mil. US$/km/2cct	700.0	450.1	mil. US$
Underground Cable	132kV	0.893	mil. US$/km/2cct	54.3	48.5	mil. US$
	230kV	1.785	mil. US$/km/1cct	30.0	53.6	mil. US$
	400kV	3.215	mil. US$/km/1cct	0.0	0.0	mil. US$
River Crossing OHL	400kV North 10km	257.2	mil. US$/2cct	0	0.0	mil. US$
	400kV Middle 4.5km	115.74	mil. US$/2cct	0	0.0	mil. US$
	400kV South 6km	154.32	mil. US$/2cct	1	154.3	mil. US$
Substation	132/33kV(2x100MW, AIS)	5	mil. US$/station	46	230.0	mil. US$
	132/33kV(2x100MW, GIS)	5.714	mil. US$/station	19	108.6	mil. US$
	230/132kV(2x500MW, AIS)	23.3	mil. US$/station	0	0.0	mil. US$
	230/132kV(2x500MW, GIS)	26.7	mil. US$/station	5	133.3	mil. US$
	230/132kV(2x300MW, AIS)	14.0	mil. US$/station	7	98.0	mil. US$
	230/132kV(2x300MW, GIS)	16.0	mil. US$/station	0	0.0	mil. US$
	400/230kV(4x500MW, AIS)	81.2	mil. US$/station	0	0.0	mil. US$
	400/230kV(3x500MW, AIS)	60.9	mil. US$/station	1	60.9	mil. US$
	400/230kV(2x500MW, AIS)	40.6	mil. US$/station	4	162.3	mil. US$
	400/230kV(1x500MW, AIS)	20.3	mil. US$/station	1	20.3	mil. US$
Switching Station	400kV	20.3	mil. US$/station	1	20.3	mil. US$
BTB	230kV, 400kV	80.0	mil. US$/station	1	80.0	mil. US$
Static Capacitor	132kV	0.017	mil. US$/Mvar	1528	25.5	mil. US$
	230kV	0.029	mil. US$/Mvar	0	0.0	mil. US$
	400kV	0.051	mil. US$/Mvar	0	0.0	mil. US$
				Total	1932.7	mil. US$

Source: PSMP Study Team

[1] Cross border transmission line is included.
Bheramara 30km

Table 9-36 Construction cost for facilities expansion (2010-2030)[1]

		Unit Cost		Required amount	Required Cost	
Overhead Line	132kV	0.1786	mil. US$/km/2cct	606.9	108.4	mil. US$
	230kV	0.357	mil. US$/km/2cct	3035.2	1083.6	mil. US$
	400kV	0.643	mil. US$/km/2cct	2693.1	1731.7	mil. US$
Underground Cable	132kV	0.893	mil. US$/km/2cct	54.3	48.5	mil. US$
	230kV	1.785	mil. US$/km/1cct	45.0	80.3	mil. US$
	400kV	3.215	mil. US$/km/1cct	0.0	0.0	mil. US$
River Crossing OHL	400kV North 10km	257.2	mil. US$/2cct	1	257.2	mil. US$
	400kV Middle 4.5km	115.74	mil. US$/2cct	1	115.7	mil. US$
	400kV South 6km	154.32	mil. US$/2cct	2	308.6	mil. US$
Substation	132/33kV((2x100MW, AIS)	5	mil. US$/station	46	230.0	mil. US$
	132/33kV((2x100MW, GIS)	5.714	mil. US$/station	19	108.6	mil. US$
	230/132kV(2x500MW, AIS)	23.3	mil. US$/station		0.0	mil. US$
	230/132kV(2x500MW, GIS)	26.7	mil. US$/station	31	826.7	mil. US$
	230/132kV(2x300MW, AIS)	14.0	mil. US$/station	47	658.0	mil. US$
	230/132kV(2x300MW, GIS)	16.0	mil. US$/station		0.0	mil. US$
	400/230kV(4x500MW, AIS)	81.2	mil. US$/station	6	487.0	mil. US$
	400/230kV(3x500MW, AIS)	60.9	mil. US$/station	5	304.3	mil. US$
	400/230kV(2x500MW, AIS)	40.6	mil. US$/station	3	121.7	mil. US$
	400/230kV(1x500MW, AIS)	20.3	mil. US$/station		0.0	mil. US$
Switching Station	400kV	20.3	mil. US$/station	2	40.6	mil. US$
BTB	230kV, 400kV	80.0	mil. US$/station	3	240.0	mil. US$
Static Capacitor	132kV	0.017	mil. US$/Mvar	1528	25.5	mil. US$
	230kV	0.029	mil. US$/Mvar	13300	386.2	mil. US$
	400kV	0.051	mil. US$/Mvar	0	0.0	mil. US$
				Total	7162.6	mil. US$

Source: PSMP Study Team

[1] Cross border transmission line is included.
400kV Kishanganj 240km, Alipurduar 170km, Fenchuganj 40km, Bheramara 30km
230kV Commila 20km, Cox's Bazar 30km

9.5 Road map and action plan for realization of Master Plan

In this clause, domestic power system expansion according to the power demand increase was summarized from short, mid and long-term perspectives aspect as shown in Table 9-37.

Table 9-37 Road map and action plan for realization of Master Plan

Aspect	Power demand milestone in Master Plan	Issue	Action plan
Short-term	10GW for 2015	Power system expansion according to the power demand increase	■ Construction of new sixty nine 132/33kV substations ■ Construction of a transmission line across the river adjacent to Padma Bridge ■ Domestic power system expansion for interconnection with Beharampur
Middle-term	18GW for 2020	Power system expansion according to the power demand increase	■ Domestic power system expansion for interconnection with Myanmar
Long-term	33GW for 2030	Power system expansion according to the power demand increase	■ Construction of a transmission line across the river adjacent to Jamuna Bridge and Bogra District ■ Domestic and international power system expansion for interconnection with Alipurduar, Kishanganj, Baharampur, Silchar, and Pllatana

Source: PSMP Study Team

9.6 Distribution system

Distribution system should be developed in line with the power generation expansion plan and transmission expansion plan contained in the Master Plan in order to match the power supply and demand. Distribution utilities must have their own Distribution Expansion Plan in conformity with this Master Plan to realize the vision to provide access to electricity to all by 2021.

9.7 Recommendations

The following items should be taking into account for reviewing this PSMP-2010.

(1) Design of the transmission line across the river
The 400kV transmission line across the river has been studied by adopting the quad conductors to secure a large capacity. As another option, the 765kV design should also be taken into account in order to cope with the ultra-long-term increasing power flow of the east-west interconnection.

(2) Promotion of underground transmission system in urban area
In the urban area, the promotion of the underground transmission system will be a key consideration because the procuring of the transmission line right-of-way and the substation site becomes more difficult as the year passes.

(3) Additional data maintenance for system analysis
There is some inappropriate data for the system analysis. In particular, as recommended in PSMP-2006, the owners of the generation facilities and PGCB will need to make a considerably greater and better coordinated effort of the data maintenance.

(4) Adoption of N-2 criteria
The adoption of N-2 criteria should be evaluated for the grid connection of large-scale power generation such as nuclear power plants on a case-by-case basis.

(5) Strengthening of human resources development for system analysis
The system analysis is a technology necessary to form a power system with high efficiency and reliability. Additionally, a technology with a high degree of specialization

peculiar to each power utility is requested, and it is an urgent issue that the human resources development for system analysis in the future be strengthened.

(6) Distribution expansion plan based on this Master Plan

Distribution system also needs to be expanded commensurate to the generation and transmission expansion plans.

Chapter 10 Financing for Materialization of the Master Plan

10.1 Total investment required and funding sources

10.1.1 Capital cost

(1) Generation and transmission plants

For the construction of new generation and transmission plants constituting the Master Plan, the total investment costs are estimated to be as follows;

Table 10-1 Generation and transmission plants and cost estimates (FY 2010 constant price)[1]

Fuel Type	Capacity	Investment Cost (Tk Billion)	Investment Cost (US$ million)
Coal			
Domestic Coal	11,050 MW	1,094	15,721
Imported Coal	8,400 MW	935	13,436
Gas	8,956 MW	531	7,630
Furnace Oil	3,817 MW	300	4,311
Diesel Oil	500 MW	39	560
Hydro	100 MW	10	144
Renewable Energy	111 MW	25	359
International Connection	3,500 MW		
Transmission	—	524	7,530
Total	36,434 MW	3,458	49,691

Source: PSMP Study Team

(2) Related facilities

The Master Plan requires the following facilities to be developed along with the development of the generation and transmission plants;

Table 10-2 Related facilities required for the Master Plan (FY 2010 constant price)[2]

Facility	Particulars	Investment Cost (Tk Billion)	Investment Cost (US$ million)
Domestic Coal Mines	4 mines at BCMC, Khalaspir, Dighipara & Phulbari	585	8,406
Domestic Gas Fields		446	6,409
Coal Center for Imported Coal	4 centers at Chittagong South, Mongla, Matarbari & Sonadia	115	1,653
Gas Transmission		87	1,250
LNG Terminal		19	273
Single Point Mooring		5	72

[1] The plants listed in the table contain the ones that will expire prior to 2030 due to a short life span and the total capacities do not tally with the net increase of capacities under and at the end of the Master Plan. The investment cost for the transmission of electricity through the international connection is included in the transmission cost. Aside from the plants listed, the government of Bangladesh maintains a plan to develop 4,000 MW of nuclear power generation. The exchange rate applied for calculation is US$1=Taka 69.59 (the actual average rate for FY 2010).

[2] Out of the plants listed, domestic gas development, gas transmission, LNG terminal, oil refinery, ports will serve their purposes including the ones other than the power supply. The cost expressed in the table indicates the cost of the portion that serves the power supply only. The exchange rate applied is the same of that of the preceding table.

Facility	Particulars	Investment Cost (Tk Billion)	Investment Cost (US$ million)
Oil Refinery		35	503
Railroad	4 lines of Mongla-Khulna, Cittagong-Chittagong South, Matarbari & Sonadia	18	259
Deep Sea Port	2 ports at Matarbari & Sonadia	140	2,012
Total		1,449	20,822

Source: PSMP Study Team

10.1.2 Aggregated amount of investment

The aggregated amount of investment for the development of the generation, transmissions and the related facilities are estimated to be as follows;

Table 10-3 Aggregated amount of investment

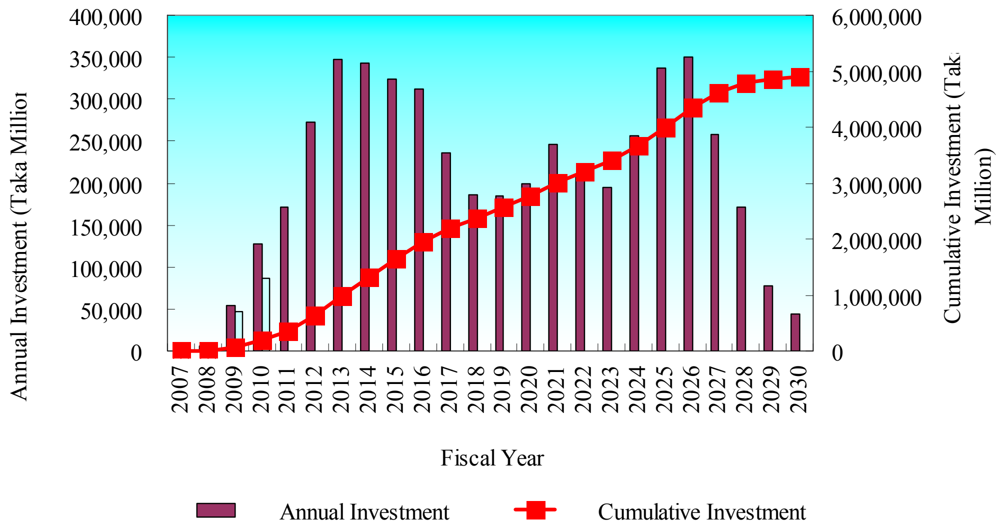
Executing Agency	Generation Capacity	Total Investment (Taka Billion)	Annual Averega of Investment (Taka billion)	ditto (US$ million)
Generation & Transmission				
Public Sector	5,787 MW	947	47.4	681
Private Sector	9,436 MW	710	35.5	510
Pub/Priv Unclassified	17,600 MW	1,776	88.8	1,276
Renewable Energy[1] & Intl Connection	3,611 MW	25	1.3	19
Sub-total	36,434 MW	3,456	172.8	2,483
Related Facilities		1,449	72.5	1,042
Total	36,434 MW	4,905	245.3	3,525

Source: PSMP Study Team

The aggregated investments for the development of the generation, transmission and related facilities are found to be at Taka 4.9 trillion (US$ 70.5 billion). The annual average of the investment amounts to Tk 245 billion (US$ 3.5 billion). The peak of the investment will be reached in FY 2013 for the amount of Tk 347 billion (US$ 5.0 billion) while the bottom will be found during the final couple of years. The amount will be Tk 78 billion (US$ 1.1 billion). The year wise investment and its cumulative total appear in the figure below.

The graph presents the twin peaks of annual investments, the first one of which is during the fiscal years of 2012 and 2017, while the second one is during FY 2024 and FY 2027. The first peak is formed by a concentration of investments that are intended to cope with the prevailing power shortage while the second one is formed by the concentration caused by the retirements of plants with shorter life spans that have been constructed during the first peak period. The issue of financing is critically important for meeting the financial needs during the first peak period, in particular. The underlying reason is found in the fact that the entire first peak of investments is the new investments that need to be identified with financing sources from scratch. The second peak, on the other hand, should be less difficult in terms of financing as the expiring plants accompany the accumulated depreciation that can be re-invested for the replacing of investments.

[1] Hydro power is excluded from renewable energy, included in "Generation & Transmission, Public Sector".



Source: PSMP Study Team

Fig. 10-1 The aggregated investment under the Master Plan (FY 2010 constant price)

10.1.3 Source of funds

(1) Government budget

The national budget is comprised of the development budget and non-development budget. The government introduced the Medium Term Budget Framework (MTBF) System in FY 2005-06 under which the government allocates all of the central ministries and agencies a pre-determined amount of budget within which the ministries and agencies are authorized to compile the development as well as the non-development budget. The MTBF is compiled every year by the Ministry of Finance, discussed and approved at the National Diet together with the annual budget.

In order for the government to cope with the acute power shortage, the government has announced the power sector as the priority sector and established a Power Generation System Development Plan[1]. The plan focuses on new development efforts in the three thronged approaches of public, private and public-private partnership efforts through which the government plans to complete the new generation capacities of ; 792 MW; 920 MW; 2,269 MW; 1,675 MW; 1,170 MW; 2,600 MW annually with an aggregate capacity of 9,426MW from the fiscal years of 2010 to 2015. Through the plan’s implementation, the government intends to resolve the deficient power supply gap. The annual budget has been compiled to achieve the target incorporated in the plan. MTBF indicates the levels of the budget required up till the fiscal year of 2013 as follows;

[1] Ministry of Finance, “Towards Revamping Power and Energy Sector: A Road Map”, June 2010

Table 10-4 Estimated level of expenditure under MTBF[1]

(Taka Billion)

Fiscal Year	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Nominal GDP	6,906	7,803	8,834	10,030	11,407	12,942
GDP Growth (Nominal)	12.3%	13.0%	13.2%	13.5%	13.7%	13.5%
GDP Growth (Real)	6.0%	6.7%	7.2%	7.6%	8.0%	8.0%
Total Budget (Total Expenditure)	943	1,138	1,295	1,500		
Total Budget／GDP (%)	16.0%	16.9%	17.2%	17.4%	17.8%	18.1%
Power Sector	27	50	45	54		
Power Sector／Total Budget (%)	2.9%	4.4%	3.5%	3.6%		

Source: Ministry of Finance, "Medium Term Budget Framework", June 2010

Meanwhile, the actual records of the national budget between FY 2006 through FY 2011 and their annual development budget (ADP : Annual Development Programme) are acknowledged to be as follows;

Table 10-5 Performance of government budget[2]

(Taka Billion)

Fiscal Year	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Total Budget	611	668	861	941	1,105	1,322
ADP	215	216	225	230	285	385
Current Expenditure Budget	396	452	711	711	820	937
Power Sector (ADP + Non -ADP)	34	29	31	27	27	50
Power／Total Budget(%)	5.6%	4.3%	3.6%	2.9%	2.4%	3.8%

Source: Ministry of Finance, "Medium Term Budget Framework", June 2010

During the past several years, investment for power sector development has been stagnant and its result has been reflected into the actual performance records of the budget. The actual amounts expended during the fiscal years between FY 2006 through FY 2010 have averaged at Tk 30 billion (=US$ 430 million) annually. It has been observed during those years that despite the budgets that were allocated with the amounts exceeding the levels of the preceding years' expenditures, the original budgets were found to be un-expendable due to delays in their implementation resulting in the reduction of the budget at the stage of compiling the revised budget. As a result, the actual records of ADP allocation for each year was found at the same level which is similar to the level of the total commitments of the three major donors to be analyzed later. This fact indicates that the constraint in the budget allocation was not the cause of delay in the development of the power sector but that the slow implementation of development caused the budgetary allocation to be halted. This reveals the prevailing fact connected to the delay in development and its implementation.

The budget allocation for FY 2010-11 amounts to Tk 50 billion which is acknowledged to cover a mere 20% of the total investment estimated for the Master Plan, indicating that the

[1] Fy 2009-10 is the revised budget, FY 2010-11 is the original budget and FY 2011-12 is the estimate by Ministry of Finance.
[2] Years up till FY 2009-10 are the revised budgets and FY 2010-11 is the original budget.

implementation of the Master Plan is by far not possible with the sole funding from the national budget. What is indicated clearly is that the only measure to cope with the situation can be found in the promotion and accelerated tapping of the private sector source for funds. It should be noted here that there exists a difference in the scopes encompassed by the Master Plan and the one for the national budget. The Master Plan includes the infrastructure required for the generation and transmission as the Related Facilities while it excludes the distribution from its scope. On the other hand, the national budget includes the distribution within its allocation for the power sector while the budget for the Related Facilities of the Master Plan are to be placed for the budget allocation under other sectors than the power.

10.1.4 Government schemes for promotion of private sector investment

The reigning government which assumed power in early 2009 resolved to achieve 8% and 10% economic growth in 2013 and 2017 respectively to be maintained thereafter. The government fully recognizes the fact that public sector investment alone is not sufficient to achieve its target and has aimed at mobilizing resources from the private sector and its investments. The government has been promoting the development of infrastructure through the promotion of Public-Private Partnership (PPP) as the policy to develop public services via private sector investment. The target sector conceived by the government for PPP lies in the sectors such as; power and energy; transportation infrastructure; water supply and sewerage; civil aviation and tourism; manufacturing; education; health care; housing, etc[1]. The governing rule for PPP is found in the "Private Sector Infrastructure Guidelines of 2004 (PSIG)"[2] There is no specific PPP definition though it is generally conceived as the ones having the following features[3];

(1) The private sector arranges resources to build infrastructure;
(2) The private sector bears the cost of building the infrastructure;
(3) The private sector bears both the fiduciary and safety related risks related to the construction;
(4) The government and public avail themselves of the service by paying appropriate prices or fees;
(5) The private sector cannot raise the prices, fees or charges unilaterally; and
(6) PPP initiatives are usually long term (15-30 years) in nature.

Since 1997, the government has established the following three institutions to promote PPP;

(1) Infrastructure Development Company Ltd. (IDCOL)[4]

IDCOL was established in 1977 under the Economic Relations Department of Ministry of Finance. The growth of its financial activities has accelerated since 2006. IDCOL has managed to arrange financing for 22 projects totaling Tk 13 billion as of June 2009, out of which IDCOL lends from its own source Tk 3.0 billion. In an annual average, the number of projects arranged is five for the financed amount of Tk 3.0 billion out of which IDCOL has lent Tk 0.8 billion from its own resources. By arranging syndicated loans, IDCOL has successfully arranged a large scale financing scheme for large projects materializing large leverage effects while using a relatively smaller amount of its own resources. IDCOL owes its primary source of funds to such organizations as; IDA; ADB; KfW; SNV-Netherlands Development Organization; GTZ; Islamic Development Bank, etc. The projects that have been arranged by IDCOL in the power sector are listed in the following table;

[1] Ministry of Finance, "Invigorating Investment Initiative Through Public Private Partnership: A Position Paper", June 2009
[2] Cabinet Division, "Bangladesh Private Sector Infrastructure Guidelines of 2004"
[3] Bangladesh Bank, "Annual Report 2008-09"
[4] Ministry of Finance, "Invigorating Investment Initiative Through Public Private Partnership: A Position Paper", June 2009

Table 10-6 List of power sector projects of IDCOL

(Taka Million)

Sector	Project	Type of PPP	Total Investment
Power	Meghnaghat 450 MW Power Plant	BOO	21,000
	Summit Power 33 MW Power Plant	BOO	1,250
	Summit Uttaranchal Power Company 44 MW Power Plant	BOO	1,970
	Summit Purbanchal Power Company 66 MW Power Plant	BOO	3,000
	VERL 34 MW Power Plant at Bhola	BOO	1,200
	BEDL 51 MW Power Plant at Sylhet	BOO	1,830
	34 MW Malancha Holdings Power Plant at Dhaka EPZ	BOO	1,650
	Shah Cement 11.6 MW Power Plant	Captive	590
Renewable Energy	IDCOL Solar Energy Program	NGO	20,060
	250 kW Biomass Gasification Based Power Plant	BERC License	25
	50 kW Biogas Based Power Plant	Govt License	5

Source: Ministry of Finance, "Invigorating Investment Initiative Through Public Private Partnership: A Position Paper", June 2009

(2) Investment Promotion and Financing Facility (IPFF)

IPFF was established in 2007 under the purview of Central Bank. IPFF provides the funds to promote PPP projects that will be implemented by the private sector. The target projects are selected in accordance with the guidelines and rules established by the World Bank (WB) but are required to be commercially viable. The total amount of funds originally provided was Tk 4.18 billion (US$ 47.5 million from IDA and US$ 10 million from GOB). The Facility has arranged finances to five power sector projects for the total capacity of 178 MW up till June 2009. The aggregate total amount of investments of the five projects was Tk 8.67 billion out of which IPFF financed Tk 4.41 billion while the private investors invested Tk 2.51 billion and the private sector financial institutions lent Tk 1.46 billion. WB acknowledges in its project evaluation report that IPFF attained a leverage effect exceeding 100% of the amount invested in successfully mobilizing the aggregated sum of no less than US$ 120 million[1]. The following table lists the projects in the power sector that are financed by IPFF;

[1] World Bank, "Investment Promotion and Financial Facility Project", April, 2010

Table 10-7 List of power sector projects of IPFF

(Taka Million)

Sector	Project	Type of PPP	Total Investment
Power	Three 22 MW Doreen Power Generation & System Ltd. (2 in Tangail & 1 in Feni)	BOO	3,430
	11 MW Doreen Power House & Technologies Limited at Mahipal, Feni	BOO	564
	22 MW Regent Power Limited	BOO	1,108
	Malancha Holdings Ltd. (44 MW Captive Power Plant at CEPZ)	BOO	1,919
	Malancha Holdings Ltd. (35 MW Captive Power Plant at CEPZ)	BOO	1,649

Source: Ministry of Finance, "Invigorating Investment Initiative Through Public Private Partnership: A Position Paper", June 2009

IPFF has used up almost all of the funds initially provided and, in May 2010, WB has approved a new facility amounting US$ 257 million through the IDA. Given the injection of the new funds, it is now capable for the IPFF to finance PPP projects amounting to approximately US$ 40-60 million (Tk 2.8-4.2 billion) annually[1].

(3) Bangladesh Infrastructure Finance Fund Ltd. (BIFF)

BIFF was established in September 2010 through a 100% investment by the government with an initial capital injection of Tk 16 billion. The Company aims at providing equity and loans to infrastructure projects including the power sector. The government is now soliciting equity participation to private sector and oversea investors.

(4) PPP funds of national budget

Aside from the aforementioned independent institutions, the government sets aside an allotment of special funds for PPP promotion. The current budget carries Tk 30 billion of such an allocation. The execution of the budget is decided by an independent organization under the purview of cabinet. The government is reported to be undergoing the selection and evaluation of the projects for financing though their details are not yet publicly disclosed. The size of the funds appears to be a potentially powerful financial source. Assuming that a portion of the funds are mobilized to the power sector to an extent similar to the resource allocation plan of IPFF, 39%, a significant amount of Tk 11.7 billion would be allocated to the sector. Should such an allocation bring about a 100%leverage effect, the combined total of potential financing of the budget and the private sector financing would be as large as Tk 23.4 billion annually.

10.1.5 Assistance by Donors

(1) Official development assistances

Significant providers of financial assistance to the power sector are the Asian Development Bank (ADB), the WB and Japan International Cooperation Agency. The assistance provided by these three donors during the past five years are listed in the following table;

[1] ditto

Table 10-8 Financial assistances provided by three major donors[1]

	JICA		ADB		WB	
	Project	Amount (JPY million)	Project	Amount (US$ million)	Project	Amount (US$ million)
2005-06	Grid S/S & Transmission	4,642			(PPP Invest Promotion)	(50)
2006-07			West Zone Power Devt	199		
			Sustainable Power Devt	400		
			Sustainable Power Devt	60		
2007-08	Haripur Power	17,767			Power Sector Devt Policy Cr.	120
2008-09	Central Zone Distribution	9,715			Siddirganj Peaking Plant	350
	Haripur Power (II)	22,210				
2009-10	Rural Area Distribution	13,241			Addl Financing for Rural Elect.	130
	Bheramara Gas CC (E/S)	2,209			(PPP Invest Promotion)	(257)
Total		69,784 (= US$ 813 mill)		659		600

Source: Websites of the respective institutions

The amounts committed to each fiscal year have been summarized as below;

Table 10-9 Year-wise commitment by the three donors

(US$ million)

	2005-06	2006-07	2007-08	2008-09	2009-10	Total	Ann. Ave.
JICA	54		208	373	181	816	163
ADB		659				659	132
WB			120	350	130	600	120[2]
Total	52	659	317	705	302	2,035	415 (=Tk 29 billion)

Source: Websites of the respective institutions

(2) Assistance for promotion of private sector investment

In addition to the official development assistance to the government, the WB has been providing financial assistances for the promotion of private sector investment to institutions such as IDCOL and IPFF through IDA or GEF. ADB is following the same track with WB for promoting private sector investment. The following are the typical cases of private sector investments for which both of the organizations extended direct assistances;

[1] Exchange Rate between JPY and US$: US$ 1=JPY 85.50

[2] In addition to what is listed here, World Bank extended financial assistances to IPFF for US$ 50 million in April 2006 and US$ 257 million in April 2010.

(a) Haripur 360 MW Combined Cycle Power Station Project (World Bank committed in 2000)[1]

The Haripur Power Station was initiated as a BOO project and awarded to AES Corporation through competitive bidding. The project raised the total funds of US$ 183 million from the sponsor, IFC and private financial institutions. The equity raised was US$ 68 million and the remaining US$ 115 million was raised from debt, out of which the IFC provided a loan for US$ 54 million (repayment in 10 to 15 years) and private financial institutions provided US$ 61 million. For the portion of the private financial institutions' lending (repayment in 10-15 years with the rate of interest at LIBOR + 2.00-2.25% p.a.), IDA provided a partial risk guarantee for US$ 61 million. The partial risk guarantee (for 15 years) issued by IDA contained such assurances as ; (i) non-compliance on the part of government institutions of PPA and GSA; (ii) political force majeure (forced acquisition); (iii) convertibility of currency; (iv) changes of laws and regulations; (v) natural calamities and force majeure, etc. based on the counter guarantee rendered by GOB. In addition to the partial risk guarantee, a financing package included, among others; (i) Implementation Agreement to be signed by Ministry of Power, Energy and Mineral Resources (MPEMR); (ii) Power Purchase Agreement (PPA) for 22 years; (iii) Gas Supply Agreement (GSA) for 22 years; and (iv) a Land Lease Agreement.

(b) Meghnaghat 450 MW Power Station Project (ADB committed in 2000)[2]

Meghnaghat Power Station was initiated as a BOO project and awarded to AES Corporation through a competitive bid. The project raised an amount of funds totaling US$ 290 million from the sponsor, ADB and private financial institutions. The equity raised was US$ 75 million and the remaining US$ 220 million was raised from debt, out of which ADB provided a direct loan of US$ 50 million and private financial institutions provided US$ 80 million. For the portion of the private financial institutions' lending, ADB provided a partial risk guarantee for US$ 70 million. The amount of the partial risk guarantee covered only 32% of the total debt portion, while the remaining part of the debt was provided by domestic financial institutions including IDCOL who were not eligible for the risk guarantee. Such experience implies that as early as in 2000, there existed domestic financial institutions that were capable of providing long term financing for the development of the power sector if the terms and conditions of such financing meet the requirements of the lender institutions. In addition to the partial risk guarantee, the financing package included among others an; (i) Implementation Agreement to be signed by MPEMR; (ii) Power Purchase Agreement (PPA) for 22 years; (iii) Gas Supply Agreement (GSA) for 22 years; and (iv) a Land Lease Agreement.

10.1.6 Probability for expansion of fund raising

(1) Conventional sources of funding

Thus far, the PSMP Study Team has reviewed the sources of funds that can be tapped into by the power sector for the implementation of the Master Plan and examined the amount of funds potentially available for the development of the power sector. The following table summarizes the sources of funds, present level and potentially available level in the near future;

[1] World Bank, "Syndicated Commercial Loan to AES Haripur (Private) Ltd. for the Haripur Power Project in Bangladesh", May 2000
[2] Asian Development Bank, "Extended Annual Review Report: Loan and Political Risk Guarantee Bangladesh: Meghnaghat Power Project", March 2008

Table 10-10 Funding source and volume of available funds

(Tk billion)

Funding Source	Allocation to Power Sector (Ann. Ave.)	Potential Allocation (in 2-3 years; Ann. Ave.)	Leverage Effect[1] (Ann. Ave.)	Particulars
National Budget (Power Sector)	50	+ 28.4	0	To grow along with GDP and donors' commitment
IDCOL	0.8		0.8	To expand by contribution of GOB and donors
IPFF	1.5	+ 0.8	2.3	IDA committed 2nd loan for US$ 257 million in 2010. The PSMP Study Team assumes the funds to be consumed in 3 years while 39% will be allocated to power sector. Leverage effect is assumed based on WB's evaluation report on IPFF[2].
PPP Fund within National Budget	0	+ 9.0	9.0	The PSMP Study Team assumes 30% to be allocated to power sector
Infrastructure Finance Fund	0	+ 1.6	+ 1.6	Initial funds of Tk 16 billion. The PSMP Study Team assumes the funds to be consumed in 3 years and 30% of the funds to be allocated to power sector.
Donor Loans[3]				
JICA	(11.3)	-	0	
ADB	(9.2)	(+ 5.7)	0	Country Operation Business Plan (2011-13) projects total commitment for US$ 3,205 million. COBP plans to allocate 30% to energy sector[4]. The PSMP Study Team assumes 20% to be allocated to generation and transmission.
WB	(8.4)	(+ 14.4)	0	Country Assistance Strategy 2011-14 plans total commitment for 3 years: US$ 6,550 million[5]. The PSMP Study Team assumes 15% of the funds to be allocated to generation and transmission.
China				Assisted Barapukuria Coal PowerStation (commissioned in 2006)
India				Agreed in 2010 to assist

[1] The leverage effect refers to the economic effects that realize in mobilizing the third party capital in addition to the investor's own equity investment. The leverage effect in the table is defined as the investment and loans to be made by the private sector to development projects while deeming the public sector investment and loans as the equity.
[2] World Bank, "Investment Promotion and Financial Facility Project", April, 2010
[3] Execution of donor assistance is carried out by being incorporated into the national budget. To avoid duplication with ADP budget, the volumes of donor's commitment are not counted here but is shown as a reference only.
[4] Asian Development Bank, "Bangladesh: Country Operations Business Plan FY 2011-13", July 2010
[5] World Bank, "Country Assistance Strategy for Bangladesh FY 2011-2014", July 2010.

Funding Source	Allocation to Power Sector (Ann. Ave.)	Potential Allocation (in 2-3 years; Ann. Ave.)	Leverage Effect[1] (Ann. Ave.)	Particulars
				Baharampur to Bheramara Power Transmission and construction of two coal based power stations.
Russia				Assisted Ghorassal Power Station (2X210 MW) and agreed in 2010 to assist nuclear power stations.
Donor Assistance to Private Sector Investment1				
ADB		+ 2.5	+ 6.8	The PSMP Study Team assumes ADB to assist IPPs similar to Meghnaghat Power Station by one plant each for three years.
WB		+ 2.5	+ 6.8	Same with for ADB
Rental Power	18	▲ 18	0	
Total	70.3 (US$1.0 B)	+ 26.8 (US$0.4 B)	+ 27.3 (US$0.4 B)	Total funds incl. leverage: Tk 122 billion (US$ 1.7 billion)

Source: PSMP Study Team

The above can be summarized in the following table;

Table 10-11 Funding source and fund volume for the Master Plan

(Taka Billion)

	Present Level of Fund Volume	Fund Volume Expected in 2-3 Years[2]	Annual Average Investment under Master Plan
National Budget (incl. ODA assistance by donors)	50	78.4	
Government Schemes for PPP Promotion	2.3	25.1	
Donors' Assistance to IPPs	-	18.6	
Rental Power	18	0	
Total	70.3	122.1	245.3

Source: PSMP Study Team

The volume of funds currently available from the identified sources of funds stands at Tk 70 billion (US$ 1.0 billion) annually. In the 2-3 years to come, the PPP funds in the national budget and commitments by donors are expected to increase. In addition to those mentioned and for the sake of analysis, the PSMP Study Team assumes that WB and ADB extend their assistance of direct loan and partial risk guarantees to one IPP plant for each three year period. Given these assumptions, the annual allocation to the power sector will increase by Tk 27 billion (US$ 0.3 billion) which will then be added by the leverage effect of Tk 27 billion (US$ 0.4 billion). The total volume that can be financed in consideration of those effects will amount to Tk 122 billion (US$ 1.7 billion). The Master Plan as a whole requires an annual allocation of Tk 245 billion and the amount calculated for future availability covers only 50%

[1] The hypothetical project is assumed to be: 400 MW in capacity, US$ 400 million in total cost which is financed by 40% in equity, 60% in borrowings. Donors are assumed to lend 45% of the total borrowing.

[2] Includes leverage effects

of the total requirement, while the remaining 50% has yet to be identified in its funding source. It is imperative that the funding source needs to be expanded and efforts should be made to increase the funding volume from each of the funding sources to fill the gap.
In the meantime, although the realization of the Master Plan requires painstaking efforts to secure the sufficient amount of funds required, it is needed to be considerate before hastily concluding that the prevailing conditions constitutes an insurmountable barriers which could endanger the implementation of the Master Plan. In general, the funds float in search of better investment opportunities while scrutinizing the risks and returns involved. The fact that power sector was not able to receive sufficient funds for development buttresses the underlying fact that the projects have not yet been formulated which is sufficiently attractive for risk-taking and investment. What is important is to carefully prepare the projects, while developing an environment conducive to investments including the assurance of a sufficient return which is matched against the risks to be taken on the investment, diversify the funding source, pursuing the expansion of funding through which the Master Plan grows as the plan assuring a high probability of funding support.

(2) Funding sources in consideration of the global climate change

In addition to what has been described of the conventional sources of funds, funding can be sought to the mechanisms such as Global Environment Facility (GEF) and Clean Development Mechanism (CDM) established for protection of the global climate. GEF is jointly managed by the WB, UNDP and UNEF and provides the developing countries in implementing the projects purported to the issues of global environment protection with the grant funds for the projects' incremental portion of the total costs. The funds have been contributed by the participating governments to the trust fund established at the WB and are utilized by the managing institutions for implementation of the projects in developing countries. As of present, an approximate number of 10 projects have been implemented in Bangladesh including one project in the power sector which is Rural Electrification and Renewable Energy Development Project in 2002.

CDM, on the other hand, is the mechanism established by Kyoto Protocol and others for protection from the global climate change. The developed countries can earn merits in implementing projects purported to the reduction of the emission of greenhouse gas (GHG), a portion of which can be credited to the donor country. The project owner is required to prepare a Project Design Document which is to be scrutinized by the Designated National Authorities of the donor and the recipient counties and be validated by the Designated Operational Entity of the system. The amount of the reduction is approved by the Executive Board as Certified Emission Reduction (CER). CER can be traded internationally and the parties obtained CER thus benefit from the investment made. The eligibility and criteria for the mechanism is stipulated under the Approved Consolidated Baseline and Monitoring Methodology (ACM). As of present, 18 categories of ACMs have been identified and rules are established for each of them that remain in force, out of which the ones that are closely related to the Master Plan are as follows;

- ACM 0002: the Consolidated Baseline and Monitoring for Grid-connected Electricity Generation from Renewable Sources,
- ACM 0007: the Methodology for Conversion from Single Cycle to Combined Cycle Power Generation, and
- ACM 0013: the Consolidated Baseline and Monitoring Methodology for New Grid Connected Fossil Fuel Fired Power Plants Using a Less GHG Intensive Technology.

Out of the 18 categories of ACMs, a large number of projects have been approved under ACM 0002 among various countries but the number of projects approved under ACM 0007 and ACM 0013 are reported to be very minimal. In particular under ACM 0013 which is relevant for the coal fired power generation, only one example of registration is reported while a relatively large number of projects are reported to be under validating assessment. The registered project is reported to be as Adani Power Ltd. in India with the generation capacity of 1,320 MW. ACM 0013 specifies the eligibility criteria as follows;

(1) Eligible project is the activity of the construction and operation of a new fossil fuel fired grid-connected electricity generation plant that uses more efficient generation technology than what would otherwise be used with the given fossil fuel. The project activity is not a co-generation power plant;
(2) The identified baseline fuel is used in more than 50% of total generation by utilities in the geographical area within the country, as defined later in the methodology, or in the country.

The conditions set out above should be relatively easier for the countries such as China or India to clear as those countries are traditionally heavily dependent on the coal fired power generation and easy to clear the threshold of 50% rule while situations are different in Bangladesh. For Bangladesh, in order to effectively benefit from the mechanisms, a proactive approach should be made to the mechanism for relaxation of the baseline rule and/or to search options that are available in other areas that are not limited to the coal fired generation plants. In the process of materialization of the Master Plan, the formulation of individual projects should take into consideration of the mechanisms that would be potentially available so as to adjust those projects to the requirement of the mechanisms and thereby enhance the probability of those advanced finance sources.

10.1.7 Promotion of private sector investment

At around 2000, the private sector development in the power sector used to be in a full swing but has lost its momentum since then. Since 2003, there has been no large scale development of IPPs. The development has been on stall for a considerable time period. The following underlying reasons behind the stagnant development are frequently referred to;

- Unfavorable business environment for investments owing to the global financial crisis and economic slump,
- Low and inadequate levels of electricity tariffs and gas tariffs,
- Vulnerable financial standing of the single power purchasing entity, BPDB,
- Unstable supply of gas for long term supply and commitment by contracts,
- Constraints of implementation capability of government institutions,
- Lack of transparency in the government processes, lack of timely decision-making and enforcement of government commitment, and
- The spreading of a skepticism among private sector investors against the government handling of private investment.

The government, on the other hand, launched a series of promotion policies and proceeded in their implementation. The following are some of the policy measures launched by the government;

- Exemption and alleviation of income taxes, import duties and value added taxes by virtue of the Private Power Generation Policy,
- The purchasing of electricity generated by captive generation plants by virtue of the Captive Power Generation Policy
- Establishment of PPP Guideline and special fund allocation for PPP within the national budget,
- Introduction of rental power generation and quick rental power generation as the emergency measures to cope with the power shortage.

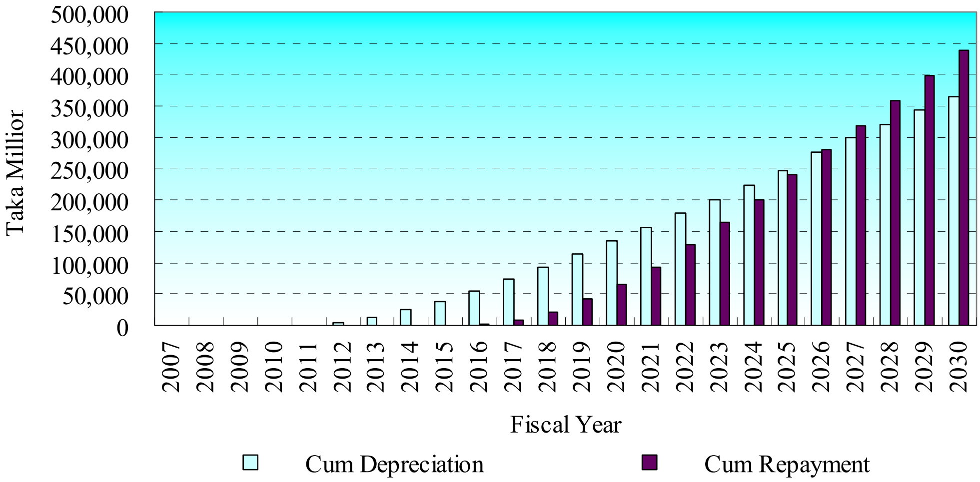
The policy measures adopted by the government directly address the improvement of investment returns and the alleviation of the shortage of funds over a shorter time span. On the other hand, the long term and fundamental elements such as protection from country risks, improvement of fundamental risk/return correlations, improvement of the financial strength of the single power purchasing entity, revision of electricity tariffs, long term assurance of fuel supply, capacity building of government institutions engaged in the power sector development, etc. have yet to be addressed and remain insufficient.

The new political regime, having assumed the power in early 2009, has started tackling the problems in the power sector by introducing and promoting a rental power generation system while launching a road-show to induce the private sector to invest in power sector development. These events are demonstrating the government attitude changes and their willingness to confront power sector issues. Such changes of the government attitude are acknowledged to have drawn positive responses from private investors. The new government has taken over from the previous government large IPPs that the previous government made repeated but abortive attempts for competitive bidding over several years in the past but has successfully approved the bidding results lately. It is imperative to capture the momentum being created and to make such changes and momentum a solid path for development. The PSMP Study Team is of the opinion that each of the aforementioned constraints needs to be addressed and measures need to be implemented for improvement, revision, alleviation and strengthening. For an individual investor facing the risk of long term investment, any one of the issues mentioned poses to be a vital factor for making his/her investment decision. The government is urged to address and resolve the following hurdles and solidify an environment conducive to investment by any means;

(1) To develop an environment which is conducive and allows for a sufficient return amount matched against the risks of long term investment,
(2) To alleviate the risks involved for the recovery of investment (strengthening of the financial health of BPDB, assurance of the government for bill collection, arrangement by the government for protection from the country risk),
(3) To revise the electricity tariffs and gas tariffs,
(4) To strengthen the financial strength of the power purchasing entity, BPDB,
(5) To promote the development of fuel and to enable a stable long term supply of fuel under a long term supply contract, and
(6) To establish a transparent process in the government handling of private investment, to proceed with a timely decision-making and its enforcement, and the due delivery of commitments.

10.2 Debt service

The above has so far delved into the fundraising for the Master Plan. For the portion of the borrowed funds, it is vital to check and confirms that the debt repayment and interest payments can be properly handled over time. With respect to the debt servicing of the principal portion, the comparison between the cumulative amount of depreciation and cumulative amount of repayment of loans provides an efficient tool for verifying that the project generates a sufficient amount cash to meet the maturities of loan installments. The relation between the depreciation and repayment in their cumulative amounts can be seen in the following figure;



Source: PSMP Study Team

Fig. 10-2 Depreciation and loan repayment (FY 2010 constant price)

The figure above illustrates that during the years under the Master Plan up till FY 2025, the cumulative depreciation stands bigger than the cumulative repayment clearly indicating that there will be no deficiency of funds for repayment of the loans borrowed during the period. During FY 2026 through FY 2030, the positions will be reversed. The depreciation will be short of the cumulative amount of repayment which will require the loans to have longer maturities than assumed in the presumption. It should be noted that, in order for the depreciation to be appropriated for the repayment, there need to be sufficient earnings that enable the depreciation to be fully accounted. The pre-requisite conditions for such earning power are connected to the sufficiency of the electricity tariff covering the cost of supply.

For all of the loans, the repayment terms have been set at 20 years[1], whereas the depreciation periods for most of the plants extend longer than the repayment period. Consequently, after 20 years has elapsed, for instance, a plant with a 30 year depreciation life shall produce 60% of the initial investment through depreciation, whereas the whole amount of the loan, being 82% of the initial investment, needs to be repaid. The situation can be easily coped with by allowing for the extension of the re-lending term of donor loans to the extent of the terms of the original donor loans. It may be argued that a longer repayment term will entail an increase of interest payments and will affect the overall generation cost. The issue can be addressed by softening the on-lending rate of interest to the extent but not lower than those of the original loans from the donors. Based on the assumption that the repayment shall be accommodated within the cumulative depreciation and the overall supply cost of electricity shall be covered by the power tariff, the interest accruing to the borrowed funds should be managed out of the current revenue of electricity sales in maintaining the healthy financial status of the power supply system as a whole. The scenario provides explicit assurance that there shall be no problems with respect to the due performance in debt servicing under the Master Plan.

10.3 Cost of input

The Sub-Chapter deals with the next issue of analyzing the overall generation cost of the country as a whole through the implementation of the Master Plan and subsequently how the electricity tariff should be adjusted in line with the Master Plan. The analysis, first, reviews the cost

[1] Ministry of Finance, "Lending and Relending Terms of Local Currency and Foreign Loans", March, 2004 establishes the standard terms and conditions for government providing funds to publicly implemented projects. The individual project can be discussed and approved for different terms and conditions with flexibility.

elements of the inputs with exception of the capital cost that has been seen before, to the power system for the implementation of the Master Plan.

10.3.1 Construction cost and O&M expense

For all generation and transmission, standard costs are contemplated for different type and size of the plants based on the latest market and technology information. In addition to the estimate of the construction cost, the O&M expense is estimated in two parts, namely; the fixed expense and the variable expense to develop analytical model that is fit for changing operational environment. For the generation plants, the following standard schedule has been applied in estimating the expense;

Table 10-12 Standard O&M expense for generation plants (FY 2010 constant price)[1]

Capacity Class & Type	Fuel	Plant Construction Cost (US$/kW)	Fixed Expense (US$/kW/yr)	Variable Expense (US$/MWh)
120 MW CT	Gas	530	10.6	0.6
120 MW CT	Furnace Oil	600	16.0	0.9
150 MW CT	Gas	500	10.0	0.6
150 MW CT	Furnace Oil	500	13.3	0.9
140 MW CC	Gas	1,170	23.4	1.3
350 MW CC	Gas	950	19.0	1.1
450 MW CC	Gas	860	17.2	1.0
450 MW CC	Furnace Oil (Dual Fire with Gas)	980	26.1	1.5
750 MW CC	Gas	660	13.2	0.8
600 MW ST USC	Coal (Imported)	1,600	53.3	3.0
600 MW ST USC	Coal (Domestic)	1,500	50.0	2.9
1000 MW ST USC	Coal	1,350	45.0	2,6
-	Hydro	1,400	2.3	4.7

Source: PSMP Study Team

10.3.2 Fuel cost

The fuel cost is derived from the ones that have been adopted by the long term development planning of the Master Plan. The system tool utilized for the long term development analyzed and obtained the optimal solution that realizes the least cost development planning, given the pre-determined assumptions. The financial analysis needs to synchronize the same terms and conditions adopted in such a planning phase to make the output of the analysis valid and relevant. The Master Plan has adhered to the following scenario of estimates;

[1] CC: Combined Cycle, ST: Steam Turbine, USC: Ultra Super Critical Generation

Table 10-13 Fuel cost scenario (FY 2010 constant price)[1]

FY	Domestic Coal		Imported Coal		Furnace Oil		Diesel Oil		Gas	
	US ¢/ MM kcal	Taka/ Ton	US ¢/ MM kcal	Taka/ Ton	US ¢/ MM kcal	Taka/ liter	US ¢/ MM kcal	Taka/ liter	US ¢/ MM kcal	Taka/ 10^3 cft
2010	1,400	5,941	1,454	5,135	4,761	31.63	7,300	45.50	3,571	595
2011	1,467	6,229	1,539	5,435	4,843	32.17	7,425	46.28	3,632	605
2012	1,530	6,497	1,618	5,713	4,925	32.71	7,551	47.06	3,693	615
2013	1,595	6,771	1,698	5,999	5,007	33.26	7,677	47.85	3,755	626
2014	1,655	7,025	1,773	6,263	5,089	33.80	7,802	48.63	3,816	636
2015	1,715	7,280	1,848	6,526	5,171	34.35	7,928	49.41	3,878	646
2016	1,773	7,527	1,921	6,785	5,330	35.40	8,172	50.93	3,997	666
2017	1,830	7,768	1,992	7,036	5,489	36.46	8,416	52.45	4,116	686
2018	1,885	8,002	2,061	7,279	5,648	37.52	8,660	53.97	4,236	706
2019	1,940	8,236	2,130	7,523	5,807	38.57	8,904	55.49	4,355	726
2020	1,992	8,457	2,193	7,752	5,966	39.63	9,148	57.01	4,474	745
2021	2,044	8,678	2,260	7,982	6,055	40.23	9,285	57.87	4,541	757
2022	2,096	8,899	2,323	8,212	6,145	40.82	9,422	58.72	4,609	768
2023	2,147	9,113	2,388	8,434	6,234	41.41	9,559	59.58	4,676	779
2024	2,196	9,320	2,449	8,650	6,324	42.01	9,696	60.43	4,743	790
2025	2,244	9,528	2,510	8,866	6,413	42.60	9,834	61.29	4,810	801
2026	2,293	9,735	2,571	9,081	6,503	43.20	9,971	62.14	4,877	813
2027	2,339	9,929	2,628	9,283	6,592	43.79	10,108	63.00	4,944	824
2028	2,386	10,130	2,687	9,492	6,682	44.39	10,245	63.85	5,011	835
2029	2,432	10,324	2,745	9,694	6,771	44.98	10,382	64.71	5,078	846
2030	2,478	10,518	2,802	9,896	6,861	45.58	10,520	65.56	5,145	857

Source: PSMP Study Team

The fuel cost adopted here is all based on international price levels and its widely acknowledged future estimate with the exception of domestic coal which the Study Team values with certain discount of the imported price. As a result of such an estimation process, the price of gas, whose domestic price is maintained at a level that widely deviates from international standards remains at a level that is approximately seven times higher than prevailing domestic prices.

10.3.3 Financing cost

The government establishes the standard terms and conditions under which the government provides the funds from the national budget and from the donor assistances[2]. For the projects to be implemented as public undertakings, the Study applies the standard conditions established by the government. For the private sector undertakings, the following terms and conditions are assumed for analytical purposes. The existing plants, whether they are public or private, are incorporated into the review based on the actual financing costs so long as relevant data or information is made available.

[1] The exchange rate applied is US$1=Taka 69.59, (the actual average rate for FY 2009).
[2] Ministry of Finance, "Lending and Relending Terms of Local Currency and Foreign Loans", March, 2004

Table 10-14 Financing terms and conditions

	Public Undertaking	Private Undertaking
Equity Ratio[1]	18%	30%
Debt Ratio[2]		70%
Donor Loan	70%	
Government Loan	12%	
Loan Period		15 years
Donor Loan	20 years	
Government Loan	20 years	
Rate of Interest		8% p.a.
Donor Loan	4.0% p.a.	
Government Loan	3.0% p.a.	
Return on Equity[3]	6.0% p.a.	15% p.a.
Depreciation[4]	Straight line method with residual value of 10%	Straight line method with no residual value

Source: PSMP Study Team

10.4 Generation cost and purchasing cost of power

The capital costs, O&M expenses, fuel costs and financing costs are integrated into calculation of the overall cost of generation and purchasing cost of electricity from which the following table is obtained. As has been mentioned before, those costs assumed in the preceding analysis are used for the new plants, whereas the existing plants are analyzed utilizing the actual cost of depreciation and O&M expenses under prevailing operational conditions. However, for both the new and existing plants, the fuel costs are incorporating the costs described in the above scenario.

1 The debt/equity ratio is predominantly determined based on the appraisal of donor. The government guideline stipulates that the government provides the portion of the funds that is not funded by the donors at the proportion of the debt equity at 40%:60%.

2 ditto

3 The government guideline does not contain any regulation on the return of equity. The guideline established by BERC for approving the electricity stipulates that the power entities may be allowed for counting the return of equity at the rate equivalent to the yields of two-year treasury bonds. There exists no recent issue of two-year treasury bond in the country. The Study Team assumed such rates to be 6% here based on the yield curve.

4 For public undertaking, the depreciation methodology of BPDB is adopted. Private undertaking assumed zero residual value at the end because the power purchase agreement to be concluded between the generation company and the single buyer might reasonably spread out the portion of the residual value evenly into the annual fixed payments.

Table 10-15 Generation cost and purchasing cost of power (FY 2010 constant price)[1]

(Taka/kWh)

	New Plants[2]	Existing Plants	Power Purchase[3]	Overall Cost
2010		7.66	6.86	7.30
2011	7.17	7.80	9.76	8.59
2012	8.45	7.84	9.91	8.84
2013	7.52	8.13	9.51	8.63
2014	7.03	8.29	9.36	8.42
2015	7.25	8.32	7.99	7.97
2016	7.44	8.55	7.72	7.96
2017	7.39	8.37	6.90	7.53
2018	8.32	8.65	6.62	7.55
2019	7.33	8.83	6.71	7.36
2020	7.89	8.81	6.42	7.27
2021	7.51	8.91	6.33	7.08
2022	7.80	8.76	6.21	7.04
2023	7.66	8.85	6.16	7.06
2024	7.78	8.65	5.94	6.91
2025	7.94	8.46	5.66	6.70
2026	7.64	8.02	5.65	6.67
2027	7.24	7.73	5.63	6.63
2028	7.06	7.51	5.60	6.57
2029	6.91	6.71	5.39	6.44
2030	6.88	6.33	5.38	6.44
Levelized Cost[4]	6.91	8.17	7.84	7.83

Source: PSMP Study Team

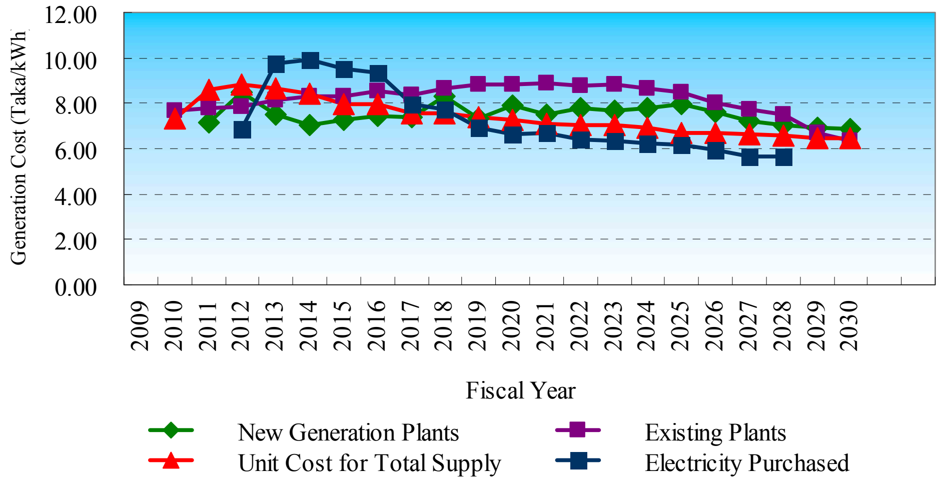
The following is a birds' eye view of the generation cost in its yearly trend;

[1] The generation costs expressed herein do not tally with those presented earlier as the outputs from PDPAT calculation. The reasons of deviations stem, primarily, from the facts such that the PDPAT outputs deal with the generation plants only whereas this Table deals with transmission facilities, and that some parameters are processed with simplified methodologies in PDPAT Calculation whereas this Table treats the depreciation costs in precise and accurate data.

[2] The cost incurred at the new generation plants, transmission plants and related facilities. The cost includes the transmission cost of the electricity generated domestically and purchased from neighboring countries through international trade.

[3] The purchasing cost of electricity acquired from private sector IPPs, small IPPs, rental power producers, nuclear generated power, power purchased from neighboring countries through cross border transactions, etc. The cost estimates are provisional ones as they involve presumptions and preliminary projections by the Study Team.

[4] The levelized cost of generation is calculated as the value at which the aggregated sum of the present value of the net annual sales (annual sales volume of the electricity sold multiplied by the levelized cost minus O&M cost) equals the aggregated sum of the present values of the capital investment. The analysis here has adopted a discount rate of 12% in calculating the levelized cost.



Source: PSMP Study Team

Fig. 10-3 Overall generation cost – base case- (FY 2010 constant price)

The table above and the figures reveal the phenomenal features of the generation and purchasing cost of electricity throughout the Master Plan as follows;

(1) Generation cost stays at a high level.
Irrespective of whether the plants are new, existing or power purchasing, the electricity costs stay at high levels throughout the Master Plan period. The overall cost which includes all of the power sources starts the Master Plan period at Tk 8.59/kWh in FY 2011, reaches its all time high of Tk 8.84 in FY 2013 and decreases in succeeding years towards the end when the cost becomes Tk 6.44/kWh in FY 2030. The levelized cost throughout the Master Plan is calculated as Tk 7.83/kWh.

(2) The generation cost of the new plants is high at the initial period and decreases gradually.
The generation cost of the new plants records high levels of exceeding Tk 8.45/kWh in FY 2012 and Tk 8.32/kWh in FY 2018 since the cost will subside gradually to Tk 6.88/kWh in FY 2030. The levelized cost stays at Tk 6.91/kWh being the lowest among the three categories.

(3) The generation cost of the existing plants remains at a high level.
The existing plants are less in terms of the capital cost in comparison with the new plants but inferior in terms of fuel efficiency. The generation cost (levelized cost: Tk 8.17/kWh) remains at the highest among the three categories.

(4) The purchasing cost of electricity varies and is uncertain.
During the initial phases of the Master Plan, power purchases come primarily from IPPs and rental power producers and purchasing costs from those sources remain at the highest level among the three alternative sources. In the latter half of the Master Plan, the cross border acquisition of power and the purchasing from nuclear power sources are assumed to take over the major role. The cost for the latter is not clearly identifiable at this moment and may be volatile depending on development in the international market. The levelized cost stands at Tk 7.84/kWh

Behind the scene of high generation costs, there obviously lies the adoption of international prices for gas. The present level of the gas prices for the power sector in Bangladesh is set and managed by the government at a level which is approximately one seventh of the international level and this causes prevailing power costs at a low level. The Master Plan, however, anticipates that gas prices will eventually be adjusted to the international level as a matter of time and resolved to adopt international prices for developing the long term power development plan. The Study above describes the analysis conducted based on the assumption of international fuel prices. In the reality of life, the adjustment of fuel prices, wherever it happens to take place, will be accompanied with shock mitigating steps and measures.

The PSMP Study Team gives thought to such practical changes in the scenario in which it attempts a simulating analysis under the assumption that the gas prices will be gradually adjusted during the FY 2011-2015 five year period. The following table shows the generation costs during the transitional phase;

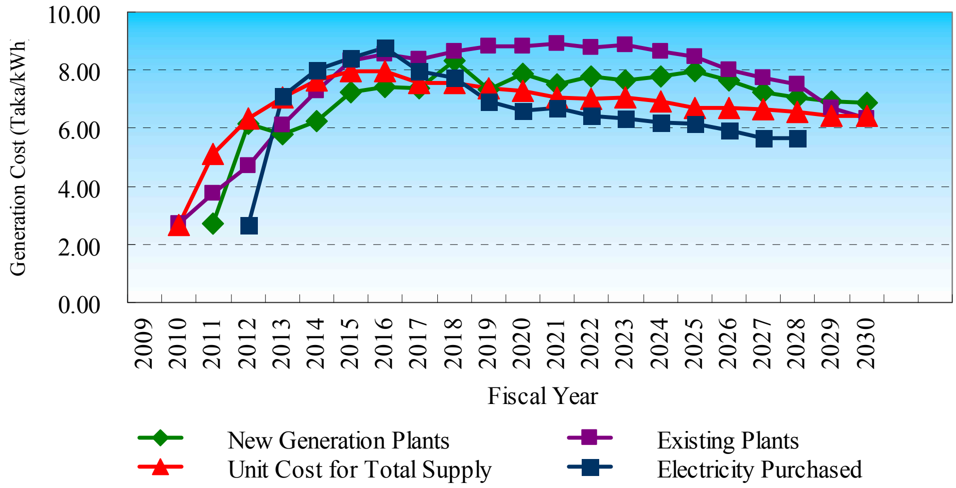
Table 10-16 Generation cost and purchasing cost of power (FY 2010 constant price)

(Taka/kWh)

	Base Case <Overall Cost>		Gas Price Adjustment Case <Overall Cost>		Difference
	Price of Gas (Tk/MM kcal)	Gen. Cost (Tk/kWh)	Price of Gas (Tk/MM kcal)	Gen. Cost (Tk/kWh)	
2010	2,485	7.30	333	2.68	▲4.62
2011	2,528	8.59	772	5.13	▲3.46
2012	2,570	8.84	1,228	6.35	▲2.49
2013	2,613	8.63	1,701	7.08	▲1.55
2014	2,656	8.43	2,191	7.65	▲0.77
2015	2,699	7.97	2,699	7.97	-
Levelized Cost (20 Years)		7.83		6.39	▲1.44

Source: PSMP Study Team

Under the gas price adjustment scenario, the generation cost starts the adjustment period at Tk 2.68/kWh assumed for FY 2010, the base year. It climbs to Tk 5.13/kWh in FY 2011 (increase by 91.4% from the preceding year), Tk 6.35/kWh in FY 2012 (by 23.8% similarly), Tk 7.08/kWh in FY 2013 (by 11.5%), Tk 7.65/kWh in FY 2014 (by 8.1%) and reaches to the level of international cost in FY 2015. The adjustment period will have to accompany an adamant increase of electricity tariff. The generation cost of the power sources when the gas price is adjusted gradually during the five years is illustrated in the following figure;



Source: PSMP Study Team

Fig. 10-4 Generation costs – gas price adjustment case – (FY 2010 constant price)

10.5 Master Plan and the electricity tariff

10.5.1 Pursuit for the electricity tariff in due reflection of the generation cost

The levelized costs during the Master Plan period turns out to be; Tk 6.91/kWh for new plant generation ; Tk 8.17/kWh from existing plants; and Tk 7.84/kWh for purchased power from third parties. The overall cost integrating all of the three is identified as Tk 7.83/kWh which is the value expressed in the FY 2010 constant price without including the inflation and levelization[1] for the whole term of the Master Plan.

The preceding sub-sections reviewed the generation cost of the generation plants and related plants together with the overall cost of generation including the purchasing costs of electricity. The cost derived indicates the total cost to be incurred to the power system of the country and the level of tariffs to be satisfied. The cost obtained stays at a high level and implies that the revision of the power tariff is required for a significant margin from the prevailing level. By all means, the tariff needs to be adjusted to a level that sufficiently covers the overall cost for the power. The prevalent bulk tariff adhered to by BPDB is Tk 2.37/kWh[2]. For the power tariff to reach the overall cost of power under the Master Plan at Tk 7.83/kWh, the bulk tariff needs to be raised to 3.3 times the prevailing level. Assuming that the gas price is adjusted to the international level in five years, the bulk tariff needs to be raised to 330%, equivalent to an annual increase of 27%. As indicated before, the overall power cost starts the Master Plan period at a high level from its very beginning and remains stagnant in the middle to latter part of the period. The start at the high level stems from the fuel cost adopting international prices, in particular, the gas price is set up at a level that is significantly higher than the prevailing price. According to the calculation, the overall cost records a peak of Tk 8.84/kWh in FY 2012. The overall cost tends to gradually decline from the year towards the final end of the Master Plan. Should it happen that the gas price is adjusted towards the international level, the storyline articulated above will become the reality in which, unless the tariff is drastically adjusted, the bulk selling business of power by BPDB will end up becoming a loss-making operation.

[1] The analysis here has adopted a discount rate of 12% in calculating the levelized cost.
[2] Based on the hearing at BPDB and BERC at the time of the revision of bulk tariff taken place in 2008.

10.5.2 Recommendation for tariff revision

As of FY 2009, the structure of the power source of BPDB, the single buyer of the power in the country, consists of; 41% from its own generation; 19% from public generation entities (government/BPDB owned); 34% from IPP purchases; and 5% from rental power producers. The costs of electricity for each of the sources are Tk 2.53/kWh for its own generation; Tk 1.21/kWh for the publicly owned generation entities; Tk 2.70/kWh for IPPs; and Tk 5.20/kWh for rental power producers. The overall acquisition cost of BPDB for all the power sources stands at Tk 3.07/kWh for the year. The average billing rate of BPDB, on the other hand, stands at Tk 2.56/kWh including its retail selling to certain designated consumers[1]. The acquisition and selling prices leave BPDB with a negative margin of Tk 0.51/kWh[2]. Of particular mention is the increase of rental power which expanded its shares among the total acquisition of BPDB from 0.2% in FY 2008 to 5.2% in FY 2009, is creating significant losses in the single buyer operation.

The purchasing of power by BPDB from the rental power producers is conducted under government initiatives and is supposed to be supported by the government in its financial outcome. The remedy assistance provided by the government remains in the provision of funds in the form of loans with interest. BPDB, though it is helped by the funds for tiding over cash flow deficiencies but is of no help in terms of profit and loss accounting in ending up with the accumulation of losses in its profit and loss statement. For BPDB, there hardly exists a source of funds for repaying the funds provided through lending by the government. The financial standing of BPDB has been placed in very weak and vulnerable position for a long time with the accumulation of losses in its balance sheet and that fact has been one of the key elements that have constrained the development of IPP market. The situation is being further aggravated in line with the promotion of the rental power generation system. The weakness and fragility of BPDB's financial position has caused long lasting and fundamental problems such as the weak capacity for power development; lack of proper maintenance activities of existing plants; constraints in the purchasing of power generated by the private sector entities; anxieties spreading about the capability for contract performance; and constraints in new investment for the development of power both in the public and private sectors. The government is urged to take immediate steps for coping with the situations and resultant issues.

In concluding this Chapter, the PSMP Study Team stands resolved to face the issues needing rectifying and recommends that the government take the necessary steps in the following specific recommendations;

(1) Subsidy to cover the deficit Incurred by rental power

Rental power is a system that has been initiated and promoted by the government as an immediate measure to cope with the critical shortage of power. With the exception of several plants whose contracts runs for a relatively long term of 15 years, most of the contracts are short term ones of three to five years in which the per unit cost of power inevitably becomes expensive as the rental power producers try to absorb the depreciation of the plant within such limited short times. BPDB is obligated to purchase the rental power produced at such high cost and to sell the power at the regulated bulk tariff with no effective means to avoid the loss creation in the dealing operation. The negative margin incurred at BPDB needs to be recognized as the cost of the policy implementation initiated by the government and there exists a legitimate reason for the government to bear such cost. The present assistance of the government through the extension of loans to BPDB should be replaced by the grant for the purpose of alleviating the burden of loss creation at BPDB. Such actions of the government, if

1 BPDB, "Annual Report 2008-2009"
2 ditto

honored, are recommended to be made retroactive to the starting year of the rental power system (FY 2008), in theory.

(2) Revision of bulk selling tariff

The preceding subsection argued that the electricity tariff should be revised to reflect the overall power cost under the Master Plan. The fundamental policy of the government for setting the electricity tariff stipulates the achievement of the cost reflective tariff in Bangladesh. In actuality, the principle has not been duly met and the history of the tariff revision has been reputed as the ones of "too little, too late". The fundamental principle laid down appears to be becoming dormant. The prevailing insufficient tariff has caused the power sector of the country problems such as the delay in development; the delay in energy saving activities; while not meeting the growing demand which is ending in the acute and aggravating shortage of power. The revision of tariffs to reflect costs is vital to develop an environment conducive to private sector investment and to activate demand side management. The power shortage issue needs to be addressed from both sides of the demand and the supply. The establishment of a cost reflective tariff is one of the indispensable steps to be taken. It is unfortunate to know that, while arguments are occurring between the government agencies and officials concerned that the cost reflective tariff is a non-negotiable must, there is no clear initiative or indicative actions for the realization of such a tariff.

The government and BERC should take strong leadership in establishing and launching an action plan to materialize the cost reflective tariff. The power cost observed in the preceding sub-chapter has been based on the international fuel prices and its wide deviation from the current tariff prevailing in the country has been observed. The first phase of the action plan should focus on achieving the cost reflective tariff based on domestic fuel prices and in the second phase to proceed to adjust the fuel price and the electricity tariff to international levels. Should it happen that the fuel price be adjusted in the nearer future, it would be necessary to execute the two phases of actions simultaneously.

(3) Raising of funds through power development surcharge

In concluding the chapter, the PSMP Study Team recommends that the government introduce a "Power Development Surcharge" System for the purpose of raising the funds for power development and moving toward the self sustaining power system in the country. The fundamental principle for the electricity tariff is laid on the cost recovery which limits the power entities to collect electricity bills only to the extent that they recover the costs invested. There is no system where the power entities gain the funds for expansion through bill collection. The funding for expansion is virtually limited to relying on government and/pr donor funding only. The following recommends that the government establish a new channel for accumulating investment funds enabling the power sector to become financially self sustainable.

【Outline of the system】

(a) Background

During the process of aggravating power shortages, it has been generally perceived that fund raising constraints have bottlenecked stagnant development. On the other hand, power demand has continually expanding in the low tariff environment resulting in a chronic supply shortage. Some of the consumers in searching for a remedy on their own found alternative supply sources through captive generation. Those consumers paid costs and expenses higher than public power tariffs for captive diesel generation while demonstrating their preparedness for bearing higher electricity costs. The PSMP Study Team finds a rational reason to request that the consumers bear a part of the development cost of power and accelerate the development process through which the returns will be given back to the consumers in the form of less expensive power cost in comparison with that of captive generation.

(b) Scheme

As an integral part of the electricity tariff, a power development surcharge shall be established. The surcharge shall be in the range of two to three percent of the retail tariff and charged to all of the electricity consumers as a part of the electricity bill. The rate of the surcharge can be adjusted in respect of the demand and supply conditions, in particular, the power shortage, progress of overall development of the power sector, etc. The funds collected through the surcharge shall be deposited into a separate fund account and managed by an independent organ to be established for that purpose. The accumulated funds shall be invested and/or loaned to the project to be implemented by the government and/or by the private investor for the purpose of power development or energy saving activities. The funds should not be used as a replacement source of funds for the national budget for expenditures that should be born by the budget in such as the counterpart funding arises with the new donors' commitments of assistance, etc.

(c) Effect expected

As an assumption, it is said that the volume of electricity sales will be 53,000 GWH, equivalent to the volume anticipated for FY 2015 under the Master Plan Scenario, the surcharge levied at Tk 0.10/kWh generates the total fund revenue of Tk 5.3 billion per year. The revenue will expand as the volume of consumption increases. The funds will accumulate in two years to about Tk 11 billion. Assuming that the construction costs of a 400 MW class power station is about US$ 400 million, the funds collected in two years might be sufficient enough to cover the equity investment for plant construction (Equity: US$ 16 million=Tk 11 billion). The project invested/financed by the funds should be made available to public visits though which the consumers and general public can enhance their awareness for power development participation, consumption and energy saving. The awareness enhanced shall be the driving force for further future development.

(d) Rationale

1) The system is as rational as;

The consumers paying high cost and expense for operation of captive generation will be able to lessen their costs for power in the long run;

2) The system is equitable as;

The surcharges shall be born by the consumers equitably in proportion to their volume of consumption. The surcharge born by the consumers shall be rewarded with the solution of power shortages and lower costs. The relation between the cost bearing and benefits is straight forward and transparent;

3) The system is stable as;

The electricity consumption is not much vulnerable to the economic fluctuation and grows steadily. The system can generate the funds with stability. The stabilized inflow of revenue enables steady power development.

4) The system needs consideration as:

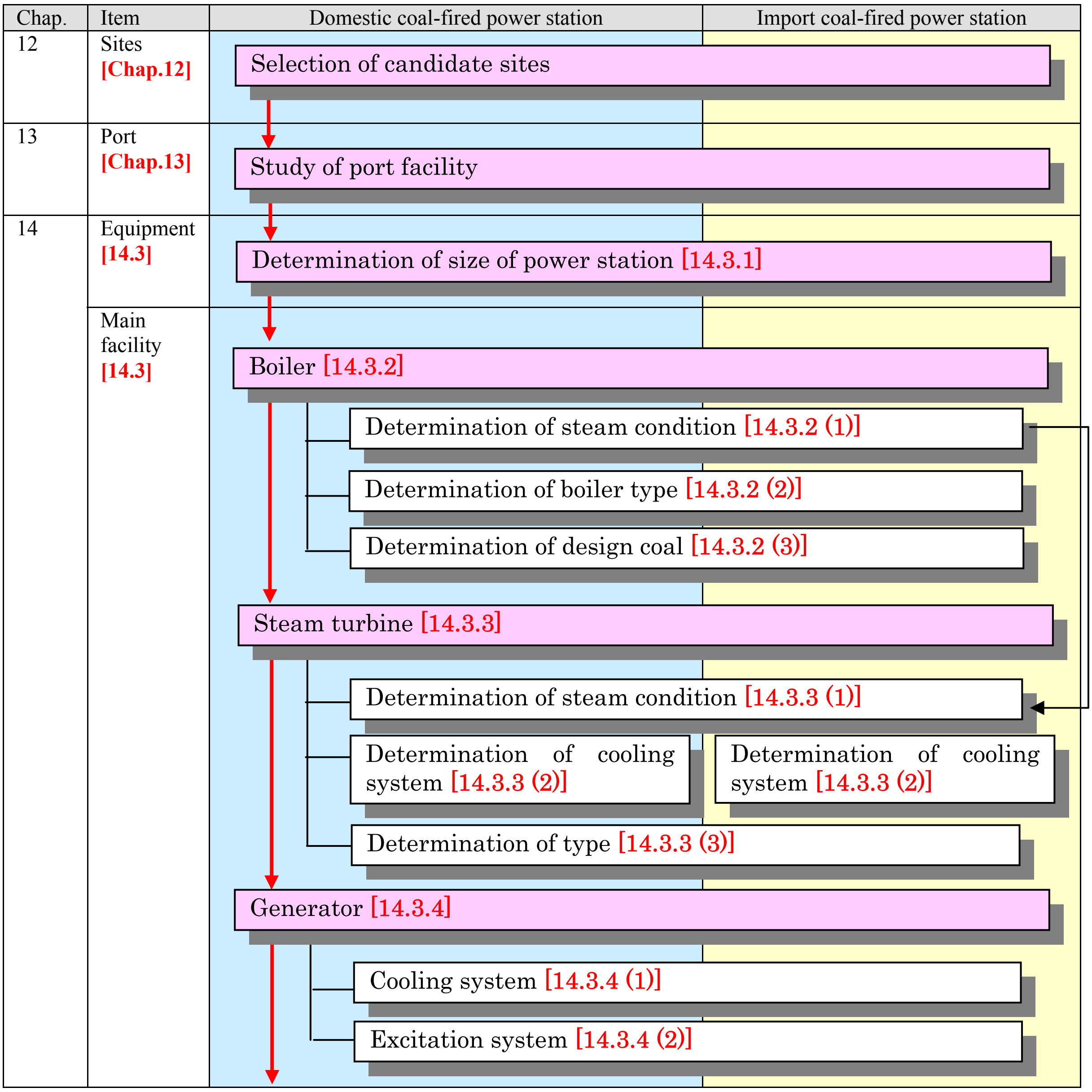
It will take a long time after the consumers start paying the surcharge before the returns materialize due to the long gestation period for development. The surcharge system might include the low income class to whom the surcharge might be a relatively heavy burden. The consumers who are not able to afford additional captive power generation costs or surcharges might deserve special consideration. Small consumers should be given due consideration when formulating the system.

Volume 2 Technical Study for the Construction of Coal-Fired Power Stations

Chapter 11 Viewpoints and Objectives towards Realization of the Most prioritized Projects

11.1 Study flow

Volume 2 considers the technical study for the construction of coal-fired power stations of most prioritized projects, the study consists of the selection of candidate sites on Chap.12, the study of the port facility on Chap.13, the conceptual study for the construction of power stations on Chap.14, the construction schedule and cost on Chap.15, economic and financial analysis on Chap.16, the study of operations and maintenance formation on Chap.17, and the environmental and social examination of Chap. 18. The following figure shows the study flow of volume 2.



Chap.	Item	Domestic coal-fired power station	Import coal-fired power station
14	Environ-mental Facility [14.3]	Environmental facility [14.3.5] Determination of type of electrostatic precipitator [14.3.5 (1)] Determination of type of desulfurization [14.3.5 (2)] Determination of type of denitrification [14.3.5 (3)]	
	Utility equipment [14.3]	Utility equipment [14.3.6] Determination of capacity of water treatment facility [14.3.6 (1)] Coal stock & handling facility [14.3.6 (2)] Determination of type of ash treatment facility [14.3.6 (3)]	
	Equipment transpor-tation [14.4]	Study of equipment transportation [14.4]	
15	Construc-tion sche-dule, cost	Study of construction schedule [15.1] Study of construction cost [15.2]	
16	Economic and financial analysis	Economic and financial analysis of high prioritized projects [Chap.16]	
17	O & M formation	Study of operation and maintenance formation of high prioritized projects [Chap. 17]	
18	Environment & social consideration	Environmental and social examination on most prioritized projects [Chap.18]	

Source: PSMP Study Team

Fig. 11-1 Study flow for technical study for the construction of coal-fired power stations on the most prioritized projects

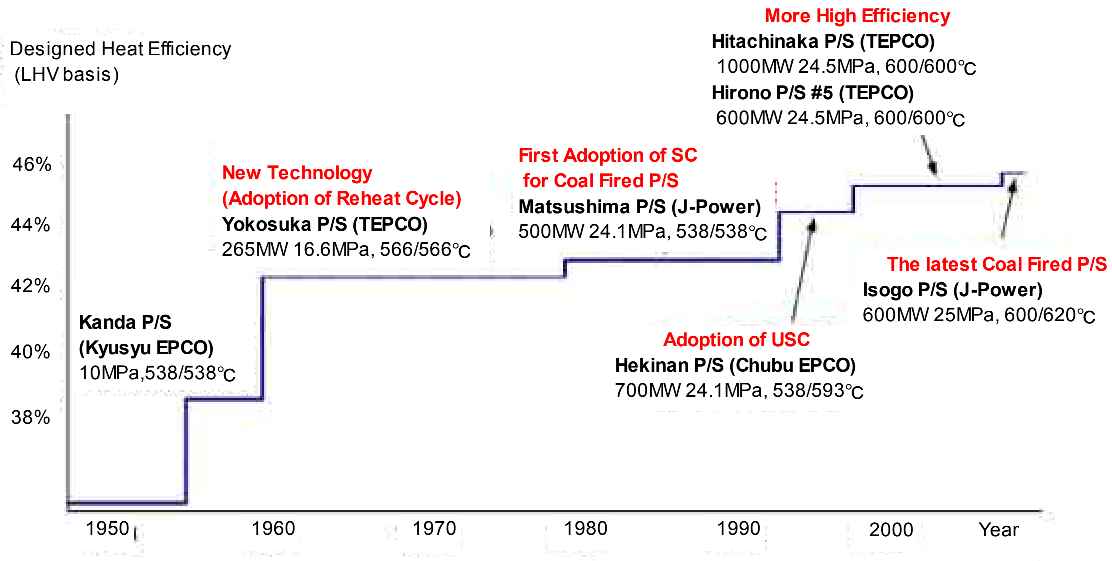
11.2 Viewpoints and objectives

As shown in Chapter 2, it is obvious that coal would play a major role in the primary energy or power sector for the long time. Under such circumstances, when coal-fired power stations are developed, the objective is that, for the "coal" which emits more CO_2 than other fuels, by adopting "Clean Coal Technology" higher efficiency is realized and the environmental load is reduced by adopting environmental facilities, and allows for the contribution to global warming prevention by exploiting the economical merits.

11.3 Study about efficiency level which could be adopted in Bangladesh

11.3.1 Application of high efficiency coal-fired power station

The thermal efficiency of thermal power stations has been improved, as it was about 30% in the 1950's but currently the state-of-the-art gas-fired combined cycle plant with an efficiency of nearly 60% is already in under commercial operations. At the same time, the efficiency of coal-fired power stations has been improved by higher temperatures and higher steam pressure. For example, it is about 43% by the Super Critical (SC) equipment already widely utilized, and it reaches 45% via the new Ultra Super Critical (USC) equipment. Such improvement of thermal efficiency refers to a decrease in the amount of fuel, which decreases the amount of CO_2 emissions contributing to prevent global warming.

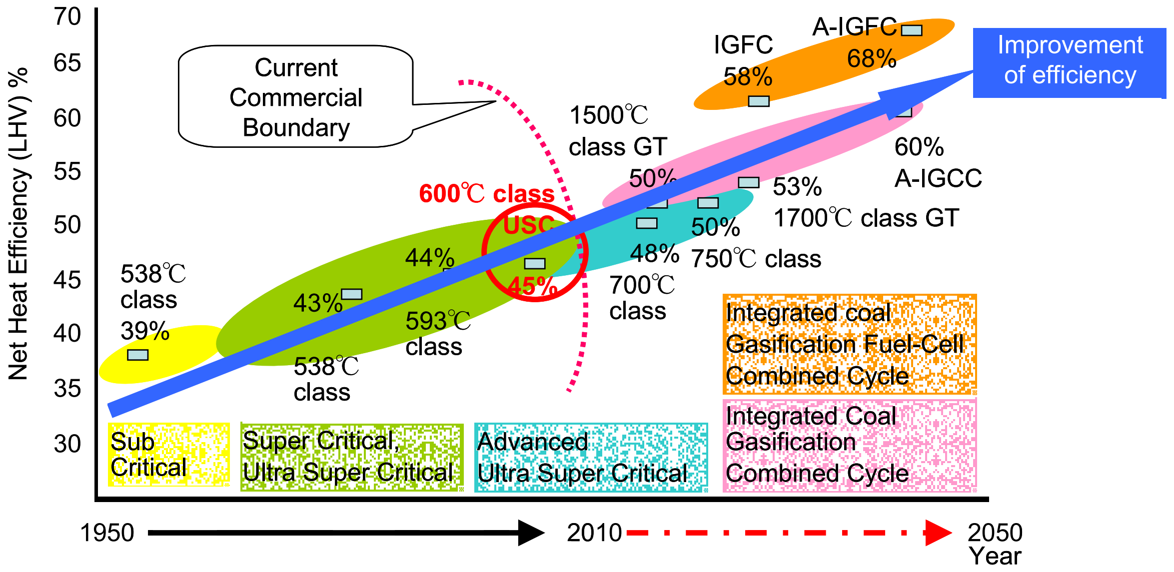


Source: "Thermal and Nuclear Power" 2006.10

Fig. 11-2 Heat Efficiency of coal-fired power stations in Japan

11.3.2 Study about efficiency level which could be adopted in Bangladesh (Target of high efficiency)

In Japan, for the purpose of the efficient utilization of coal, not only the Clean Coal policies in the formation organized by the Ministry of Economy, Trade and Industry (METI), but the private companies are proceeding with many technical developments. The following figure shows the perspective of technical development regarding coal-fired power stations.



Source: Arranged by PSMP Study Team from "Cool-Earth 50"

Fig. 11-3 Improvement of efficiency on coal-fired power stations

Regarding the development of IGCC, currently the verification test by 250MW demonstration plant is proceeding under the "Clean Coal Power Institute" which was established by power companies. By reflecting its results, a commercial level facility would be developed;, however, the procedures depend on the results of the verification test.

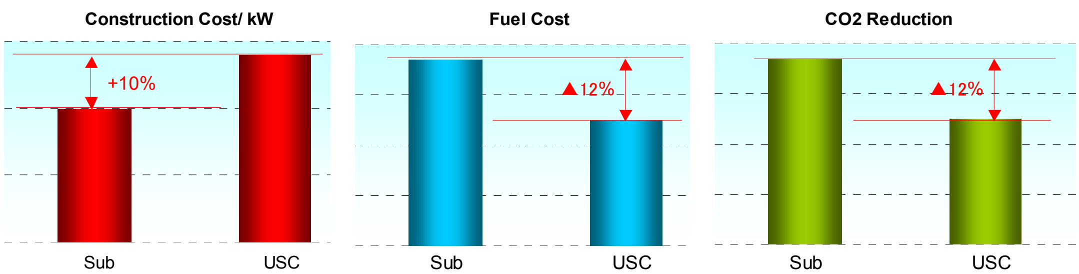
Regarding advanced USC (A-USC), although the basic system is the same as the conventional type, it needs new developed materials which can endure very high pressure and temperature conditions, so that it takes a long time even after the developed new materials in order to achieve sufficient reliability.

Therefore, although USC technology is not at a "state-of-the-art" level compared with other new technology which is currently at the development stage, it is at the highest level at the commercial stage which has sufficient reliability, so that it is the best choice to adopt in this master plan. In this master plan, USC technology would be adopted and its target thermal efficiency is 45%.

As a facility which would be adopted in Bangladesh, the A-USC or IGCC technology which currently is under development could be one of the options in the future. However, a detail study for reliability and economy should be conducted in the stage of adoption of available technology.

11.4 Verification of economic priority by adopting high efficiency technology

The following figure shows the relationship between the construction costs, fuel costs, and CO_2 emissions comparison image between the sub-critical power station and the USC power station.



Source: PSMP Study Team

Fig. 11-4 Comparison between sub-critical facility and USC facility (image)

As explained in Chapter 2, the construction costs of the USC plant, especially those connected to the materials for high pressure and high temperature are higher than the sub critical plant which became widely used throughout the world. However, fuel consumption is lower because of high efficiency; it leads to lower fuel costs, so the increase of construction costs would be recovered via a certain period of operation. Moreover, CO_2 emissions could be reduced.

11.5 Highest level environmental equipment in the world（measure for NOx, SOx, Particle Matter, Vibration, Noise, Coal Dust）

Though there is a difference of characteristics depending upon the area of production, the coal which is the main fuel in coal-fired power station which is proposed in this Master Plan contains more nitrogen content, sulfur content, and ash content than other thermal power fuel (gas and oil etc) with in comparison, there are more NOx, SOx, Particle Matter generation due to combustion of coal. In addition, the coal dust occurs by handling of coal, it is said that environmental impact by using coal is higher including health and safety aspect. Therefore, it is important to make environmental impact minimized by introduction of the highest-level environmental equipment in the world, which is described below.

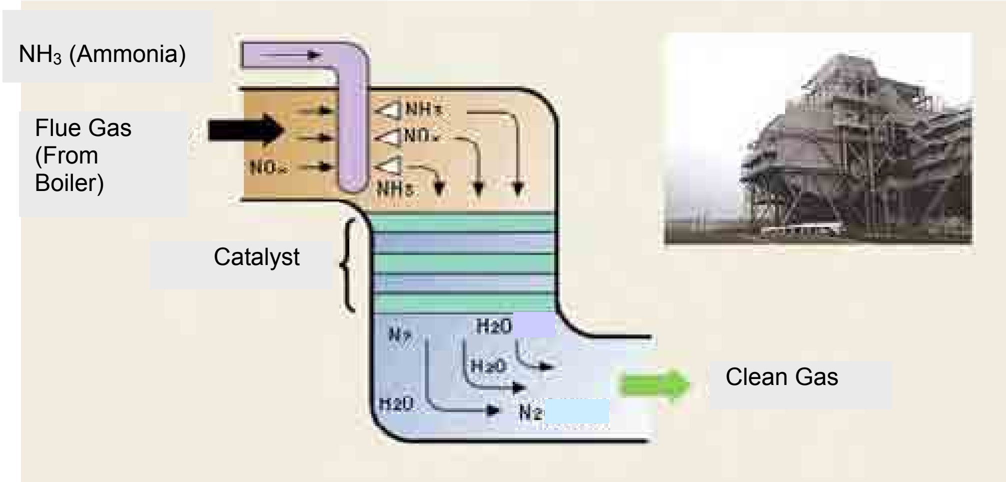
11.5.1 Flue gas denitrification equipment

There are two types of nitrogen oxide by combustion (NO_X). One of them is the Fuel NO_X which is generated from being oxidized nitrogenous substance which is included in the fuel when combustion. The other is the Thermal NO_X which is generated from being oxidized nitrogenous substance which is included in the combustion air. Ratio of Thermal NO_X with the coal combustion is from 10% to 20 %. Measure for flue gas denitrification is executed combining below three measures.

- Usage of low nitrogen content fuel
- Improvement of combustion
- Application of flue gas denitrification equipment

With the NO_X control by improvement of combustion, mainly thermal NO_X generation is controlled by reducing the flame temperature inside the boiler. Equipments which used for improvement of combustion are over fire air duct (two-stage combustion), gas-mixture-fan and additional duct（flue gas recirculation） and low NO_X burners.

It is possible to roughly classify type of flue gas denitrification equipment to dry method and wet method, various systems are developed in principle. Among those systems, selective catalytic reduction (SCR) which is one of dry method and uses ammonia as the reducing agent is main denitrification equipment for power boiler. This system can make NO_X disassemble to harmless nitrogen and water, and it is suitable for large amount flue gas treatment since the system composition is simple. Following shows the mechanism of SCR.



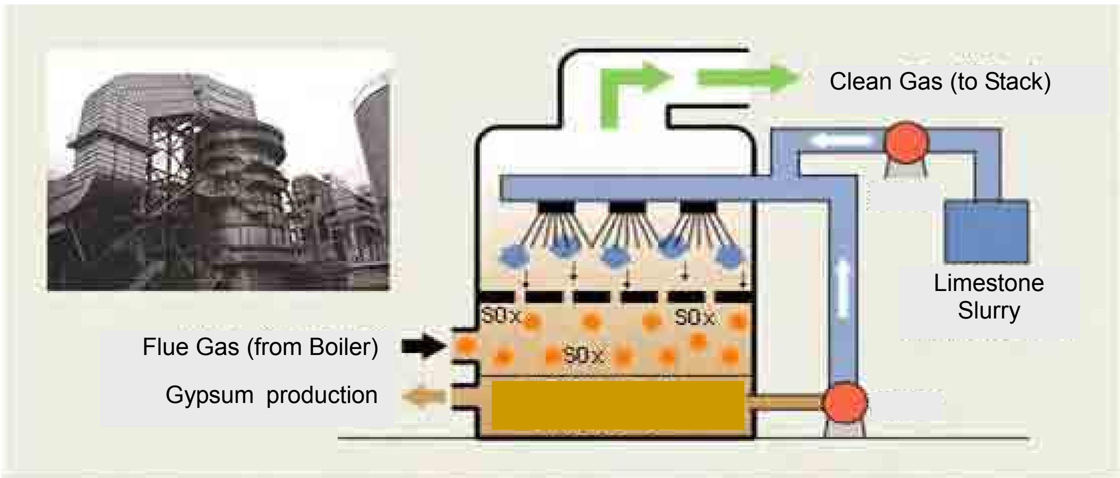
Source: TEPCO website

Fig. 11-5 Flue gas denitrification equipment (SCR)

11.5.2 Flue gas desulfurization equipment

Sulfur oxide (SO_X) is generated by being oxidized sulfur content which is included 0.3 to 2.6 weight percent in fuel due to combustion. In coal-fired power plant, SO_X is reduced by introduction of the flue gas desulfurization equipment. The flue gas desulfurization equipment can be roughly classified to wet method and dry method. Most of flue gas desulfurization equipment for current large power boiler is limestone gypsum FGD, wet method. In limestone gypsum method, HCO_3- from slaked lime is used for the absorbent.

There are past record of seawater scrubber type desulphurization equipment which has almost same component configuration and is simplified the system by using HCO_3- in seawater for absorbent. And it is effective to use dry process activated carbon absorption method at inland area where is difficult to acquire industrial water. Following shows the mechanism of limestone gypsum FGD, wet method.



Source: TEPCO website

Fig. 11-6 Flue gas desulfurization equipment (limestone gypsum FGD, wet method)

11.5.3 Dust collection

Ash from coal-fired boiler can be roughly classified as following table.

Table 11-1 Classification of coal ash

Classification of coal ash	Meaning	Part	Distribution(%)
Fly ash	The fine grain ash which is formed by combustion	Dust collector	Circa 80～90
Cinder ash	The grain ash which is formed by combustion	Air heater, economizer	Circa 5
Clinker ash	Massive form ash which is formed by combustion	Boiler bottom	Circa15～5

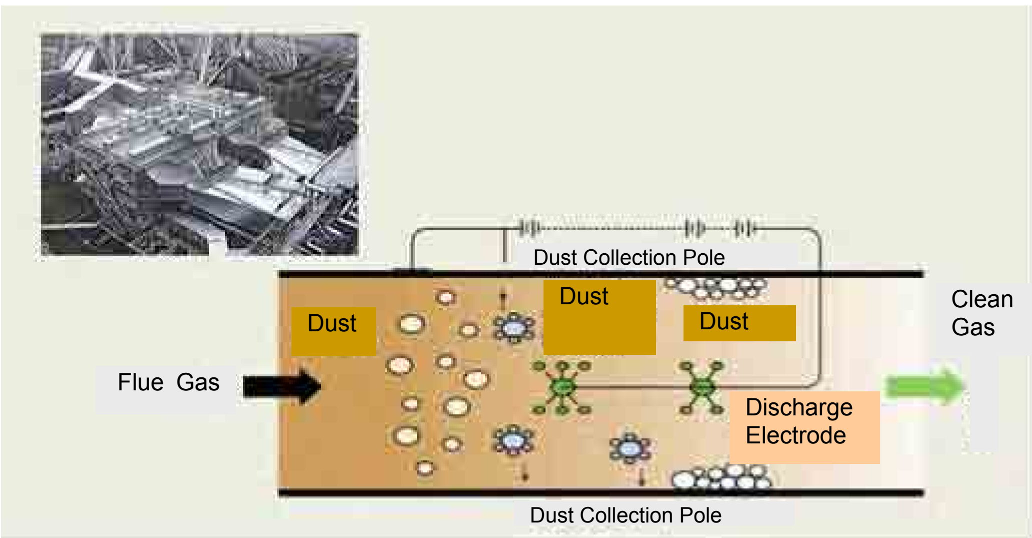
Source : Thermal and Nuclear Power Engineering Society

Dust collector collects the fine grain ash. The way of dust collection is roughly classified physical method (gravity, inertial forces, centrifugal force, and spreading force) and electrical method (electric force). Bag filter and Cyclone separator are typical physical methods and Dry Electrostatic precipitator (Dry ESP) and Wet Electrostatic precipitator (Wet ESP) are typical electrical methods. Dry ESP is common in especially large-sized thermal power boiler.

Fly ash from coal-fired boiler has features like below, and up-to-date ESP is designed corresponds to these ash qualities.

- Medium diameter (dp50) is circa from 13 to 40 micro meter and that is larger than fly ash from oil-fired power boiler
- Adhesion is strong
- Dust layer resistivity is high and tends to occur back corona

In this master plan, it has been determined to adopt EP which is suitable for coal quality in order to reduce air pollution to a minimum level. The following shows the mechanism of the EP.



Source: TEPCO website

Fig. 11-7 Electrostatic precipitator (EP)

11.5.4 Measure for coal dust

Table 11-2shows measure for coal dust according to coal handling.

Table 11-2 Measure for Coal dust

Equipments	Area	Note
Sprinkler	Coal storage yard	Measure for self-ignition
Windbreak fence	Coal storage yard	-
Sealed conveyer	Coal conveyer	Measure for foreign object
Dust collector for coal conveyer	Transfer point of coal conveyer, entrance of coal banker etc	Measure for explosion protection

Source: PSMP Study Team

11.5.5 Target by adopting environment facilities

The merits via adopting the above environmental facilities is assumed to be as follows,

- To lead the preventive measure of pollution problem
- To improve social understanding that leads to smooth development
- To improve technical levels that lead to the adoption of new technology minus future difficulties

11.6 Contribution to the social and economic by mutual collaboration with local communities

Generally, the power station is one of the national important facilities so that there is no contact with normal citizens. However, this engenders bad feelings among citizens resulted in hindered development.

In Japan, on the contrary, the power stations have a good relationship with local communities because it is based on the concept of "mutual collaboration with local communities" . It results in limited objections from local communities concerning power development and the social position of the power company is to maintain and lead smooth power development.

That concept should be adopted in Bangladesh. The following concepts are proposed in this master plan concerning the construction of coal-fired power plants,

- To increase the "green ratio" of the power plant, to make a "Green Power Plant."
- To create some public space like a park, ground that is open to the public.
- To create a staff residence area, and to create a power plant town.

Through the development of power stations under the concept of "mutual collaboration with local community", it is accepted that this will create new employment opportunities for the local population that would contribute to poverty reduction.

There are co-products from the environmental facilities of the coal-fired power station, such as coal ash, gypsum from desulfurization equipment, and sludge from the wastewater treatment facilities. The beneficial utilization for these co-products should be conducted. Currently, the most common usage is the material for cement. The demand of cement for buildings and infrastructure would increase in concert with the development of the economy in Bangladesh, the supply of material would help the demand, this means coal-fired power plants would contribute to the economic development in Bangladesh.

Chapter 12 Selection of Most Prioritized Projects

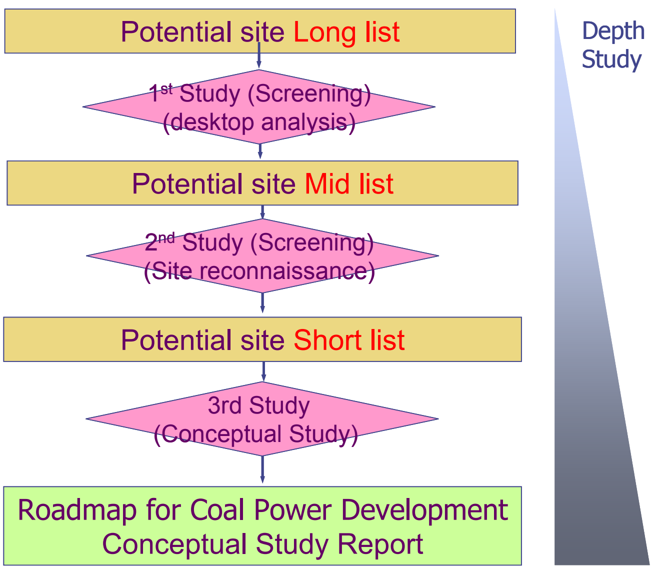
In this chapter, most prioritized projects were selected from potential candidate sites for development via the AHP method. In conclusion, the B-K-D-P site as the domestic coal-fired power plant, and Chittagong, Meghnaghat as the import coal-fired power plant were selected as most prioritized projects in this study.

12.1 Selection flow for most prioritized projects

Potential candidate sites for coal-fired power plants were identified in advance to materialize the optimum power development Master Plan, which is called as long-list.

Out of the long-list, the more promising sites are selected according to the major selection criteria, which are called middle-list. Middle-list selection was implemented by basically lap-top evaluation, which was used to identify the project where the PSMP Study Team conducted site survey.

After the site survey at 2nd mission, each expert evaluated the middle-list to nominate the first priority projects in view of higher feasibility according to the detailed selection criteria and the results of site survey, which is called short-list. The selection criteria were established by discussion with CP. Selection flow diagram is shown as follows;



Source: PSMP Study Team

Fig. 12-1 Selection flow for prioritized projects

12.2 Selection result

This Study formulates the optimum power development master plan for twenty years from year 2010, targeting whole country of Bangladesh. Coal power development plays key role to materialize this Master Plan. The most prioritized coal development projects are selected, prioritized and finally short-listed by screening from potential development sites from technical, economic & financial, and environmental and social point of views, with consideration of funding from overseas like Japanese Yen loan. Short-listed projects regarded as the most feasible will be further investigated from technical, economic & financial, and environmental and social point of views, and then implemented more detailed outline study for technical support to materialize the projects.

Based on the discussion with CP, following sites were nominated as potential coal development sites as Long-list. For the points mentioned in Long List, the PSMP Study Team conducted evaluation according to pre-determined major and detailed selection criteria to narrow down to Mid-list and then Short-list.

Table 12-1 Selection of most prioritized project

No.	Site Name	Planned Use Coal	Long List	Middle List	Short List
1	Barapukuria	Domestic		1st screening (desktop evaluation)	2nd screening (site survey)
2	Phulbari	Domestic			
3	Kharaspir	Domestic			
4	Dighipara	Domestic			
5	Jamalgonj	Domestic			
6	Kuchma	Domestic			
7	Bheramara	Domestic/Import			
8	Chittagong	Import			
9	Cox's Bazar	Import			
10	Mongla	Domestic/Import			
11	Khulna	Import			
12	Meghnaghat	Import			
13	Zajira	Import			
14	Maowa	Import			
15	Chandpur	Import			
16	Matarbari	Import			

Source: PSMP Study Team

12.3 Selection by AHP method

12.3.1 Selection standards

In the process for the selection of projects, in order to weigh objectively the evaluation items and evaluations between all projects, the AHP (Analytic Hierarchy Process) Method was adopted. The most important point in adopting the AHP Method for decision-making is the selection of evaluation standards. It is important that the items are selected independently of each other (one item should not influence another). Next, it is imperative that the importance in comparison between each evaluation is weighed as a basis for determining the level of importance for evaluation items. From the Long List which is a list of potential candidate site for coal power development, based on the following selection standards, Middle List and Short List are selected.

Table 12-2 Selection standards (major item and detail item)

Major Item		Detail Item	
A	Fuel Security	1	Fuel Transportation
		2	Port Facility
B	Feasibility Factor for Construction	1	Securing the Necessary Amount of Ground Space
		2	Transportation of Facilities
		3	History of Flood
		4	Topography / Geology
C	Operational Conditions	1	Securement of Cooling Water
		2	Ash Treatment
D	Economic Conditions	1	Distance with Existing Power System
		2	Project Cost
E	Local Demand-Supply	1	Advantage on Power System Viewpoint
F	Needs of Bangladesh	1	Needs Level of Bangladesh
G	Donor	1	Plan and Priority of WB,ADB Finance
H	Environmental Influence	1	Air Pollution
		2	Water Contamination
		3	Soil Pollution
		4	Bottom Sediment
		5	Noise and vibration
		6	Offensive Odor
		7	Waste
		8	Ground subsidence
		9	Geographical feature
		10	Biota and Ecosystem
		11	Water usage
		12	Accidents
		13	Global warming
I	Social Considerations	1	Involuntary resettlement
		2	Local Economy such as employment and livelihood etc.
		3	The poor, indigenous and ethnic people
		4	Misdistribution of benefit and loss
		5	Local conflict of interests
		6	Gender
		7	Children's right
		8	Land use and utilization of local resources
		9	Social institutions such as social infrastructure and local decision making institutions
		10	Existing social infrastructures
		11	Cultural heritage
		12	Infectious diseases such as Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (HIV/AIDS) etc

Source: PSMP Study Team

12.3.2 Weighting of evaluation items by the AHP method

The greatest characteristic of the AHP Method is a "pair comparison". In this stage which judges importance, a one-to-one comparison is conducted instead of a comparison of all the items at one time.

Because every judgment measures the importance and level of only one item from two, it is easy to make comparisons, and weigh importance.

Therefore, in this study, the weighting of an evaluation item is preceded by the AHP method as follows.

Table 12-3 Result of evaluation by AHP method for major items

	Major Items	A	B	C	D	E	F	G	H	I	Geometric Average	Level of Importance	Point Allocation
A	Fuel Security	1	2	2	2	2	2	2	1	2	1.7145	0.1818	18.15
B	Feasibility Factor for Construction	1/2	1	1	1	1	1	1	1/2	1	0.8572	0.0909	9.10
C	Operational Conditions	1/2	1	1	1	1	1	1	1/2	1	0.8572	0.0909	9.10
D	Economic Conditions	1/2	1	1	1	1	1	1	1/2	1	0.8572	0.0909	9.10
E	Local Demand-Supply	1/2	1	1	1	1	1	1	1/2	1	0.8572	0.0909	9.10
F	Needs of Bangladesh	1/2	1	1	1	1	1	1	1/2	1	1.7145	0.1818	18.15
G	Donor	1/2	1	1	1	1	1	1	1/2	1	0.8572	0.0909	9.10
H	Environment al Influence	1	2	2	2	2	2	2	1	2	0.8572	0.0909	9.10
I	Social Considerations	1/2	1	1	1	1	1	1	1/2	1	0.8572	0.0909	9.10
Summary													100

Source: PSMP Study Team

12.4 1st screening (desktop evaluation)

Table 12-4 shows the result of selection from long list to mid list (1st screening). After judging and comparing each view totally,16 sites with over 5 points, that are Barapukuria, Phulbari, Khalaspir, Dighipara (as the candidate for domestic coal), Chittagong, Cox’s Bazar, Mongla, Khulna, Meghnaghat, Zajira, Maowa, Matarbari (as the candidate for import coal) was narrowed down to Mid-List.

Table 12-4 Evaluation result of 1st screening by AHP method

		A	B	C	D	E	F	G	H	I	Total	Ranking
		Fuel Security	Feasibility Factor for Construction	Operating Conditions	Economic Conditions	Local Demand and Supply	Needs of Bangladesh	Donor	Environmental Influence	Social Considerations		
No	Site Name	18.15	9.10	9.10	9.10	9.10	18.15	9.10	9.10	9.10		
1	Barapukuria	0.0516	0.0939	0.0250	0.0625	0.0960	0.0627	0.0417	0.0696	0.0306	5.8892	11
2	Phulbari	0.0516	0.0939	0.0425	0.0625	0.0960	0.0627	0.0417	0.0696	0.0306	6.0485	9
3	Khalaspir	0.0890	0.0939	0.0425	0.0625	0.0960	0.0627	0.0417	0.0696	0.0583	6.9801	5
4	Dighipara	0.0516	0.0939	0.0425	0.0625	0.0960	0.0627	0.0417	0.0696	0.0583	6.3010	6
5	Jamalgonj	0.0144	0.0939	0.0425	0.0625	0.0960	0.0627	0.0417	0.0188	0.0306	4.9122	13
6	Kuchima	0.0144	0.0939	0.0425	0.0625	0.0960	0.0627	0.0417	0.0188	0.0306	4.9122	14
7	Bheramara	0.0144	0.0120	0.0250	0.0625	0.0516	0.0627	0.0417	0.0214	0.0583	3.8792	16
8	Chittagong	0.0906	0.0512	0.0820	0.0625	0.0287	0.1210	0.1250	0.1217	0.1713	9.6864	1
9	Cox’s Bazar	0.0529	0.0512	0.0820	0.0625	0.0287	0.0319	0.0417	0.0235	0.1047	5.1279	12
10	Mongla	0.0906	0.0512	0.0820	0.0625	0.0516	0.0319	0.0417	0.0650	0.0583	5.9760	10
11	Khulna	0.0906	0.0512	0.0820	0.0625	0.0516	0.0627	0.1250	0.1247	0.1047	8.2580	2
12	Meghnaghat	0.0906	0.0512	0.0820	0.0625	0.0516	0.0627	0.1250	0.1288	0.0583	7.8737	3
13	Zajira	0.0906	0.0512	0.0820	0.0625	0.0516	0.0627	0.1250	0.0643	0.0583	7.2869	4
14	Maowa	0.0906	0.0512	0.0820	0.0625	0.0516	0.0627	0.0417	0.0643	0.0306	6.2761	7
15	Chandpur	0.0270	0.0147	0.0820	0.0625	0.0287	0.0627	0.0417	0.0188	0.0583	4.4188	15
16	Matarbari	0.0890	0.0512	0.0820	0.0625	0.0287	0.0627	0.0417	0.0514	0.0583	6.1738	8

Source: PSMP Study Team

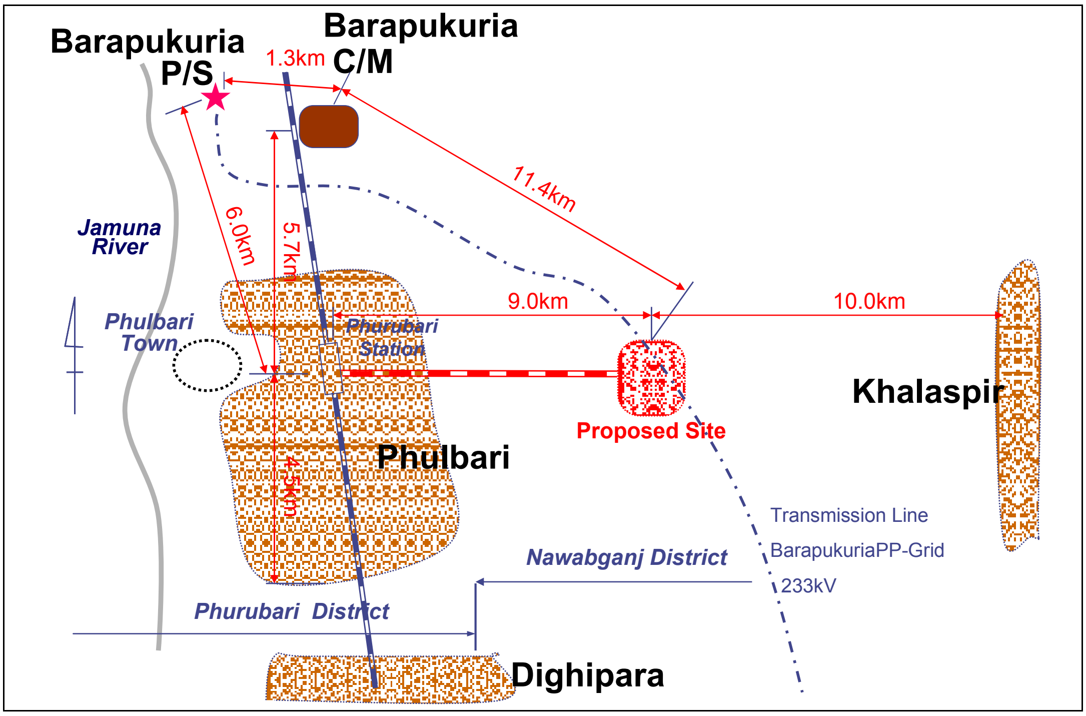
12.5 2nd screening (site survey)

The site survey was conducted for the purpose of the 2nd screening from the 12 sites of the long list which have been selected from the 16 sites by the 1st screening.

12.5.1 Site survey

(1) Candidate site for the domestic coal-fired power plant

Barapukuria, Phulbari, Karaspir and Dighipara are treated as one single domestic coal candidate site where designates particular area located from nearly equal distance from each potential sites (hereinafter B-K-D-P site).



B-K-D-P site		
		
Candidate site	Neighbor river	Barapukuria coal mine

Source: PSMP Study Team

Fig. 12-2 Location and site photos of B-K-D-P site

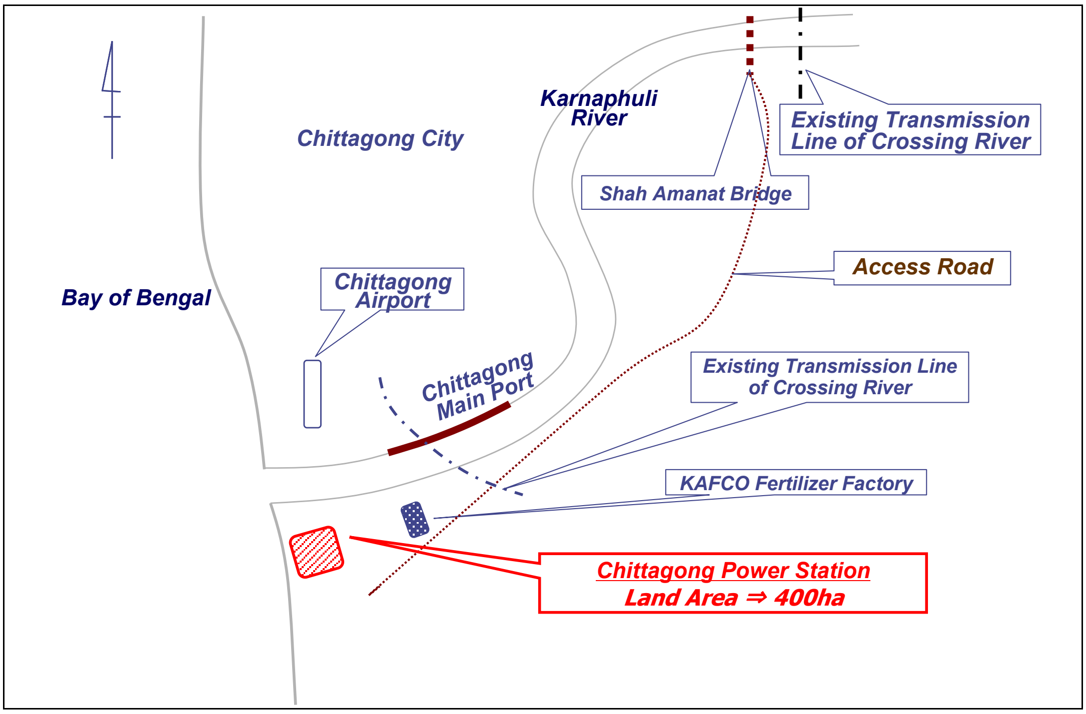
While Barapukuria is the only coal mine in operation, the other 3 sites are hopeful points for the future production of coal. As these sites are close each other, it would be ideal that coal power station is constructed on the point at the same distance from these sites.

(2) Candidate site for the import coal-fired power plant

The site survey was conducted for 8 sites, Chittagong, Cox's Bazar, Mongla, Khulna, Meghnaghat, Zajira, Maowa, and Matarbari.

(a) Chittagong

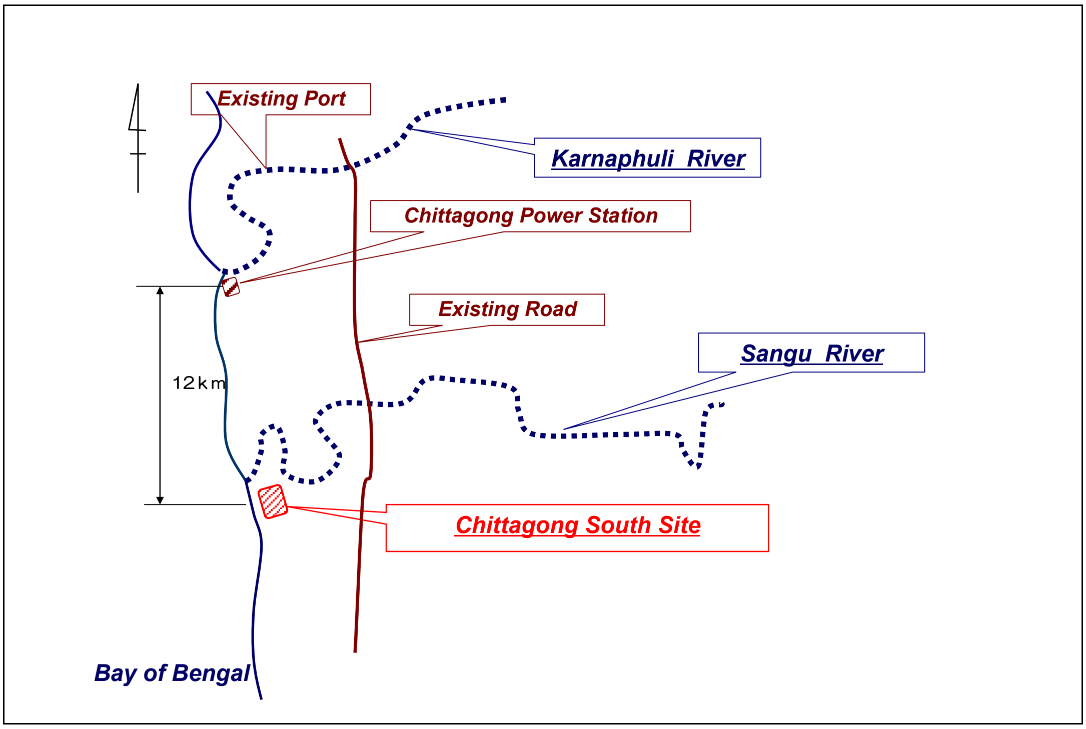
There is a biggest port facility in Bangladesh, it would be the most prioritize site for import coal power station. Needs of Bangladesh is also high.



<table>
<tr><th colspan="3">Chittagong site</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Candidate site</td><td>Candidate site and neighbor factory</td><td>Chittagong port</td></tr>
</table>

Source: PSMP Study Team

Fig. 12-3 Location and site photos of Chittagong site



Chittagong South site		
		
Sangu River	Candidate site	Candidate site

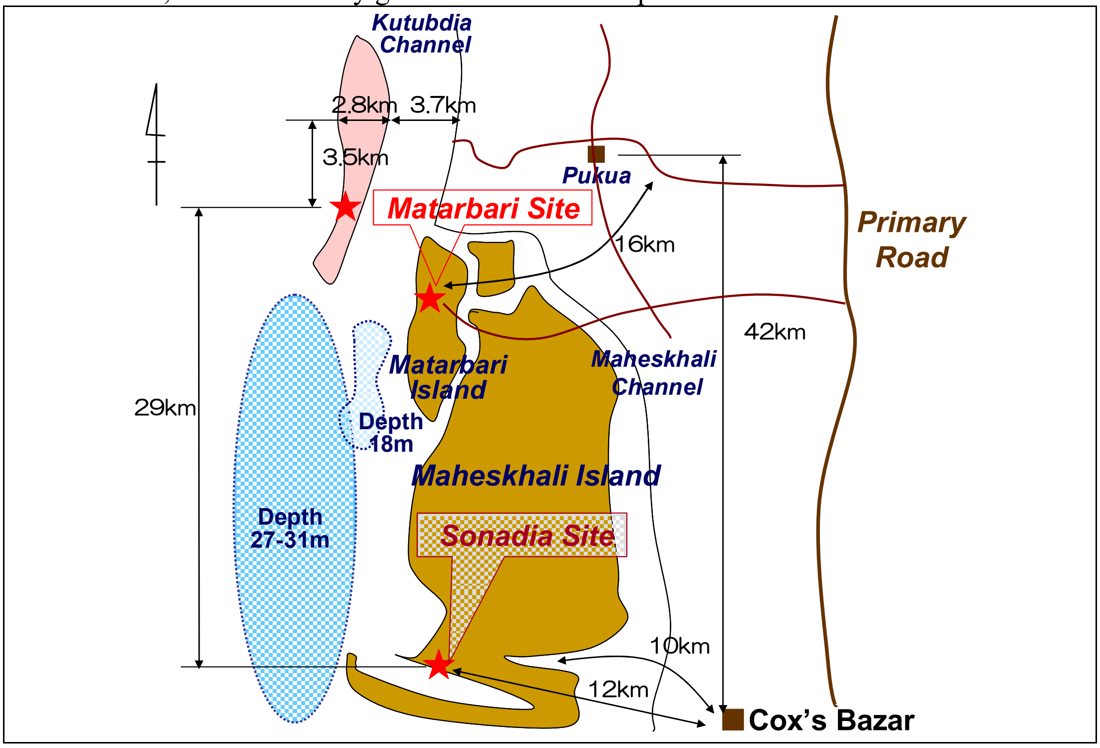
Source: PSMP Study Team

Fig. 12-4 Location and site photos of Chittagong South site

As candidate site points for Chittagong, one is Anwara which is closed to the existing international port, and another is Sangu which is about a 20km distance to south. For the Anwara site, the government of Bangladesh is already planning to carry out the FS for a coal-fired power plant, so that the Sangu site is determined to be candidate site as the Chittagong South“ for avoiding redundancy.

(b) Cox's Bazar, Sonadia, Matarbari

Cox's Bazar is a resort spot with the longest beach in the world. Sonadia Island which is located on the opposite side has a deep sea area and it is a candidate site of deep sea port development, so that it has a potential for economic development. Matarbari is located about 20km north of Sonadia Island, where relatively good access to the deep sea area as well.



Cox's Bazar site		
		
Beach	Road near beach	Identification of location

Matarbari site		
		
Candidate site	Candidate site	Candidate site

Source: PSMP Study Team

Fig. 12-5 Location and site photos of Cox's Bazar, Matarbari, Sonadia sites1

Sonadia site		
		
View from Cox's Bazar	DSP development site	Residence

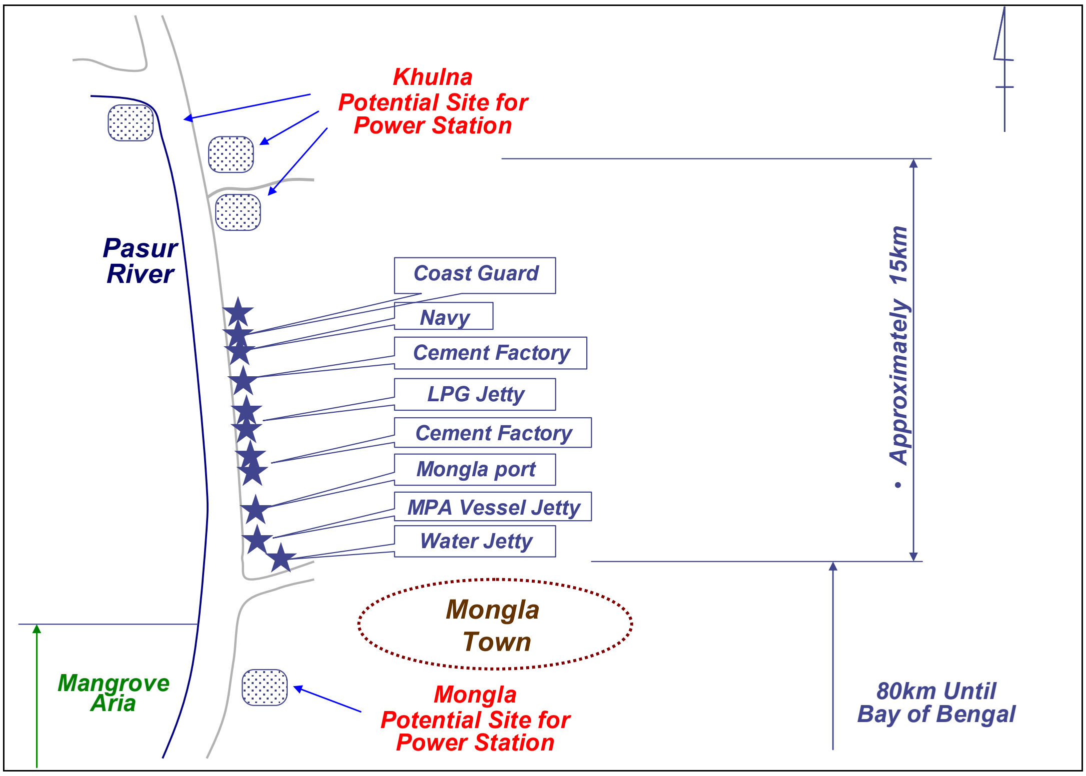
Source: PSMP Study Team

Fig. 12-6 Location and site photos of Cox's Bazar, Matarbari, Sonadia sites2

Cox's Bazar in not only a resort spot but also an environmental protected zone by the government, so it is difficult to develop a power station.
Sonadia and Matarbari has a deep sea area, so it is good for the development of a deep sea port, It is also capable to secure enough space in the land, so it leads to the efficient handling of coal by developing power stations and the coal center. However, Sonadia is not suitable for power station installation because it is near Cox's Bazar, environmental protected zone.

(c) Khulna, Mongla sites

Khulna is located about 15 km from Mongla which is the second biggest international port. Therefore, it uses import coal to come to the Mongla port.



Khulna, Mongla sites		
		
Khulna candidate site	Mongla port	Mongla Port Authority

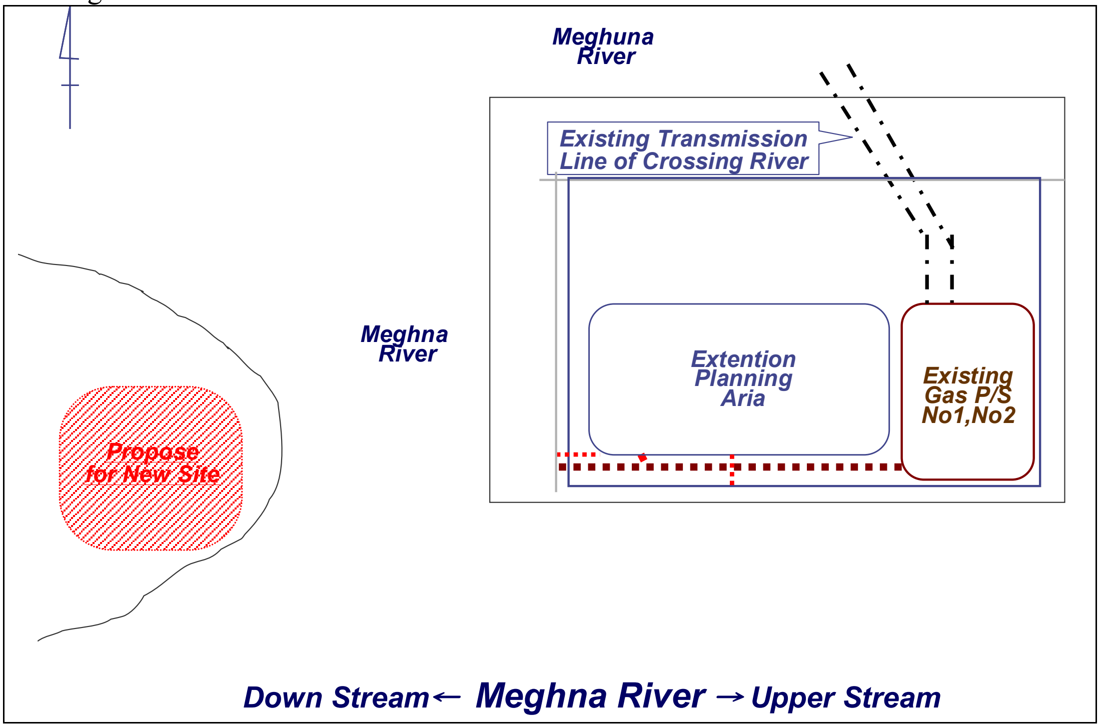
Source: PSMP Study Team

Fig. 12-7 Location and site photos of Khulna, Mongla sites

Because Khulna doesn't include a world heritage area which is different from Mongla, it is easier to develop. It is easier to secure coal by import than using domestic transportation. It should be under consideration as a prioritized site. Therefore the government of Bangladesh is already planning to develop a coal-fired power plant with a target to commence commercial operations in 2016.

(d) Meghnaghat site

As it is near Dhaka, which is only 20 km away, it is good for a power plant for the load center. The gas-fired power station (IPP 450MW) is already in operation. The transmission conditions are also good.



Meghnaghat site		
		
Existing transmission line	Existing IPP power plant	Meghna River

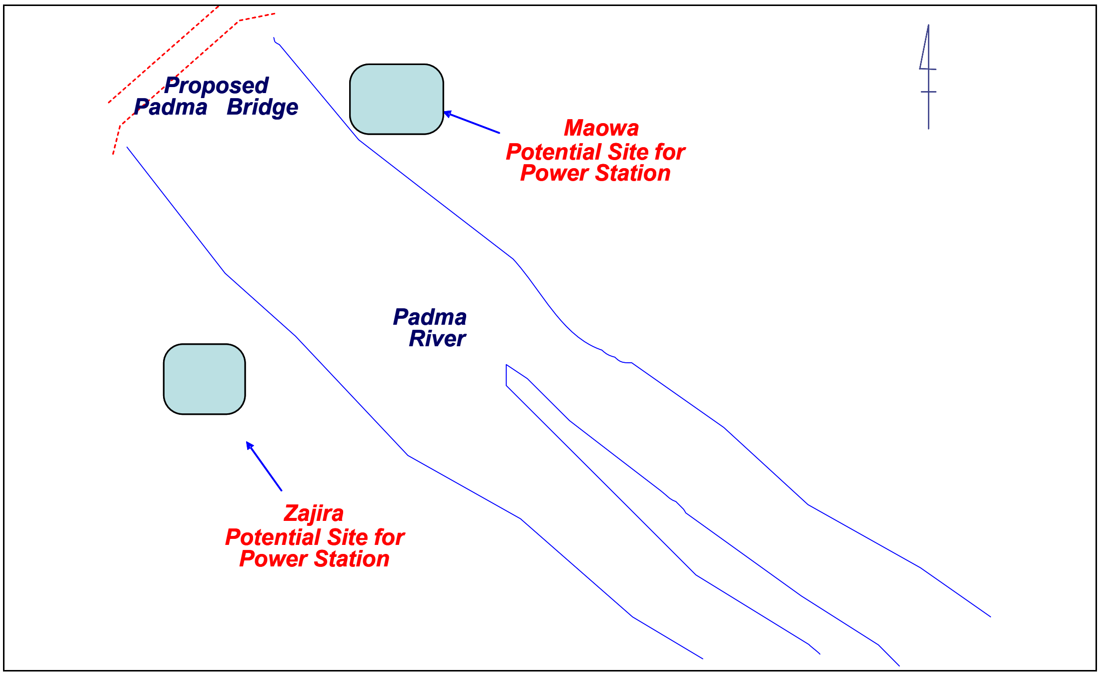
Source: PSMP Study Team

Fig. 12-8 Location and site photos of Meghnaghat site

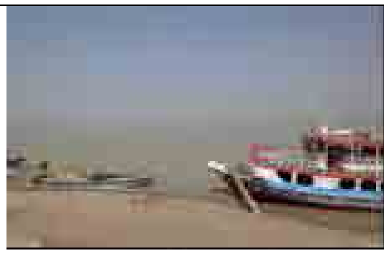
It would be possible to secure land near an existing IPP power station. Enough water for cooling could be secured from river as the same as existing IPP. A plan for expand power system line is existing. Even though coal have to be transported by small ship, it can be developed quickly.

(e) Zajira, Maowa sites

They are located near the proposed Padma Bridge on the Padma River. Coal is to be transported by domestic vessels.



Maowa site		
		
Candidate site	Candidate site	Candidate site

Zajira site		
		
Candidate site	Candidate site	Candidate site

Source: PSMP Study Team

Fig. 12-9 Location and site photos of Maowa, Zajira site

These two sites are located on both banks of the Padma River, currently there is a jetty for a ferry. Area development is also needed in order to develop the power station, but the land could be secured.

12.5.2 Screening result

The following shows the results of the 2nd screening by a site survey.
Further, it shows the characteristics about fuel secure.

Table 12-5 Result of 2nd screening (According to priority)

Priority	Site	Domestic coal	Import coal	
			Import vessel	Domestic vessel (from Coal Center)
1	Chittagong		○	
2	Khulna		○	
3	Meghnaghat			○
4	B-K-D-P	○		
5	Matarbari		○	
6	Zajira			○
7	Maowa			○
8	Cox's Bazar		○	

Source: PSMP Study Team

12.5.3 Selection of most prioritized project

The results of the 2nd screening shows that the ranking of sites is Chittagong, Khulna, Meghnaghat, B-K-D-P, Matarbari, Zajira, Maowa, Mongla, and Cox's Bazar. When a most prioritized project in this study is selected, based on the concept that it is for the basic of future development of coal power by Bangladesh itself, the following concept was adopted without using a simple selection from the ranking.

- Based on the national policy that domestic resources should be developed preferentially, one site which mainly used domestic coal should be selected.
- From the sites for using import coal, each site has a different type of fuel transportation (means one has coal center capability and another needs domestic transportation).

Based on above concept, the following sites were selected as Most prioritized Projects in this study.

- Chittagong : It has a 1st ranking, and it is capable of maintenance for import coal port, it is selected as a site with a coal center
- Meghnaghat : It is as high as a 3rd ranking, and has a 1st ranking for the sites which are not capable of receiving imported ships directly. It is a site selected for its internal transportation capabilities of import coal.
- B-K-D-P point : It is ranked as 4th, so it has been selected as a site for domestic coal

Table 12-6 Result of 2nd screening

Item		Point Allocation	1	2	3	4	5	6	7	8	9
			K-D-P	Chittagong	Cox's Bazar	Mongla	Khulna	Meghnagh at	Zajira	Maowa	Matarbari
			Domestic	Import	Import	Import	Import	Import	Import	Import	Import
A Fuel Security											
1	Fuel Transportation	12.1	0.1200	0.1200	0.0400	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200
2	Port Facilities	6.05	0.0276	0.1793	0.0638	0.1793	0.1793	0.0638	0.0638	0.0638	0.1793
B. Feasibility Factor for Construction											
1	Securing the Necessary Amount of Ground Space	3.03	0.1065	0.1150	0.0550	0.1065	0.1065	0.1910	0.1065	0.1065	0.1065
2	Transportation of Facilities	1.52	0.0625	0.1250	0.0625	0.1250	0.1250	0.1250	0.1250	0.1250	0.1250
3	History of Flood	1.52	0.1538	0.0769	0.0769	0.0769	0.0769	0.1538	0.1538	0.1538	0.0769
4	Topography / Geology	3.03	0.1043	0.1043	0.1043	0.1043	0.1043	0.1656	0.1043	0.1043	0.1043
C Operational Conditions											
1	Securement of Cooling Water	6.8	0.0588	0.1176	0.1176	0.1176	0.1176	0.1176	0.1176	0.1176	0.1176
2	Ash Treatment	2.3	0.1561	0.1561	0.0691	0.0393	0.1147	0.0631	0.1338	0.1338	0.1338
D Economic Conditions											
1	Distance with Existing Power System	6.07	0.1361	0.1361	0.0703	0.1361	0.1361	0.1361	0.1361	0.0426	0.0703
2	Project Cost	3.03	0.2172	0.1195	0.1195	0.1195	0.1195	0.0617	0.0617	0.0617	0.1195
E Local Demand-Supply											
1	Advantage on Power System Viewpoint	9.1	0.1251	0.1251	0.0422	0.0422	0.1251	0.2214	0.0688	0.1251	0.1251
F Needs of Bangladesh											
1	Needs Level of Bangladesh	18.15	0.1898	0.1898	0.0396	0.0396	0.1898	0.1107	0.0649	0.0649	0.1107
G Donor											
1	Plan and Priority of WH,ADB Finance	9.1	0.0588	0.1765	0.0588	0.0588	0.1765	0.1765	0.1765	0.0588	0.0588
H Environment Influence											
1	Air Pollution	0.91	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
2	Water Contamination	0.91	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
3	Soil Pollution	0.45	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
4	Bottom Sediment	0.45	0.2727	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909
5	Noise and Vibration	0.48	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
6	Offensive Odor	0.41	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
7	Waste	0.48	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
8	Ground Subsidence	0.96	0.0244	0.1220	0.1220	0.1220	0.1220	0.1220	0.1220	0.1220	0.1220
9	Geographical Feature	0.77	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
10	Biota and Ecosystem	0.96	0.1304	0.1304	0.0435	0.0435	0.1304	0.1304	0.1304	0.1304	0.1304

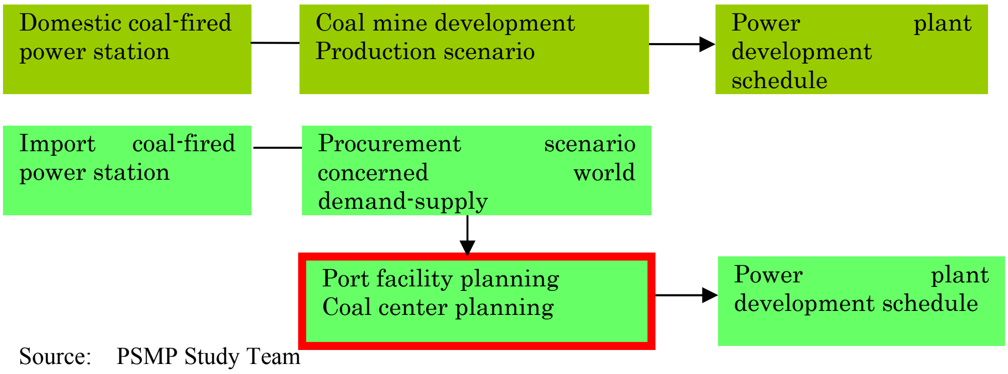
Item		Point Allocation	1	2	3	4	5	6	7	8	9
			K-D-P	Chittagong	Cox's Bazar	Mongla	Khulna	Meghnagh at	Zajira	Maowa	Matarbari
			Domestic	Import	Import	Import	Import	Import	Import	Import	Import
11	Water Usage	0.96	0.0244	0.1220	0.1220	0.1220	0.1220	0.1220	0.1220	0.1220	0.1220
12	Accidents	0.45	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
13	Global Warming	0.91	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
I Social Issues											
1	Involuntary Resettlement	0.98	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
2	Local Economy Such as Employment and Livelihood etc.	0.78	0.0769	0.1538	0.1538	0.1538	0.1538	0.0769	0.0769	0.0769	0.0769
3	The Poor, Indigenous and Ethnic People	1.04	0.0769	0.1538	0.1538	0.1538	0.1538	0.0769	0.0769	0.0769	0.0769
4	Misdistribution of Benefit and Loss	0.59	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
5	Local Conflict of Interests	0.59	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
6	Gender	0.52	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
7	Children's Right	0.52	0.0400	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200
8	Land Use and Utilization of Local Resources	0.83	0.2000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
9	Social Institution such as Social Infrastructure and Local Decision Making Institutions	0.65	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
10	Existing Social Infrastructures	0.93	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
11	Cultural Heritage	0.93	0.2603	0.0879	0.0879	0.0475	0.1649	0.0879	0.0879	0.0879	0.0879
12	Infectious Diseases such as HIV/AIDS etc	0.74	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
Total			12.0090	14.1490	6.9717	9.1832	14.0996	12.8948	10.3968	9.2700	11.0259
Ranking			4	1	9	8	2	3	6	7	5

Source: JICA Study Team

Chapter 13 Conceptual Study for Port Facility

13.1 Study item

As shown in the following figure, the possible capacity and development schedule of coal-fired power plants are determined, for domestic coal-fired power plant cases via the coal mine development schedule, and for the import coal-fired power plant case by a procurement scenario concerning the demand-supply status in the world, and the schedule of port facility development that is the capacity of imports. In this chapter the conceptual study for the port facility is studied, which is important for imported coal-fired power plants developed in Bangladesh.



Source: PSMP Study Team

Fig. 13-1 Port facility and power plant planning

13.2 Outline of deep sea port master plan

The Ministry of Shipping of Bangladesh proceeded with the F/S in the development of the deep sea port (DSP) as a necessary development for the processed-export type industry. The contents are, first to select candidate sites which have the potential to be deep sea ports in the Bay of Bengal of which most of the area is shallow, and proceed with a site survey and technical and economic evaluation. After that to specialize on the Sonadia site (a sand island located north of Cox's Bazar) as a final candidate site and proceed with the detailed plan (average freight 30 million ton per year, project cost 5 billion USD, 2055 completion).

In this study, five candidate sites for the deep sea port were investigated in consideration of appropriate sites for the fuel center.

13.3 Study for coal center concept

Almost all candidate sites of import coal-fired power stations on Chapter 12 are not located near deep seas or rivers of which international coal vessels can access. So that this Master Plan proposes a coal center system as a way to secure and transport import coal which Japan has quite experienced in. The following shows the coal center system and its application for this Master Plan.

13.3.1 Concept of site selection

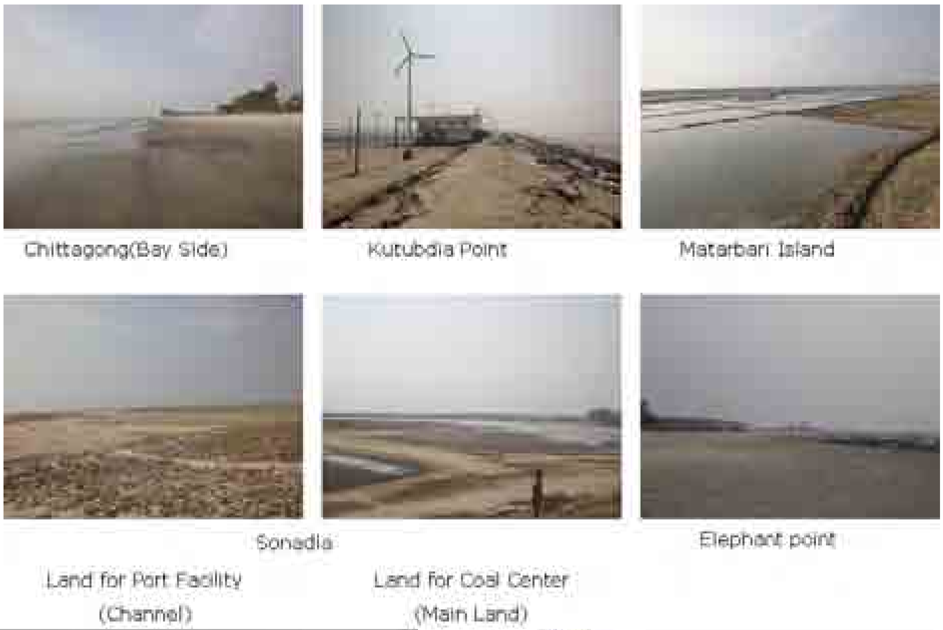
The condition for the candidate site of the coal center is as follows;

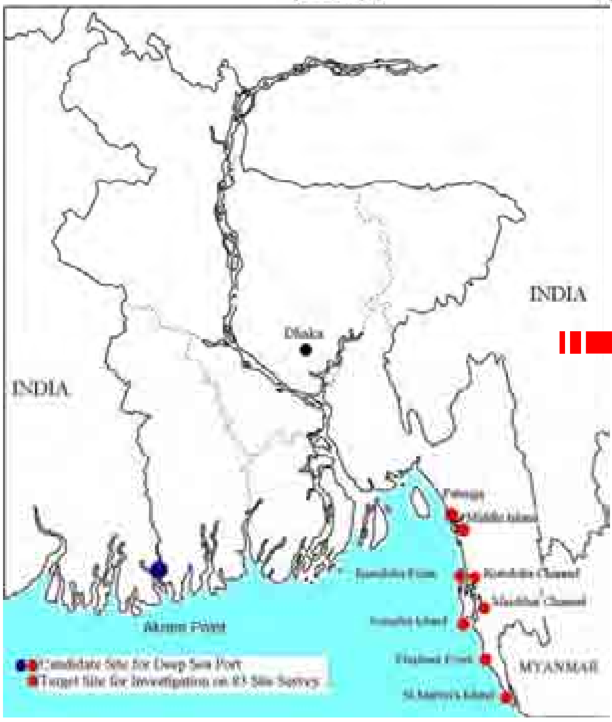
- Capability to approach for the international coal vessel
- Enough area for the coal stock yard

Further, it would be more rational and economic for the operation of the coal handling facility by setting the coal-fired power station adjacently. So that the candidate sites for the coal center would be selected prior to the candidate site for the power station.

13.3.2 Site survey

A site survey for the following 5 points was conducted.





Candidate site for deep sea port in the F/S

Candidate site for port facility in this Master Plan

Source: PSMP Study Team

Fig. 13-2 Relationship between port facility and power plant planning

After site survey, the candidate sites for the coal center were selected from the power station sites under the condition that international vessels could approach, the results are Chittagong South and Matarbari. In addition, Sonadia has been selected as a site only for the coal center. Mongla is the point of relay towards Khulna. However, it has been determined as a coal center in this Master Plan.

The relation of each coal center and power station is as follows, considering the power development plan and the priority of each site.

Table 13-1 Relation between coal center and power station

Coal Center	Power Station (required Coal amount)
Mongla	Khulna (3.5 mil t/y)
Chittagong South	Chittagong (3.5 mil t/y) Chittagong South (1.75 mil t/y)
Matarbari	Meghnaghatt (3.5 mil t/y) Matarbari (7 mil t/y)
Sonadia	Mawa (3.5 milt/y) Zajira (1.75 mil t/y)

Source: PSMP Study Team

13.3.3 Formation of coal transportation

For the coal transportation, domestic vessels for the exclusive use of the coal have been adopted. The influence on the availability of the operation schedule the Bay of Bengal's weather conditions should be considered.

There are about 3 or 4 months of bad conditions for the ship operation by the Monsoon in the Bay of Bengal. So that the capacity of the coal stock yard in the power stations should be determined after considering whether or not it can secure enough coal during the term the vessel cannot operate.

13.3.4 Vessels for coal transportation

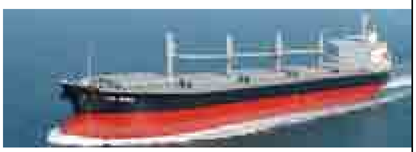
The depth of Chittagong port, which is currently under operation as the trading port, is only 8 to 9m, the Chittagong Port Authority determines the regulations for the restriction of the length of the ships as 186m. The coal vessel which could qualify this condition should be 28,000 ton class.

On the other hand, the coal center which would be constructed as the fuel center in the deep sea port can accept larger vessels, even a 50,000 ton class vessel can be accepted. For reference, Paradip Port, the east coast of India, 210 nautical miles south of Kolkata, developed the artificial deep sea port in 1962, which draft is 15 meter and accepts 75,000 ton class coal vessel.

Regarding domestic vessels, according to BIWTA (Bangladesh Inland Water Transport Authority), the levels of operation capability are determined in the Bay of Bengal according to weather conditions, and the largest size of the ship which can pass through the worst level area is 5,000 tons. Because the planning route for the domestic vessel in this Mater Plan includes this area, 5,000 ton class vessels have been selected as the domestic vessels.

The following table shows the vessels which would be used for coal transportation in Bangladesh.

Table 13-2 Coal vessels

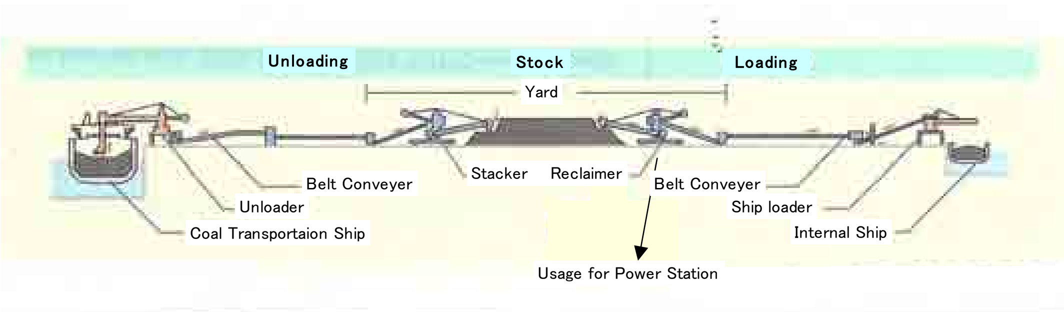
Example picture	Type	DWT	Length	Draft
	International vessel 1 (from Indonesia, Australia to Bangladesh)	50,000t Class	190m	12m
	International vessel 2 (from Indonesia, Australia to Bangladesh)	28,000t Class	170m	7m

Example picture	Type	DWT	Length	Draft
	Domestic vessel	5,000t Class	90m	5m
	Domestic vessel (Berge)	10,000t Class	80m	2m

Source: PSMP Study Team (photos from website)

13.3.5 Study for the capacity and the number of coal center

Regarding the capacity of the coal center, it would be rational to set 1 or 2 million tons as the maximum size of the coal stock yard, and 3 or 4 million tons as the maximum handling amount for a year concerning the current largest coal center (coal stock yard capacity: 2.5 million ton, coal handling amount: 6.25 million ton per year). The number of coal centers would be calculated from the total required amount of import coal, concerning the years up to 2030, 2 or 3 would be reasonable and realistic. In consideration that each coal center has a power station whose size is almost the same as the other power station which is the destination of the coal transportation, the 1 set of the coal center system has 6 to 8 million tons per year, and 24 million tons per year which has 3 sets of system would be the maximum amount for handling import coal.



Source: Idemitsu Kosan

Fig. 13-3 Role of coal center

13.3.6 Determination of the number of berth

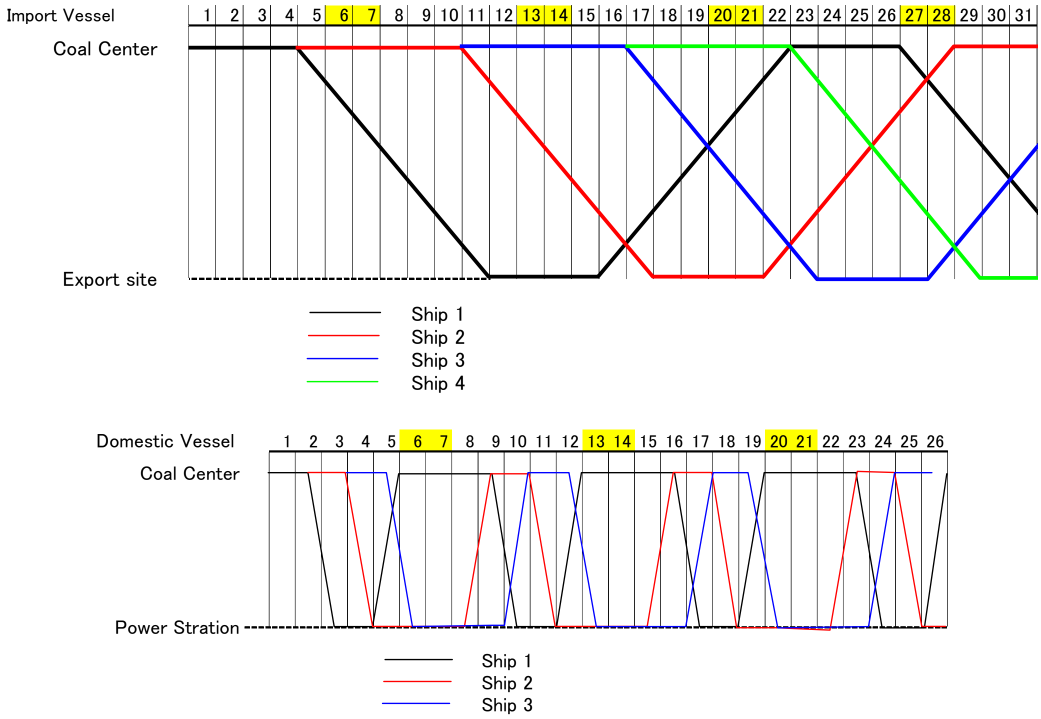
The number of required berths for each coal center and power station, the maximum handling amount for one berth, the operation schedules for international and domestic ships are calculated as follows;

Table 13-3 Required time for coal vessels

	International vessel	day	Domestic vessel	day
Work on berth	・Preparation, arrival	0.3	・Preparation, arrival	0.3
	・Preparation for loading, Custom	0.7	・Preparation for loading,	0.1
	・Loading	2.5	・Loading	1
	・Finishing, departure	0.5	・Finishing, departure	0.1
	Total	4	Total	1.5
Time for sailing	Indonesia <-> Bangladesh	7	Coal Center <-> Power Station	1

Source: PSMP Study Team

Based on it, the simulation result of ship operation is shown as follows, under the assumption that there is no work during the holidays.



Source: PSMP Study Team

Fig. 13-4 Operation simulation of coal vessels

13.3.7 Analysis of wave height data of the Bay of Bengal

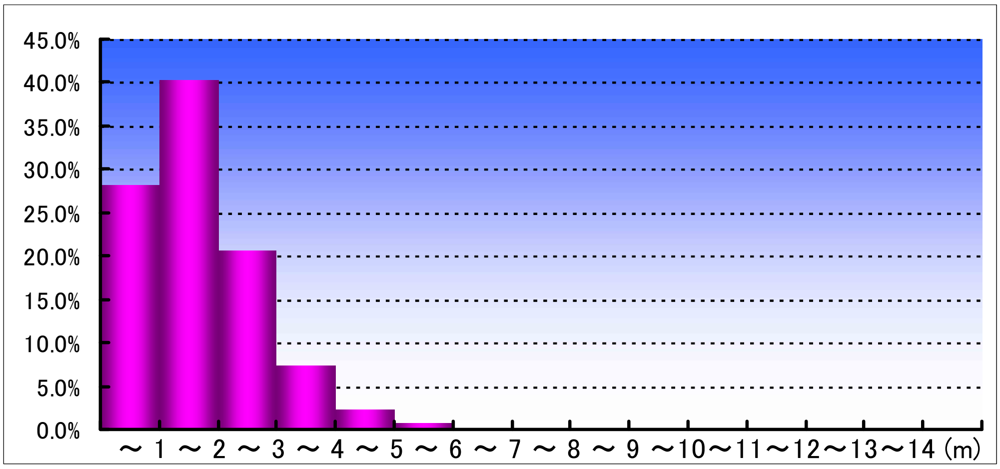
Theoretically, it is clear that,

Average work days of a year : 52 (weeks) * 5 (days) = 260 (days)

Number of ships of a year : International vessel 260 / 4 = 65

Domestic vessel 260 / 1.5 = 173

Actually the risk of bad weather, delays, or shutdown to worker strikes should be taken into consideration. Regarding bad weather risks, the following shows the summary of the wave height data at the Bay of Bengal.



Source: The Global Wave Statistics

Fig. 13-5 Wave height data of the Bay of Bengal

13.3.8 Annual number of ships for 1 berth

From the regulation for operation of a general shipping company as a reference, it has been determined that the condition for the enter/clear port is less than 3m of wave height. Therefore, the risk of weather is 10%.

And 3% is considered for other delay risks.

The worker strike risk is set as 2%, which translates into 7 days a year.

The result is shown as follows based on the above conditions,

Table 13-4 The number of ships for 1 berth per year

	International Vessel	Domestic Vessel
Theological Yearly Number of ships	Work day 52*5=260 260 / 4＝65	Work day 52*5=260 260 / 1.5＝173
Weather risk	10%	10%
Delay risk	3%	3%
Worker strike risk	2%	2%
Total risk	15%	15%
Yearly number of ships including risks	65×85%＝55	173×85%＝147

Source: PSMP Study Team

13.3.9 Annual amount of coal transportation for 1 berth

Regarding the loading of vessels, concerning that the number of DWT includes fuel and drinking water etc. and the loading loss is determined at 5%, therefore, the coal handling amount of 1 berth a year is shown as follows,

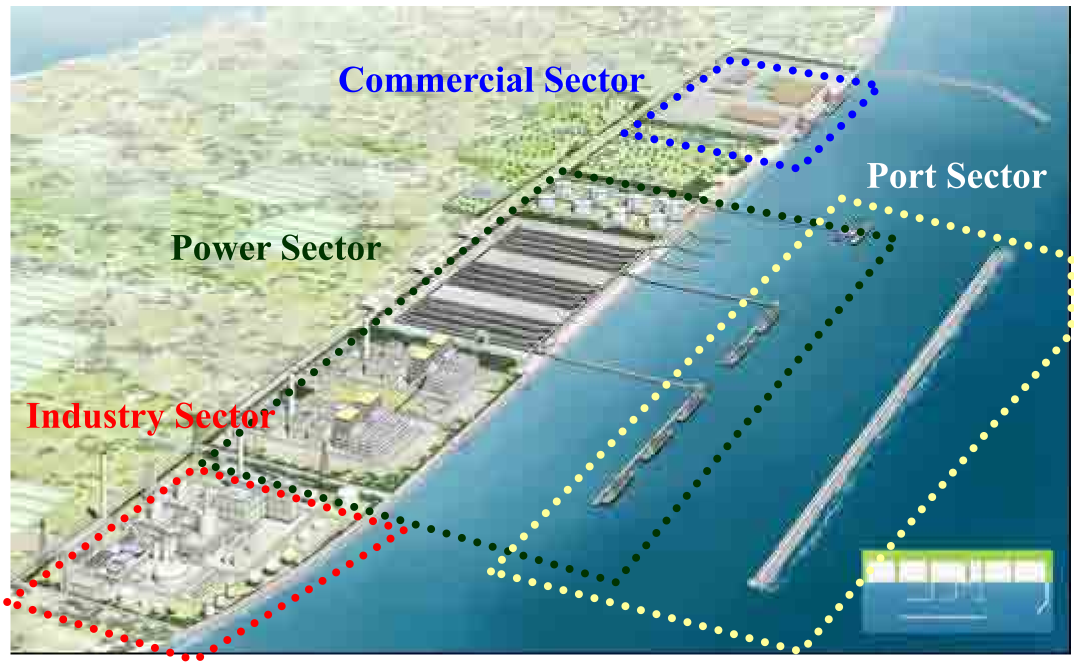
Table 13-5 Total coal amount per year for handling by 1 berth

	International Vessel		Domestic Vessel
	28,000t	50,000t	5,000t
Actual Loading	26,600 t (95% of DWT)	47,500 t (95% of DWT)	4,750 t (95% of DWT)
Yearly Amount	1,463,000 t	2,612,500 t	698,250 t

Source: PSMP Study Team

13.3.10 Necessity of collaborative development with multi sectors

It is obvious that the incremental power system adjustments are necessary in order to meet future demand increases, it is also necessary to develop the gas pipeline, deep sea port, inland water transportation, railways and so on as relating facilities with the power system. It needs a large amount of funds so that only the power sector is not able to proceed. Further, the realization of cost reductions and synergy are expected by proceeding with the collaboration with multi sectors. Furthermore, it is also possible to turn the area into an “industrial complex” in which not only an electric power supply but also heat supply could be shared and the transportation system could be developed by multi sectors. Based on the above, the following shows the concept of multi sector development.



Source: PSMP Study Team

Fig. 13-6 Image of deep sea port development at Matarbari

13.3.11 Schedule of coal center concept

In order to realize that coal center concept, the development of large-scale port facility is necessary, it means not only huge amount of fund but also long term development period should be needed. Considering these situation, the basic concept of schedule for secure import coal is as follows,

(1) Offshore unloading by using Mother-ship concept (until 2020)

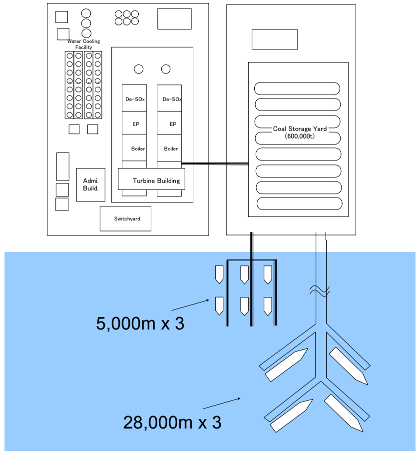
Considering necessary period for developing deep sea port, the coal center would be in service after 2020. So that until 2020, coal is transported by big coal vessel, and transshipped to a small vessel off the coast of power station (Mother ship system).

(2) Construction and operation of coal center (after 2020)

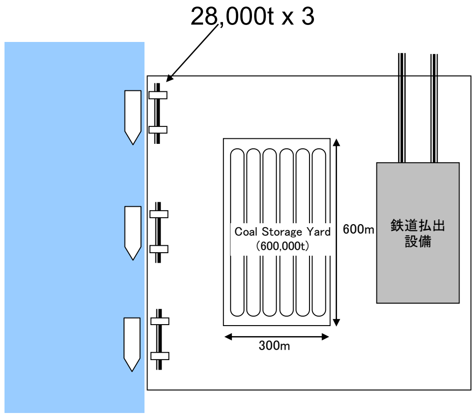
After 2020, the coal center would start construction and operation with the development of port facility. At the same time, the Mother ship system would be transferred to the coal center.

13.3.12 Conceptual layout plan of coal centers

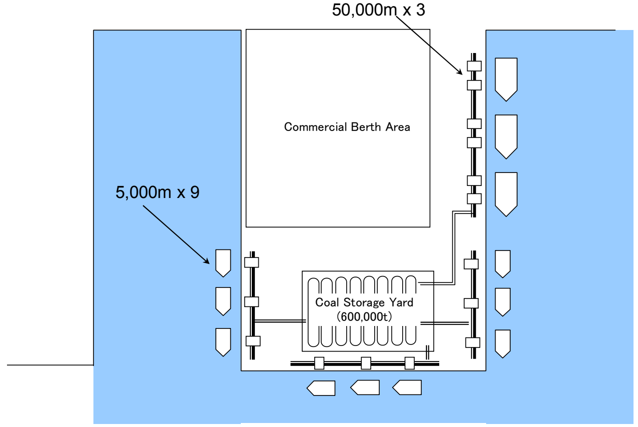
The following shows the conceptual layout plan of each coal center.



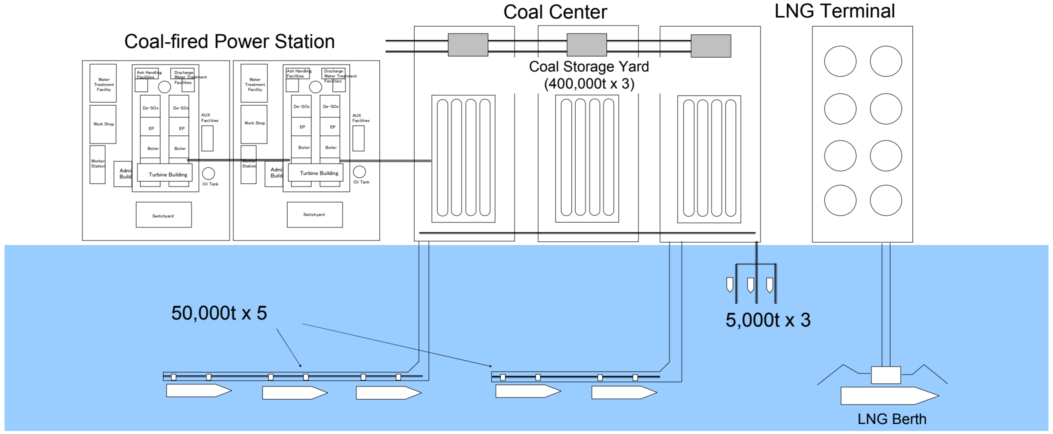
Chittagon-south site



Mongla site



Sonadia site



Matarbari site

Source: PSMP Study Team

Fig. 13-7 Conceptual layout plan of each coal center

Table 13-6 Specification of import coal-fired power plants and coal center

		Power Station							Coal Center (C/C)			Fuel Procurement			
		Specification	Per Capacity	Unit No.	Total Capacity	Port Facility portion for P/S			C/C +Port Facility for C/C						
			[MW]		[MW]	Type	Capacity	No of berth	Type	Capacity	No of berth	Chg S C/C	Matarbari C/C	Sonadia C/C	Mongla C/C
Import Coal P/S	Chittagong South P/S, C/C	P/S: USC (45%)	600	1	600	Import Berth	28,000	2	Import Berth	28,000	2	X			
		C/C: 5.25mil ton/year (3.5mil ton/year for ship)			0				Domestic Berth	5,000	6				
	Matarbari P/S, C/C	P/S: USC (45%)	600	4	2400	Import Berth	50,000	2	Import Berth	50,000	3		X		
		C/C: 8.25mil ton/year (1.75mil ton/year for ship)			0				Domestic Berth	5,000	3				
	Khulna P/S	P/S: USC (45%)	600	2	1200										X
					0										
	Chittagong P/S	P/S: USC (45%)	600	2	1200							X			
					0	Domestic Berth	5,000	5							
	Meghnaghat P/S	P/S: USC (45%)	600	2	600								X		
					0	Domestic Berth	5,000	5							
	Mawa P/S	P/S: USC (45%)	600	2	1200									X	
					0	Domestic Berth	5,000	5							
	Zajira P/S	P/S: USC (45%)	600	1	600									X	
					0	Domestic Berth	5,000	3							
	Mongla C/C				0				Import Berth	28,000	3				
		C/C: 3.5mil ton/year			0										
	Sonadia C/C				0				Import Berth	50,000	3				
		C/C: 5.25mil ton/year			0				Domestic Berth	5,000	9				
	[Total]			**14**	**7800**			**22**			**29**				

Source: PSMP Study Team

Chapter 14 The Conceptual Study on the Construction of Power Stations of Most Prioritized Projects

In this chapter, the concept of the study for power station construction according to Chapter 11's study flow is based on most prioritized projects in this study as models. It would be the base concept for the feasibility study of future power station planning. The objectives of this chapter are 2 types, the domestic coal-fired power station (B-K-D-P site) and the import coal-fired power station (Chittagong South and Meghnaghat).

14.1 Basic idea about conceptual study for most prioritized projects

14.1.1 Study condition

(1) Design code

The following international standard or Japanese standard which is the same or more than the material standard, design standard and test standard for the design of equipment and buildings.

- The American Society of Mechanical Engineer (ASME)
- International Electrotechnical Commission (IEC)
- Japanese Industrial Standard (JIS)

(2) Reliability

Because these power stations would be operated as the base load, reliable equipment and system should be adopted.

(3) Coal

Basically, domestic coal-fired power station would use the domestic coal of Bangladesh; import coal-fired power station would use imported coal which is imported from Bangladesh.

(4) Steam condition

Ultra super critical pressure condition which is state-of-the-art but much experience would be adopted. The steam condition is as follows;

- Main Steam Pressure 24.5 MPa
- Main Steam Temperature 600 degree C
- Designed Heat Efficiency 45% (LHV)

(5) Cost down

Tandem compound steam turbine, single series of boiler equipment would be adopted for cost cuts.

(6) Automatic control system

Coal-fired power station has more auxiliary machines compared with gas-fired ones so that the operation control is complicated. In order for Bangladesh, which does not have enough experience in operating coal-fired power stations to adopt easily, the integrated control system including automatic control system would be adopted.

(7) Climate condition

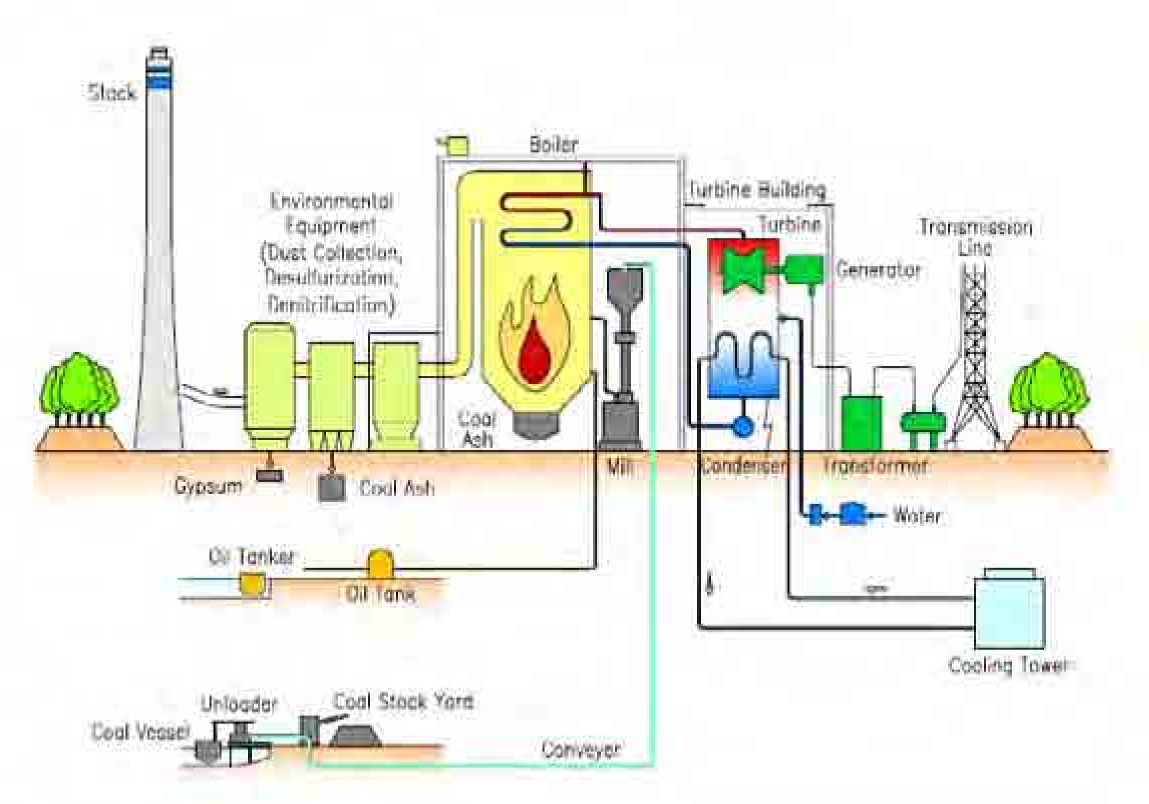
The climate condition for the conceptual design is determined as follows according to the site survey in consideration of the climate of Bangladesh;

- Ambient temperature 27 degree C Average
- Designed wind speed 30 m/s
- Humidity 90 % Max

14.2 Equipments of coal-fired power station

14.2.1 Equipment flow of thermal power station

A thermal power station is to change from thermal energy by firing fuel to electrical energy. Generally, a coal-fired power station is to make steam from high pressure and high temperature, and the steam swings the steam turbine, and to make and transmit electricity by the generator which is at the same shaft with the steam turbine, it consists of not only a boiler which makes steam by firing fuel, the turbine which spins by steam, generator which makes electricity by the steam turbine, the environmental facility which cleans up flue gas, the transformer and switchgear facility which transmits electricity to the grid, but also the coal stock and handling facility, coal ash treatment facility, water treatment facility which makes pure water for the power station. The following figure shows the equipment flow of the thermal power station.



Source: PSMP Study Team

Fig. 14-1 Equipment flow of thermal power station

14.2.2 Equipment specification of most prioritized project

The following table shows the equipment specification of most prioritized project. Each concept is explained from next section.

Table 14-1 Specification of coal-fired power station for most prioritized project

Item		Specification
General spec.	Capacity Thermal efficiency Steam condition	600MW 45%(LHV) 24.5MPa、600/600℃
Major Equipment	Boiler Turbine Generator Environment facility	Ultra Super Critical (USC) variable pressure once-through Tandem compound (single shaft) H2 cooling type Electrostatic precipitator, Flue gas desulfurization

Item		Specification
	Ash treatment facility	(limestone gypsum wet method), 11.5.1 Flue gas denitrification (Selective catalytic reduction) Clinker system: wet treatment, Fly ash system: dry treatment
Coal consumption	Condition Annual consumption	Thermal efficiency 45%(LHV), Plant factor 85%, Heat value 7,100kcal/kg (domestic), 5,100kcal/kg (import) 1.4 mil t/y (domestic), 1.75 mil t/y (import)
Ash production	Condition Clinker production Fly ash production	Ash 15% 20,000 t/y (domestic), 30,000 t/y (import) 200,000 t/y (domestic), 230,000 t/y (import)
Water	Cooling water flow for Condenser (water cooling type) Water consumption	100～110,000t/h Pure water : 700～1,000 t/d Living water : 250 t/d
Flue gas desulfurizatio n	Limestone consumption Gypsum production	18,000～20,000 t/y 34,000～38,000 t/y

Source: PSMP Study Team

14.3 Conceptual study for the equipments of coal-fired power stations

14.3.1 Determination of size of power station

By taking into account current situation of Bangladesh, the demand forecast and power development, which is explained in the previous section, the size of coal-fired power stations which have been adopted for most prioritized projects is 600MW per single unit and 2 plants per one site. Because it needs a big amount of capacity of the coal-fired power station, a 1000MW facility could be adopted for domestic coal on the condition that the entire infrastructure is made.

14.3.2 Boiler facilities

The boiler is a facility to make steam from water by firing fuel.
The item for consideration is as follows,

(1) Determination of steam condition

As was explained in Chap.11, generally the thermal power station is such that higher steam conditions correlate to higher efficiency. However, the cost becomes higher because of the material which can be used for high pressure and high temperature. So that the steam conditions should be determined by optimum cost condition.
The type of steam conditions of the thermal power station are divided at the critical point of water

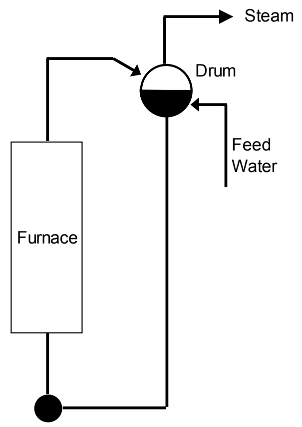
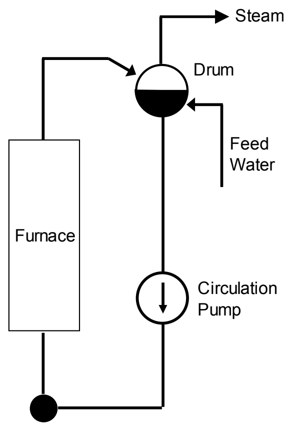
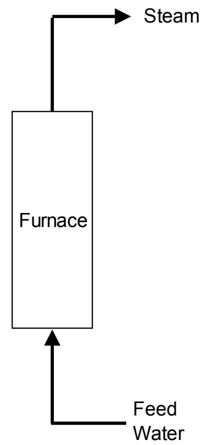
- Temperature 373.95 degree C
- Pressure 22.064 MPa

It is called Sub critical for under this point, and super critical for over this point, and it is called Ultra Super Critical for the point of very high pressure and temperature.
In this Master Plan, 600 decree C, 24.5MPa (USC) has been adopted for high efficiency and experience.
It is necessary to use a compound metal steel or stainless steel for the high pressure and temperature part. There is a reliability difference depending on the country where it is made and which standard is adopted. It requires high level technology for welding, thermal treatment, and the nondestructive inspection.

(2) Determination of boiler type

Because the amount of vaporization of the boiler for the power station is large, high pressure and high temperature steam is needed, “water pipe type boiler” is adopted. The water pipe type boiler is such that, fine tubes absorb heat energy. Then the water in the pipe changes to steam.
The boiler categorized as a circulation boiler and once-through boiler by its water supply. Generally, the once-through boiler is adopted for large scale boilers. Furthermore, only the

once-through boiler is adopted for super critical condition, so in this Master Plan, the once-through boiler is adopted.

<table>
<tr><th></th><th></th><th colspan="2">Circulation boiler</th><th>Once-thorough boiler</th></tr>
<tr><td colspan="2">Model of water circulation</td><td>(Natural circulation)
</td><td>(Forced circulation)
</td><td></td></tr>
<tr><td colspan="2">Adoption</td><td colspan="2">Small and medium size</td><td>Medium and large size</td></tr>
<tr><td rowspan="2">Pressure</td><td>sup critical</td><td colspan="2">○</td><td>○</td></tr>
<tr><td>Super critical</td><td colspan="2">×</td><td>○</td></tr>
</table>

Source: PSMP Study Team

Fig. 14-2 Type of boiler for generation

(3) Determination of design coal

It is necessary to determine coal quality to determine the standard for the boiler design. Generally, in cases where only a certain type of coal is used, this coal would be the designed coal, and in case the number of types of coal is used, the design will be for some type of coal by making a range. Anyway, the design coal is determined after deciding which coal would be used.

The consideration point for the designing boiler after the determination of the design coal is that the shape and size of boiler should be designed so that the coal could be fired perfectly. Therefore, the design for low quality coal is larger than normal coal.

In this Master Plan, design coal cannot be determined, but the following concept would be adopted.

(a) Domestic coal

The domestic coal-fired power station should be designed basically only for domestic coal. The quality of coal is of little difference between Barapukuria and other developing mines shown in Table 4-7 to 4-9, but generally the coal in Bangladesh is of high quality (heat value 7,100 kcal/kg). It should be determined which design coal should be for main use.

(b) Import coal

As mentioned in Chapter 4, the candidate countries for import coal to Bangladesh are Indonesia, South Africa and Australia, the quality varies according to the site, generally, their coal is of low quality coal (heat value 5,100 kcal/kg). The design coal should be determined on the F/S stage after clarifying the site and quality of the coal. On the operation stage, it may be possible to blend with domestic coal, but the design is by import coal.

From above, the approximate size of the boiler, the import coal boiler is larger than the domestic coal boiler about 1.1.

(4) Other considering points

For the design of the boiler in this Master Plan, the following points also should be considered.

(a) Single series auxiliary facility to cost down

Recently, coal-fired power stations in Japan adopt a single series auxiliary facility for the FDF-IDF air and exhaust gas system. So that the house use ratio is about 3.5%. In this Master Plan, a single series is adopted.

(b) Perfect automatic control to reduce operator load

For Bangladesh, which has minimal experience of coal-fired power stations, when a USC plant is adopted, the mastering of operational skills would be a big problem. Therefore, the plant can perform an auto start and auto stop so that the operator load lessens.

Further, a data control system should be installed in order to share operational information with all of the workers in the power station.

The following are data control system examples that should be collected,

- All of plant PI data : every 1 minutes
- Log sheet data : every day
- Generation report data : every day
- Heat efficiency calculation data: every day
- Performance test result : every performance test
- Start stop loss calculation data : every start and stop
- Turbine vibration data when start : every start
- Message data : every occurance

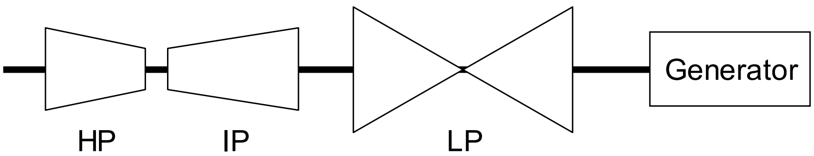
(c) Other specific item

- Axial flow type should be adopted for FDF, IDF, PAF and BUF.
- The size of coal banker should be 10 hours.
- Vertical type roller mill or vertical type ball mill should be adopted.
- Feed water pump should power by steam turbine.
- Air heater should include sensor drive system.

14.3.3 Turbine facility

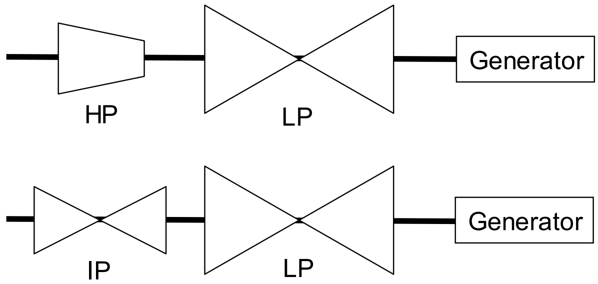
Turbine changed from the high pressure high temperature steam to spinning energy (from heat energy to kinetic energy), and spin generator for generation.

Generally, the steam turbine in the thermal power station consists of a high pressure turbine, an intermediate pressure turbine and low pressure turbine according to steam pressure. A high pressure turbine receives steam from the boiler directly, an intermediate pressure turbine receives reheated steam, after that the low pressure turbine is on the receiving end of the intermediate turbine. The tandem compound refers to those turbines in one shaft, and the cross compound means separate.



Source: PSMP Study Team

Fig. 14-3 Tandem compound (single shaft) turbine



Source: PSMP Study Team

Fig. 14-4 Cross compound (double shaft) turbine

The cross compound was developed in order to shorten the length when a large amount of the facility was developed. The generator could also be made small. Currently, the technology of the big blades of the turbine has been developed, the big size tandem compound turbine has been developed and it contributes to cost cuts.
The item for consideration is as follows

(1) Determination of steam condition

The steam condition of the boiler is also for the turbine.
In this Master Plan, 24.5 MPa 600/600 degree c has been adopted.

(2) Determination of cooling system

There are two types of steam turbine condensers, air cooling and water cooling. Almost all Japanese thermal power stations adopt the water cooling type using sea water, overseas water cooling with a cooling tower or an air cooled condenser are also adopted. It should be chosen according to water securing methods.
In this Master Plan, for imported coal-fired power stations, because it is located riverside or seaside so that water cooling with seawater is one of the options, however, considering neighboring influence of warm water, the water cooling system with a cooling tower would be adopted.
For the domestic coal-fired power station, the how-to regarding securing water is a big issue. The following are some considerations.

(a) Type of water

First, there are two types of water required by a thermal power station, depending on the intended use.

- Cooling water
  When the condenser or bearing cooling system applies the water-cooling system, it needs cooling water. The amount of cooling water changes depending on the cooling system.
- Unit water
  It will be needed make-up water to compensate for the decrease in water used by the power generation facilities, such as boiler circulating water or bearing cooling water, and to maintain the quality of water. The required amount of water is 1,000–2,000 t/day per unit of 600 MW.

(b) Water securing method

Second, the PSMP Study Team studied the method to secure water in the candidate site as follows.

1) Securing water from deep wells

In Barapukuria, the neighboring area of this site, the water for the power station is secured from deep wells (14 wells in total). However, as a result of the survey and interview in the

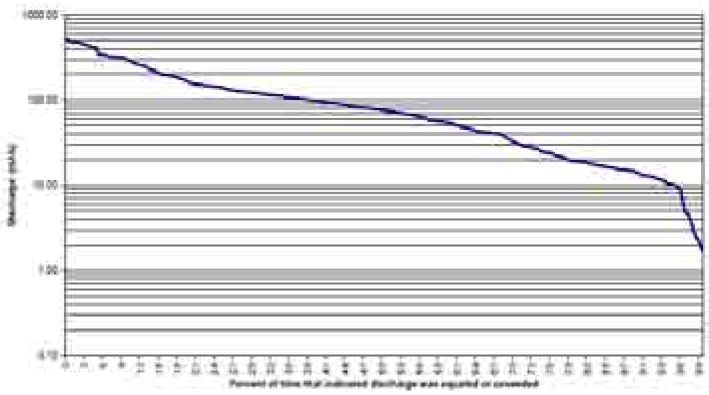
neighboring residential area conducted by the PSMP Study Team, it was found that there is a problem of land subsidence that appears to be caused by taking water from the deep wells.
Although the PSMP Study Team do not conduct a full-scale investigation (boring, etc.) of this site in the survey to explore the possibility of deep wells, it is highly probable that a similar problem will arise in this site, too, as the PSMP Study Team have already confirmed the influence in the neighborhood as stated above.

2) Securing water from rivers

The PSMP Study Team confirmed that there are two rivers (the Little Jamuna River and the Karotoa River) in the neighborhood of this site (a few kilometers away). In order to confirm the availability of water from these rivers, the PSMP Study Team collected flow data and created a duration curve as follows.

a) Little Jamuna River

The flow, level and speed of this river are recorded at the No.62 Gauging Station. Every month has only 2 data.
The following is the duration curve based on 1998 to 2006 flow data;

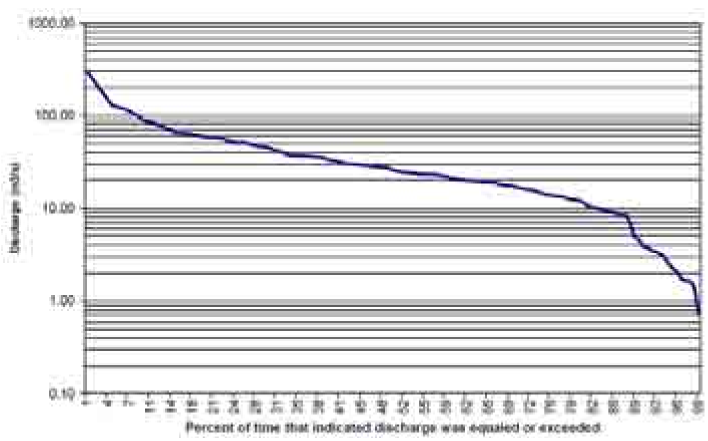


Source: PSMP Study Team

Fig. 14-5 Duration curve of Little Jamuna river

b) Karotoa River

The flow, level and speed of this river are recorded at No.133 Gauging Station. Also every month has only 2 data.
The following is the duration curve based on 1987 to 2006 flow data;



Source: PSMP Study Team

Fig. 14-6 Duration curve of Karotoa river

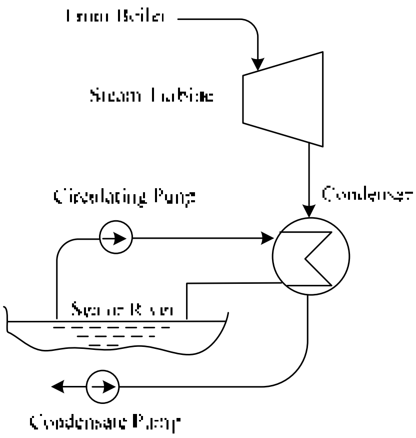
According to the guideline from BWDB, the maximum water intake from the river is 70% of the flow, so that the maximum water intake is 1.75m^3/s (1.75t/s) and 0.74m^3/s (0.74t/s).
Based on this result, it is clear that the amount for unit water can be secured from these rivers. However, the amount of cooling water cannot be secured annually. Based on this, the study for the cooling method is as follows.

(c) Study on the cooling method

The PSMP Study Team studied the cooling method of the power station as follows.
There are three options of the cooling method to be applied at the thermal plant currently projected in this survey: the transient cooling system, mechanical-draft cooling tower system, and mechanical-draft air-cooling tower system. The characteristics of each are as follows.

1) Transient cooling system

It is adopted in case abandoned cooling water could be secured. There is no need of a cooling tower and high cooling efficiency. In Japan, almost all thermal power stations adopt it by using sea water.



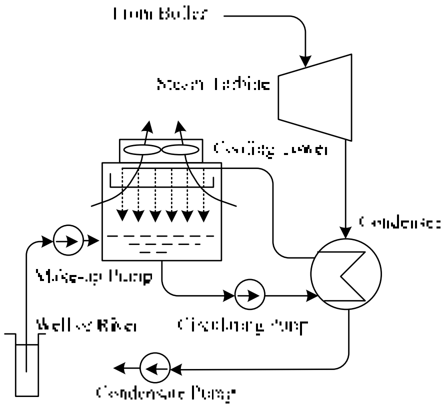
Source: PSMP Study Team

Source: TEPCO

Fig. 14-7 System and adoption example of transient cooling system

2) Mechanical draft cooling tower system

In case enough water cannot be secured, there are many cases adopted mechanical draft cooling tower system in the world. It needs equipment cost of cooling tower, cooling efficiency is high, and it is adopted in many cases in China and so on.
The necessary water supply for 600MW is about 1.5 t/s in total vaporization and make up.
At B-K-D-P site, the necessary amount of water for 600MWx2 is 3 m/s, however there are periods when it is impossible to intake enough water from the river, 10% for the Karatoa River (37 days), 4% for the Little Jamuna River (15 days). In order to stock water for these terms, 3x3600x24x37=9.6 million t of water stock is needed and it is not realistic. It is also difficult to use wells only during these seasons in consideration of the impact to neighboring residents.



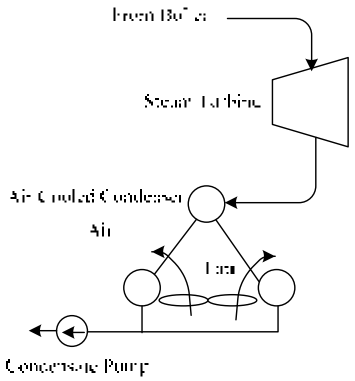
Source: PSMP Study Team

Source: PSMP Study Team

Fig. 14-8 System and adoption example of mechanical draft cooling tower system

3) Mechanical draft air cooling condenser system (ACC)

It has been adopted in case there is no cooling water. The required space and cost is high, house power consumption is high, cooling efficiency is low. However, the biggest merit is that there is no need to secure water. Large scale adoption examples for are the Mathinba Power Station (670MWx6) in South Africa and the Hancheng Power Station phase 3 (600MWx1). For this site, securing the required amount of space would not be a problem, and the merit of no water requirements is big compared with cost and efficiency.



Source: PSMP Study Team

Source: TEPCO

Fig. 14-9 System and adoption example of mechanical draft air cooling condenser (ACC)

The following is a summary of the above study.

Table 14-2 Comparison of cooling system

Item	Transient Cooling	Mechanical draft cooling tower	Mechanical draft air cooling condenser
Cooling Efficiency	High efficiency is expected by a large amount of water	Influence from climate	Enough efficiency cannot be expected in case high temperature
Facility Cost (600MW)	Construction of intake and exhaust water 15 mil USD	Cooling tower 10 mil USD	Air Cooled Condenser 50 mil USD
Running Cost (House Use	Only for Circulation Water Pump (small)	Circulation Water Pump + make up water pump	Big size cooling fan (big)

Item	Transient Cooling	Mechanical draft cooling tower	Mechanical draft air cooling condenser
Power)		+ cooling fan (Medium)	
Necessity to secure water	Need big amount of water (20 ～ 30 t/sec for 600MW)	Need make up water (1 ～ 2 t/sec for 600MW)	No need
Social considerations	Big influence for the neighbors by using big amount of water and warm exhaust water	In case of usage of well, influence about ground settlement	No influence regarding secure water

Source: PSMP Study Team

As the above study, regarding the selection of the cooling system, it is necessary to select an appropriate system for each site in consideration of how to secure water. The following is the selection in this Master Plan.

(d) Domestic coal-fired power station

According to the above study, first of all, at the B-K-D-P site, it is impossible to secure abandoned water, so the transient cooling system cannot be adopted. In the case of adopting a cooling tower system, the water intake from the river will not be enough for the whole of the year. So that, in this Master Plan, a mechanical draft air cooling condenser (ACC) system would be adopted. However if there is a possibility to secure water during the F/S, a cooling tower system should be adopted because its cooling efficiency is high. The following method for securing water could be expected;

- To supplement the insufficient part with deep well water. (a detailed study of environmental impact should be a requirement.)
- The power station is set near Jamuna River and the intake water is from Jamuna River. (Comparison of the fuel transportation cost should be needed)
- To use water from Phulbari O/C mine. (There is some experience in Europe, a detailed investigation should be a requirement.)

(e) Import coal-fired power station

Each site is located riverside, so it is better to adopt a transient cooling system. However, in consideration of the impact the warm water will pose to neighboring residents, the cooling tower system should be adopted.

(3) Determination of type

The types of turbines, tandem compounds or cross compounds, should be determined. The following is a comparison of these types, almost the difference of space.

Table 14-3 Type of turbine

	Tandem compound	Cross compound
Necessary area	Length long Width short	Length short Width long
Equipment	- 1 large capacity generator - large LP turbine	- generator capacity can be divided - not so large LP turbine

Source: PSMP Study Team

Recently a low cost large turbine has been developed, so the tandem compound is more economical if there are no transportation restrictions.
In this Master Plan, after an investigation of the transportation there is no problem, so a tandem compound has been adopted.

14.3.4 Generator

A generator consists of a stator, a rotor, a bearing, a cooling system and an exciter, the exciter provides electrical current to the rotor coil, to create a necessary magnetic field for the electro motive force.

The items for consideration are as follows;

(1) Cooling system

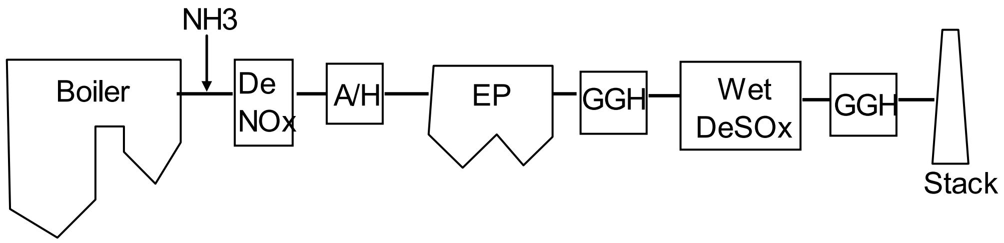
The turbine generator generates a tremendous amount of heat, so that a gas-cooling or liquid cooling system should be adopted. Currently, the almost large capacity generator adopts a H2 cooling system. The H2 is good for the cooling generator for many reasons like cooling efficiency and its lifespan. In this Master Plan, an H2 system should also be adopted.

(2) Excitation system

The DC supply is needed for the excitation system. In the past, the same shaft exciter was used. Currently, the AC generator and rectifier are popular. In this Master Plan, an AC generator and rectifier type should be adopted.

14.3.5 Environmental facility

Regarding NOx and SOx emissions, a system that eliminates stray dust will be employed. The compositional unit even in Japan is a general method. An example of how the equipment is arranged is shown below:



Source: PSMP Study Team

Fig. 14-10 An arrangement example of the environmental apparatus (Low-temp EP type)

(1) Determination of type of electrostatic precipitator

In order to primarily collect flue gas including "fly ashes", an electrostatic precipitator will be installed. Although there are instances where a bag filter is employed at coal-fired power stations in one part of the country, in Japan, utilizing an electrostatic precipitator (EP) has become the standard. The types of EP are categorized into High, Low and Low-low temperatures depending on the temperature during operations. Specifically, the combustion ashes from designed coal are analyzed and after coming to an understanding of the electric resistance from ashes, it will be moved on to the designing stage. Further, given that the capacity and generation amounts (the contained amount of ash content) are the determining factors, design based on the type of coal is necessary. Hence, the coal type is decided on, and once the coal ash properties and its chemistry are understood, it will be moved on to the design specifics. In addition, a vacuous space in the EP's exit is created in light of future coal property transformations and increases in the coal's ash content as well as plans to affix dust collection electrodes and discharged electrodes to for the purpose of performance recovery when such performance begins to decrease. Furthermore, in order to prevent the re-entrainment of dust collection electrodes and discharged electrodes attached to ashes during "hammering", a damper will be installed at the EP exit.

(2) Determination of type of desulfurization

The Desulfurization Facility is apparatus that eliminates flue gas including SOx particles, and for coal-fired power stations is considered to be the most widespread limestone-gypsum wet scrubbing method and via contact with limestone slurry, SOx particles are reacted with limestone resulting in a method that generates gypsum. Further, when seawater HCO3 is used as an absorbent, it is possible to come up with a simplified seawater scrubber-based desulfurization apparatus. Inside the "reaction tower", when emitted gas comes into contact with limestone slurry, it produces the following reaction, and gypsum (CaSO4・2H2O) is generated.

$$SO_2 + H_2O \rightarrow H_2SO_3$$
$$H_2SO_3 + 1/2O_2 \rightarrow H_2SO_4$$
$$H_2SO_4 + CaCO_3 + H_2O \rightarrow CaSO_4 \cdot 2H_2O + CO_2$$

When actually choosing a method in light of existing regulations, it is important to take into consideration the desulfurization efficiency and the costs. For this Master Plan, first with regards to domestic coal-fired power stations, the Desulfurization Facility will be planned with an eye towards cheap design and operational costs utilizing the "Blended Ash Method". From the perspective of the quality of the calcium sulfate, although the interfusion of impurities such as fly ash is to be expected, since it can be utilized as a "gypsum board", it is considered to be efficient.

(3) Determination of type of denitrification

The Desulfurization Facility is apparatus that eliminates flue gas including NOx particles, and for power plants is considered to be the most widespread Ammonia Catalytic Reduction Method available Furthermore, in concert with desulfurization apparatus, in order to reduce nitrogen oxide in the boiler, a "Low NOx Burner, two-staged combustion" is utilized. As with the Desulfurization Facility, in accordance with regulations a comparison of the desulfurization efficiency and costs are taken into consideration before adopting a method.

14.3.6 Utility equipment

(1) Determination of capacity of water treatment facility

Regarding the aforementioned inside of the unit's artificial ditch, given that fine, high grade water is required, especially for the water used to replenish the boiler's water supply etcetera, it is necessary to have water treatment apparatus inside the generator (water purifying apparatus). With regards to the design, after determining the required amount of water based on the design of the boiler and the environmental facilities, it is necessary to apply an appropriate amount of capacity.

(2) Coal stock & handling facility

At a stage of determination the capacity of coal stock facility in the power station, it should be determined how much needed according to the way of fuel transportation. For example, if the coal is provided continuously by truck or direct from coal mine, it is no need to secure large capacity of coal stock yard, but in case the transportation is vessels, 30 or 50 days of stock should be needed considering climate risk. According to risk, it should be determined.

In this Master Plan, for the import coal-fired power station the capacity of coal stock yard is determined as 45 days, to set 200,000 t capacity of coal stock yard is set for 600MW. For the domestic coal-fired power station it is determined as 15 days considering short span transportation from coal mine.

About coal handling facility, the item of consideration is different between domestic and import.

(a) Domestic coal-fired power station

In case of this site, because of its feature of being close to the coal mine that is the procurement source of fuel (several kilometers away), possible alternatives of fuel transportation mode are belt conveyors, trucks, and railways.

1) Belt conveyor

It is characterized by the low cost of construction and transportation on short haul. But if it is a long haul, maintenance cost is high and there is little performance record.

2) Truck

It is characterized by easy loading/unloading and easy adjustment of the amount of load by increasing or decreasing the number of trucks, but to make an efficient transportation stable, you need the road maintenance (pavement), which costs a lot (you should construct exclusive lanes for mass transportation). Also, for mass transportation, you need many trucks; hence, the purchasing cost of vehicles and the labor cost for drivers will increase. In addition, there is a big risk of traffic accidents.

3) Rail

It has an advantage over other transportation modes because it can transport a large amount of load at one time; however, you need various costs, including cost for rail development, cost for constructing loading/unloading facilities, cost for purchasing freight cars, etc. It helps to reduce operational cost for a long haul but can be rather expensive for a short haul.

The PSMP Study Team summarized the above studies in the following table (details of the amount, etc., are under investigation).

Table 14-4 Comparison of fuel transportation modes

Item	Belt Conveyor	Truck	Rail
Construction and equipment cost	Approx. 5,000 USD /m	Road Truck : Approx. @100,000USD	Rail : Approx.2 mil USD/km Car : Locomotive 4 mil USD Freight Car 200,000 USD
Running Cost	(Power for Conveyor・Maintenance cost)	(Fuel cost, Maintenance cost)	(Train Operation cost, Maintenance cost)
Operation	(Fixed route)	(Flexible (amount control, route change))	(Transportation on the rail)
Maintenance	(cleaning of conveyor joint point)	(Car maintenance, Road maintenance)	(Car maintenance, Rail maintenance)

Source: PSMP Study Team

As for the cost, while the cost for a belt conveyor is proportional to the distance, truck and railway require a large amount of initial investment such as purchase of vehicles that are not proportional to the distance; therefore, the belt conveyor will be advantageous if it is a short haul. But on the negative side, the weak point of the belt conveyor is that it can transport only on a fixed route; however, flexibility counts for little if it is used for a fixed route such as between a coal mine and a power station.

In addition, it is proposed that railway should be developed to transport domestic coal from coal mine to import coal-fired power station such as Khulna, Meghnaghat by mixing domestic coal which is cheap and good quality with import coal, to make stable firing and to hedge the risk of the import coal chain.

(b) Import coal-fired power station

In the case of import coal-fired power station, the conveyance of the coal will be connected to the sea port as specified in Chapter 13 where it states that Chittagong South will serve as the coal center for coal supplies to Chittagong. On the other hand, Meghnaghat will only be

responsible for incoming domestic vessels from Matarbari. Import vessel entry will be prohibited.
For the base of Chittagong South's import vessels, given that area along the coast is too shallow, a T-shaped off-island location about 1km away with a 10m depth and a 28,000t capacity will be utilized. However, the domestic vessel berth will be constructed connecting to the dry land. The following indicates the necessary base numbers for the two locations.

Table 14-5 Necessary berth number of Chittagong South and Meghnaghat

	Chittagong South	Meghnaghat
Import Vessels	4 (5)	0
Domestic Vessels	6	5

Source: PSMP Study Team

With regards to coal transport (from ship to land) and storage, import coal-fired power station are different than their domestic counterpart in that they are not dealing with only one set type of coal. Further, depending on the type of coal, given that a coal mixture may be necessary, specifications overseeing coal transport and storage to ensure proper "coal mixing" will be required. Specifically, at the storage site, a system must be set up whereby the coal is properly divided into piles by type and then in order to create a coal type that is close to the boiler's design specifications, have the necessary amount of coal taken from each pile and then placed in a "delivery line" from where it will be sent to the "blending apparatus". For "reclaims" and "stock reclaims", the number of piles will be installed.
Further, since coal transport and storage for incoming foreign vessels will be a 24hour operation, a system capable of overall operational handling and supervision will be built to be installed in the "Coal Transport Control Room." Several TV cameras connected "changing-screen monitors" will be installed in the control room to allow for surveillance of the berth and coal storage activities. The same will be applied to outgoing transfer work of other firepower.

(3) Determination of type of ash treatment facility

How ash exhaust from the boiler is collected and disposed are the determinants of the type of apparatus and capacity amount (how much is capable of being stored).
With regards to the 600MW plant equipment planned for this master plan, per each generator, approximately 200,000 tons per year of coal ash is generated. Categorically speaking, 15% of this is clinker ash (ash that accumulates at the bottom of the boiler) and 85% is fly ash (ash from flue gas and ventilation pipes that is primarily collected by the EP). The clinker ash is collected utilizing water (a wet cleaning method) from the bottom part of the boiler while fly ash is collected via a dry method. Further, next to the generator, a spot has been secured for the disposal of ash which under normal circumstances would be buried in the ground. However, in terms of construction materials, given that coal ash has many utilitarian purposes such as serving as mixture material for concreter, a thick alternative to cement, fertilizer for soil enhancement, landfill reclamation and marine reclamation etcetera, at the ash disposal site, it is put aside and categorized as a substance that in an emergency can serve many beneficial purposes.

14.3.7 Other common facility

(1) Main building

For the main power generator building, in order to install the steam turbine, it is supported by a very strong, highly reliable foundation and in order to lessen damage from machine vibrations, a design employing a sufficient amount of rigidity and intensity is applied to the uneven settlement.

(2) Stack

From the perspective of environmental safety, the height of the chimney was determined to be 140m in consideration of exhaust input/output speed and concentration diffusion.

(3) Attached buildings

The administration office, separate from the machinery operators, has been designed for full-time workers. On the first floor, there is a chemical analysis laboratory, a cafeteria, a resting area, air-conditioning equipment room, storage. On the second floor, there is an office, meeting room, head office, dressing room, and a material room. Other buildings include the repair factory, parts storage building, Coal Transport Control Building, Environmental Apparatus Control Building, Hazardous Materials Storage Building, the Water Treatment House, and the Security building (guard house).

14.3.8 Facilities for co-existing areas

In order to promote harmonious co-existence between power station and their local surroundings, it is of vital importance that a relationship of trust be established with surrounding residents. Hence, the power station should adopt a position of openness to the public and actively contribute to the area's lifestyles. In this master plan, there are plans to construct a park, a cricket field, and a pool in the nearby surroundings for local inhabitants. Further, the promotion of planting greenery in the power station's surrounding areas will also be encouraged.

14.4 Study of equipment transportation

During the construction stage of the power station, the main equipment such as the boiler, turbine, and generator are partly assembled in the factory prior to being transported to the site, so there are large equipment that needs to be transported via special means. If the power station site is located seaside, it is possible to use a barge ship. However in case that the site is inland, land transportation is needed. So it is necessary to deeply consider the logistics of land transportation. After designing, what kind of equipment, how it is packaged, actual route verification, optimum route selection, and bridge or road repairs if necessary.

On this Master Plan, the B-K-D-P site has the most restrictions concerning the transportation of equipment, so the study for transportation is conducted as follows;

14.4.1 Specification of transportation

The major equipment for the 600MW class coal-fired power station is as follows;

Table 14-6 Specification of equipments

Equipment	Specification	Remarks
(Major equipment)		
Generator	600MW class	Including stator, rotor
Transformer		Impossible to separate
Turbine	Single shaft (HP,IP,LP)	Possible to separate
Boiler		Assembly at site
Cooling system	Air Cooled Condenser	Possible to separate
Anxiety equipment		Possible to separate

Source: PSMP Study Team

For the transportation, in case of ship, choose freight vessel, in case of usage of river, rush vessel or barge vessel would be used. At the road transportation, it is generally to use the railway or large trailer. Therefore, not to make damage is important especially for main equipments.

And it is necessary not to exceed construction limit, the generator and transformer are the maximum pack.

Following is transportation specification.

Table 14-7 Specification for transportation

Equipment	Size	Weight
Generator	15m×7m×5m	400t(stator)
Transformer	14m×13m×10m	320t

Source: PSMP Study Team

14.4.2 B-K-D-P site

B-K-D-P site is located N-25° 23.491’ E89° 07.003’, about 15km distance from Barapukuria coal mine, and 7km east side from Nababganj Upazila in Dinajpur.

Source: PSMP Study Team

Fig. 14-11 B-K-D-P site map

14.4.3 Selection of transportation route

It is assumed that the equipment and materials for the new power station will be off-loaded at either Chittagong seaport or Mongla seaport from where these may be carried by waterways and/or roads/railways etc. From any of the seaports, the cargoes containing the power station equipment and materials will be loaded on the barges for transportation through waterways to the nearby river port from where the cargoes will be loaded on the multi-axle trailer to carry them to the B-K-D-P site through roads. Another option is to unload the equipment and materials from the barges to the trailer at the seaport and then transported to the B-K-D-P site through roads. Hence, the following three routes have been proposed to carry the equipment and materials from the seaport to B-K-D-P site:

Route-1: River route from Mongla port to Balashi Ghat and thereafter overland route from Balashi Ghat to B-K-D-P site;

Route-2: River Route from Chittagong Port to Balashi Ghat and thereafter overland route from Balashi Ghat to B-K-D-P site;
Route-3: Overland route from Mongla Port to B-K-D-P site.

14.4.4 Study for the transportation from Mongla port to B-K-D-P site

(1) Geographical position of Mongla port

Mongla Port is situated on the East Bank of Pussur River near the confluence of Pussur River and Mongla Nulla at Channel distance of 71 Nautical Miles from the Fairway Buoy situated (Lat. 21026.9` N. long. 890 34.4 E) in the Bay of Bengal.

Mongla Port is controlled by the Mongla Port Authority, the second largest port in Bangladesh, 350 ships arrive at the port every year, the amount of cargo treatment is 3.4 million tons per year as follows;

Table 14-8 Trend of cargo treatment amount of Mongla Port

(1,000 t)

FY	Import	Export	Total
1995	2,322	725	3,047
1996	2,443	396	2,839
1997	2,174	520	2,694
1998	2,340	508	2,848
1999	3,054	382	3,436

Source: Mongla Port Authorlty

Source: Mongla Port Authority

Fig. 14-12 Pussur River with Mongla Port

(2) Mooring and anchoring facility of Mongla port

There are 5 mooring facilities at Mongla port for normal cargo and container, and also 7 at the river mooring berth and 14 at the anchorage berth. The maximum capacity of the cargo treatment is currently 40 t, so a 500 or 800t crane barge is needed.

Source: PSMP Study Team

Fig. 14-13 Mooring facility of Mongla Port

(3) Mongla port and approach channel from the Bay of Bengal

The Mongla Port Authority (MPA) maintains a draught above 7 meter near the jetties by dredging for ship berthing. No-heavy lift cargo can be easily unloaded on the jetties (5 nos.). Outer anchorages have draughts of 9 meters and above. There should be no problem for ships to offload the heavy lift cargo on to the barges. The port area being 131 km away from the Bay of Bengal and is safe in respect of storms and tidal bores.

The approach Channel with draught of 28meter is very wide (7000m) and has sufficient draughts (9m to 28m) for bigger ships to ply to the port.

(4) Tide

The tides are important for navigation as determines the possibility of crossing the shallow outer bar at the entrance. The tides are semi diurnal with prominent diurnal effect. The approx. tidal range is between 1.2 m. to 3.5 m. all over the channel.

(5) Navigational facilities

Maximum length of ship that can enter Mongla Port is 225m. Pilotage is compulsory. Anchorage condition is good.

(6) Unloading and loading at Mongla port

For the proposed B-K-D-P Coal Fired Power station, the heavy lift equipment with maximum single package may be assumed to weigh up to 400tons has to be transported by barges or road from the seaport to the B-K-D-P candidate site at Nababganj, Dinajpur

(7) Transportation

Barge (L38.5mxW20.0mxD2.13m capacity 600tons)	:	1 No.
Tugboats (Twin screw, 500hp)	:	2 Nos.

Tugboats (Twin Screw) each of 500hp capable to operate during high river velocities up to 3.5m per second will have to be arranged. This may hired locally.

All heavy cargoes will arrive at Mongla port by ship from abroad. The existing jetty at Mongla port can not handle such heavy cargoes. The carrying ship will have to unload with its own crane all the heavy equipment packages at outer anchorage on to special barge detailed by the carrying contractor. For the heaviest single lift cargo of 400tons, the barge deck has to be reinforced and leveled by steel sheeting adapting to the size of the equipment packages of stator of generator. After placing in position on the special barge, the package should be covered and wrapped adequately for protection and special care should be taken during transportation. Specially trained and experienced crew and staff including security force should be deployed for the purpose.

14.4.5 Study about river transportation from Mongla port to Balashi Ghat

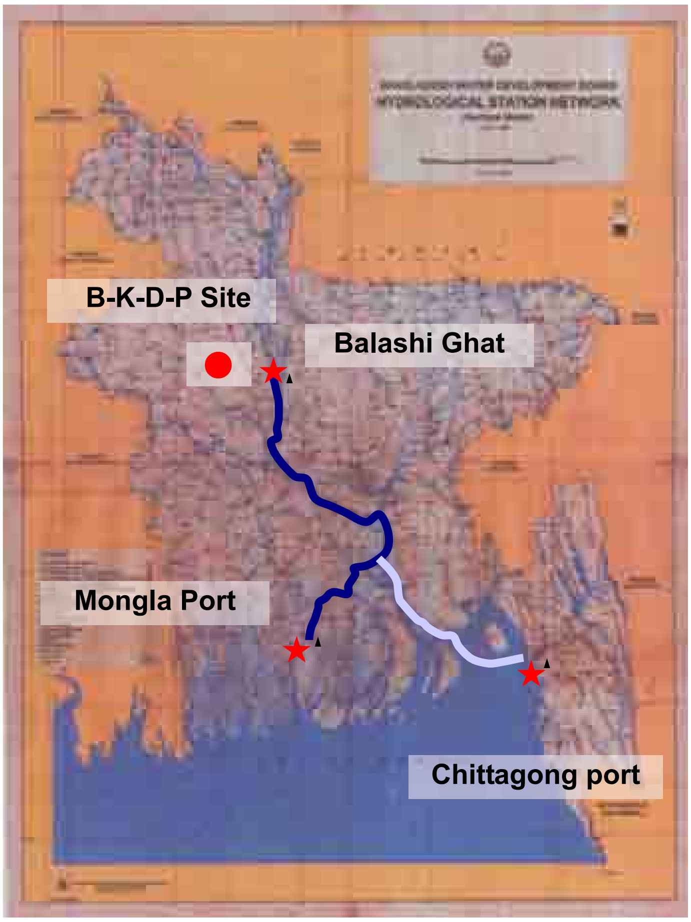
Possible river route from Mongla port to Balashi Ghat has been studied. The river route from Mongla Port to Balashi Ghat is about 468km long.

(1) Transportation route

The route has passed through the rivers Pussur, Mongla, Kumarkhali, Ghashiakhali, Panguchi, Kacha, Gabkhan, Gajal, Nalchiti, Barisal, Arialkhan, Azimpur, Dharmogonj, Meghna, Padma/Ganges and Jamuna. Satellite image showing River route from Mongla Port to Balashi Ghat is given as follows;

(2) Condition of river

Following table shows the condition of Jamuna river from Mongla Port to Balashi Ghat.



Source: PSMP Study Team

Fig. 14-14 Route map of river transportation

Table 14-9 Channel condition from Mongla Port to Balashi Ghat

No.	Section		Distance from Mongla Port(km)	Width (m)	Depth (m) at mid point	Remarks
	From	To				
1.	Mongla	Morelgonj	38	200-700	4.6-10.2	
2.	Morelgonj	Kawkhali Ferighat	77	700-2500	9.5-22.1	
3.	Kawkhali	Barisal CSD Ghat	114	120-800	6.2-24.4	
4.	Barisal	Hizla	142	300-1700	5.3-25	
5.	Hizla	Chandpur	193	600-10000	4.8-40.5	
6.	Chandpur	Mawa	241	300-3900	4.8-27.1	
7.	Mawa	Daulatdia	295	400-5300	11.5-53.9	
8.	Daulatdia	Chowhali	332	2000-7000	6.2-39.3	
9.	Chowhali	Sirajganj	365	500-6000	4.8-32.2	
10	Sirajganj	Balashi Ghat	468	500-6000	4.8-32.2	

Source: PSMP Study Team

(3) The channel Mongla to Hizla (142km)

This section having widths of 120meter to 2500m and draughts of 4.6m to 25m is suitable for all season transportation of cargoes by barges.

(4) Hizla to Daulatdia (153km)

This section is very wide and deep with a number of islands. Its navigation line having draughts of 4.8m to 53.9m is also suitable for all season transportation of cargoes by barges.

(5) Daulatdia to Balashi Ghat (173km)

This section is also very wide and deep with a number of islands. Its navigation line is very narrow and un-navigable during winter. But it becomes navigable during monsoon period particularly between July and September (draught 4.8m to 39.1m). Transportation of cargoes by barges is possible only during this period. A dredger of adequate size and pilot service from BIWTA will have to be arranged for this section with every trip. Channel dredging will be required to extend the navigability beyond monsoon period i.e. up to June-November, if desired. In this section, Jamuna Multipurpose Brride (JMB) known as “Bangabandhu Shetu” is located near Serajgonj. Although the height of this bridge above flood level is about 30m, special care must be taken to avoid any accidents during carrying the heavy cargoes.

Source: PSMP Study Team

Fig. 14-15 Below Bangabandu Shetu

(6) Balashi Ghat

Balashi Ghat is situated on the west bank of the Jamuna River in the district of Gaibandha. It is located at N 25018.908’, E-89036.938’. This is used as river port from where the ferries, launches, boats and oil tankers etc are plying to other river ports e.g. Sirajganj, Daulatdia etc. There is one pontoon for loading and unloading of ferries, launches, boats etc. The draught at Balashi Ghat in the winter is about 4.5m. Jetty may be installed at this Ghat to unload heavy cargoes of B-K-D-P Power station to transport from this Ghat to B-K-D-P site by road.

	
Oil Tanker & Launch waiting	Boat waiting at Balashi Ghat
	
Ferry Mooring	Downstream view
	
Upstream view	Opposite side view

Source: PSMP Study Team

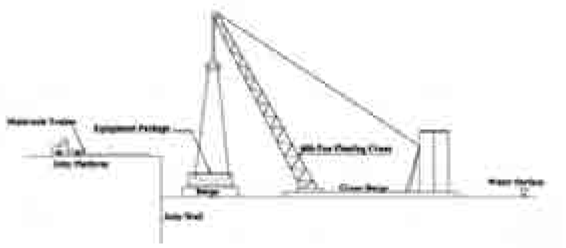
Fig. 14-16 Photo of Balashi Ghat

14.4.6 Unloading methodology at Balashi Ghat

There is no Jetty at present at Balashi Ghat except one pontoon. A jetty has to be built by the EPC Contractor. During the Survey a possible site for Jetty was found at the bank of the River Jamuna. The carrying ship will unload with its own crane all the heavy equipment packages on to special barge. The heavy equipment above 40tons would be loaded on 600-ton barge and would be towed by tugboats to Balashi Ghat. Pilot service is essential for safe cruising. Tugboats will tow the barge to Balashi Ghat Jetty. Cargoes offloaded from the barge by 600-ton self propelled barge mounted floating crane on the trailer placed on the jetty.

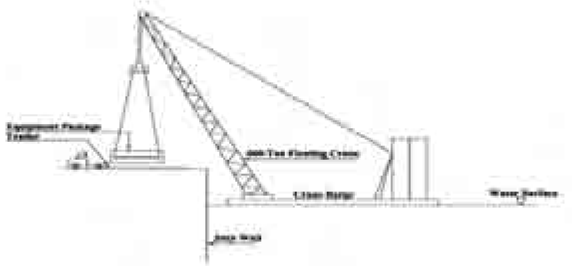
Steps to be followed at Balashi Ghat for the single lift cargoes above 40tons:

(1) On arrival of special barge with cargo a high capacity barge mounted floating crane will be placed along the barge carrying the cargo.
(2) The floating crane will lift cargo from barge to the required height
(3) The empty barge will be moved away by the tug
(4) The floating crane will proceed with the equipment towards unloading point of the jetty.
(5) The crane will lower the cargo on the trailer placed on the jetty platform specially prepared by others
(6) The cargo will be wrapped after placed on the trailer and the wire will be removed.
(7) Trailer (driven by Prime mover) will carry the cargoes to the site following the overland route.
(8) The equipment will be off-loaded from the trailer by suitable crane.



Source: PSMP Study Team

Fig. 14-17 Unloading from barge

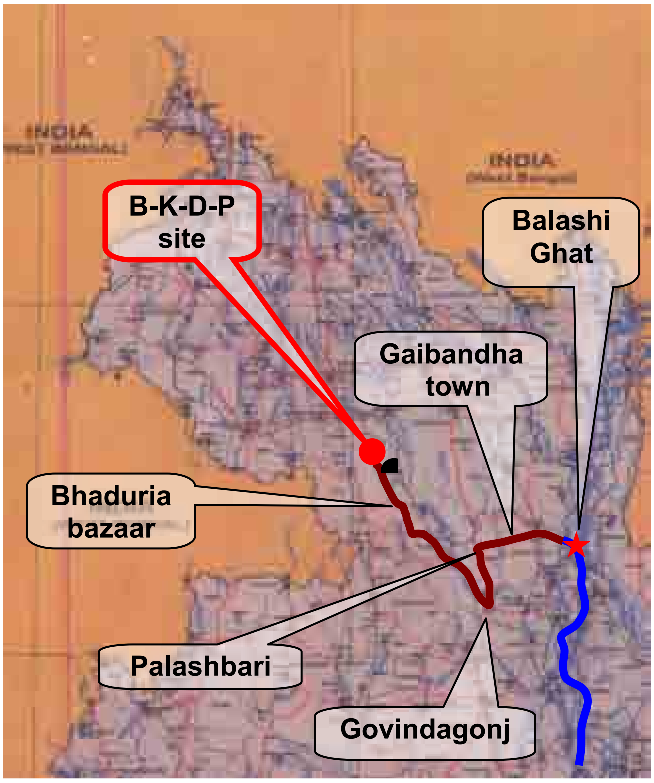


Source: PSMP Study Team

Fig. 14-18 Loading to trailer

14.4.7 Overland route from B-K-D-P site to Balashi Ghat

B-K-D-P site is located Daudpur Bazar, Nababgonb upazila, Dinajpur.



Source: PSMP Study Team

Fig. 14-19 Transportation route to B-K-D-P site

(1) Maximum cargo loading

Following table shows the general regulations governing loading according to Roads & Highway Department;

Table 14-10 Maximum loading for general cargo

Type	Max. Length	Max. Width	Max. Height	Max. Loading	Remarks
	(m)	(m)	(m)	(t)	
Truck	7.0	2.3	3.5	10.0	
Trailer				25.0	Certificate required for over 10 ton

Source: PSMP Study Team

As per gazette notification of Bangladesh Govt. published on May 5, 2004 laden weight of vehicles with length more than 10m shall be limited to 44tons for plying over the highway of specific larger dimensions of cargo, prior permission of Roads & highway Department shall be required.

Maximum allowable weight limit for single rear axle with 4 tires is 10tons as per RHD regulation.

(2) Investigation of bridges on the route between B-K-D-P and Balashi Ghat

Following table shows the bridges on the route.

Table 14-11 Bridge list between B-K-D-P and Balashi Ghat

NO	Section		Length	Width	No. of Bridges/Culverts				Overall Condition
	From	To			Bridge	Baily Bridge	Culvert	Total	
			(km)	(m)					
1	B-K-D-P Site	Bhaduria bazaar	6.71	3.5			12	12	Needs to strengthen
2	Bhaduria bazaar	Govindagonj	34.47	5.5	3		21	24	Good except all bridges to be rehabilitated
3	Govindagon	Palashbari	16.99	7.2	6		4	10	Good
4	Palashbari	Gaibandha town	21.02	5.5	3	1	9	13	Good except Bailey bridge to be rehabilitated
5	Gaibandha town	Balashi Ghat	6.20	3.5	1		4	5	Needs to strengthen
Total			85.39		13	1	50	64	

Source: PSMP Study Team

(3) Road from B-K-D-P site to Bhaduria Bazar (6.71km)

This section is categorized as Zila Road of Roads & Highway (R&H) Department having average width of 3.5 meter. It is almost straight from B-K-D-P site to Bhaduria Bazar where it joined with Regional Highway (Gobondagonj to Dinajpur) of R&H Department. The total length of this section is 6.71km. There are 12 culverts of RCC in this section. The conditions of all culverts are in the good condition. The overall condition of this section is good to carry the normal cargoes say below 40tons. But for carrying heavy lifting cargoes, it is required to strengthen this road by widening and reconstructing all culverts. Moreover, this road at the Bhaduria Bazar Junction needs to bypass Bhaduria bazar area to join with Gobindagonj-Dinajpur highway to make bend within acceptable limit say 30degree.

(4) Bhaduria Bazar to Govindagonj (34.47km)

This section is categorized as Regional Highway of Roads & Highway (R&H) Department having average width of 5.5 meter with 2 lanes. It is almost straight from Bhaduria Bazar to Govindagonj where it joined with National Highway (Bogra to Rangpur) of R&H Department. The total length of this section is 34.47km. There are 21 culverts of RCC and three bridges in this section. The conditions of all culverts are in the good condition. One of the bridges at Khulshi is under construction. At present, the bridge under construction is being bypassed by bailey bridge with steel bed. The conditions of other two bridges are not in good condition. The overall condition of this section is good to carry the heavy cargoes above 40tons except the bridges to be rehabilitated. Moreover, this road at the Govindagonj Junction needs to bypass Govindagonj town to join with Bogra-Rangpur National highway at an acceptable bend to move the long trailers.

(5) Govindagonj to Palashbari (16.99km)

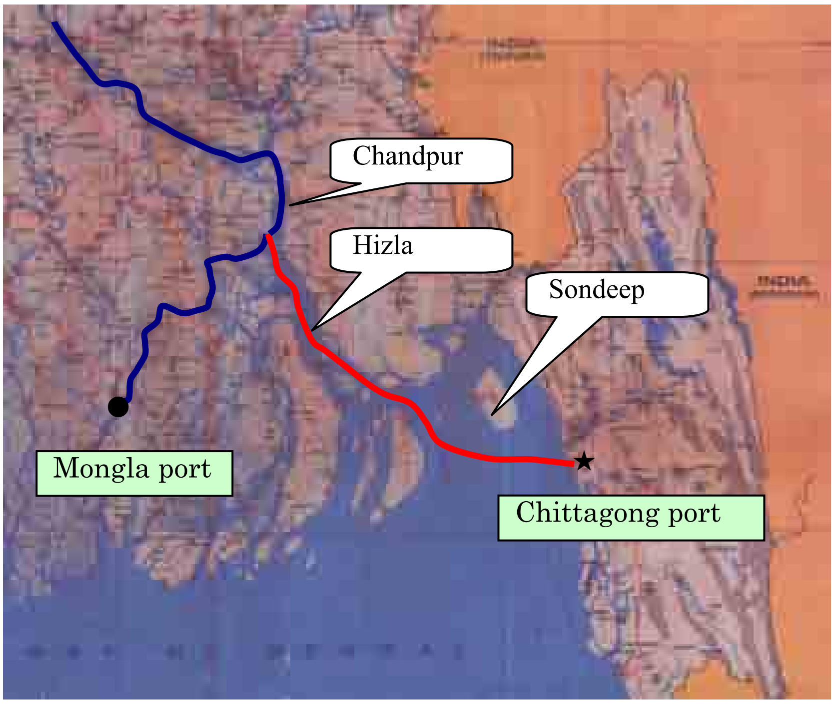
This section is categorized as National Highway of Roads & Highway (R&H) Department having average width of 7.2 meter with 2 lanes. It is almost straight from Govindagonj to Palashbari from where a side road was constructed towards Gaibandha Town. The total length of this section is 16.99km. There are 4 culverts of RCC and six bridges in this section. The conditions of all culverts and bridges are in the good condition. The overall condition of this section is good to carry the heavy cargoes above 40tons.

(6) Palashbari to Balashi Ghat (27.22km)

This section is categorized as Regional Highway of Roads & Highway (R&H) Department having average width of 5.5 meter with 2 lanes. It is almost straight from Palshbari to Balashi Ghat. The total length of this section is 27.22km. There are 13 culverts of RCC, four bridges and one bailey bridge with steel bed in this section. The conditions of all culverts between Palashbari and Gaibandha Town are in the good condition. But the narrow bailey bridge is not in the good condition. The culverts and bridges from Gaibandha Town to Balashi Ghat are not in the good condition and the width of the road is about 3.5m. The length of this narrow road from Gaibandha town to Balashi Ghat is about 6.2km. The overall condition of this road from Palashbari to Gaibandha Town is good. Only one bailey bridge in this section needs to be rehabilitated. But it is required to strengthen the road from Gaibadha Town to Balashi Ghat to carry the heavy cargoes. Moreover, at the Palashbari Junction, the road needs to bypass Palashbari town to join with Bogra-Rangpur National highway at an acceptable bend to move the long trailers.

14.4.8 River route from Chittagong port to Balashi Ghat and then overland route to B-K-D-P site

In this route, the equipment is unloaded at Chittagong port and transported to Balashi Ghat by barge, after that, the mean of land transportation remains the same.



Source: PSMP Study Team

Fig. 14-20 Transportation route from Chittagong to B-K-D-P

(1) Transportation

Barge (L38.5mxW20.0mxD2.13m capacity 600tons) : 1 No.
Tugboats (Twin screw, 500hp) : 2 Nos.

(2) Chittagong port

Chittagong Port [3] is the principal port of the People's Republic of Bangladesh. It is situated on the right bank of the river Karnafuli at the estuary of the river at Patenga Package, near the city of Cittagong at a distance of about 9 nautical miles from the shore line of the Bay of Bengal.

Table 14-12 Trend of cargo treatment amount of Chittagong port

(1,000 t)

FY	Import	Export	Total
1995	8,638	1,417	10,055
1996	8,738	1,451	10,189
1997	9,063	1,435	10,498
1998	7,295	589	7,884
1999	8,973	1,031	10,004
2000	12,675	631	13,306

Source: Chittagong Port Authority

Geographic location of Chittagong is at latitude 22019' N and longitude 91049'E. It is not a deep seaport but vessels up to 10,000QWT can berth at this port.
The way of export from Chittagong port is that, first to transport from Chittagong to Malaysia or Singapore by 10,000t class vessels, and then load to mother ship to transport Europe or America.
The economy of Bangladesh is currently developing. Textile as example, the ratio of textile out of whole export products is 80%, and export amount is 5,686 mil US$ for 2003-04 and 12,347 mil US$ for 2007-08, it means 2.2 times growth by 5 years.
For Bangladesh the development of transportation and power sector is very important.
The following facilities of Chittagong Port are available;

Table 14-13 Mooring facilities of Chittagong port

For ocean-going vessels	Amount
General Cargo Berths	12
Container Berths	8
Specialized Berth for bulk handling	3
Dolphin Oil Jetty for POL	1
Grain Silo Jetty	1
Cement Clinker Jetty	1
CUFL Jetty	1
KAFCO Urea Jetty	1
Ammonia Jetty	1
Repair Berths	
a. Dry Dock Jetty	2
b. Mooring Berths	5
For inland coasters & vessels	
Jetty Berths for POL	1
Concrete Berth for Grain handling	1
Pontoon Berth for POL	3
Pontoon Berth for cement	1
Single Point mooring	1

Source: Chittagong Port Authority

Table 14-14 Cargo handling equipment

Equipment	Capacity	Amount
Shore crane	2-3 tons	26
Mobile crane	10-50 tons	33
Forklifts	3-5 tons	29
Low mast forklift	2.5-5 tons	45
Industrial tractor	25 tons	16
Trailer	6-25 tons	39

Source: Chittagong Port Authority

Table 14-15 Container handling equipment

Equipment	Capacity	Amount
Ship to Shore quay gantry crane	50 ton	4
Ribber tyred gantry crane	40 ton	11
Straddle carrier	40 ton	19
Fork lift truck	5-42 ton	9
Fork lift truck (spreader)	16 ton	10
Fork lift truck	16 ton	3
Reach stoker	7-45 ton	21
Container mover	50ton	3
Tractor	50ton	64
Trailer	40ton	57

Source: Chittagong Port Authority

(3) Waterways from Chittagong port to Hizla

The waterways from Chittagong port to Hizla will pass through the Bay of Bengal, Sandeep channel, Hatiya channel and Meghna river. The distance of this route from Chittagong port to Hizla is about 160km. This water route is navigable throughout the year.

The heavy cargoes have to be offloaded by cranes overboard on to the barges in the outer anchorage from where the cargoes may be transshipped to Balashi Ghat by barges.

At during monsoon, the Bay of Bengal remains very rough and turbulent and there is very less possibility of having good weather. The barge shall have to pass through the Bay of Bengal and as such it should be designed especially so that it can withstand rolling and pitching. It is not advisable to carry such heavy equipment through the Bay of Bengal during monsoon.

14.5 Layout and bird-view image

14.5.1 Power station layout

Based on above study, the power station layout is concerned.

(1) Required area

Power station consists of 1) generation facility area, 2) coal stock and handling area, 3) ash handling area, 4) other utility area. The required area for the domestic coal-fired power station in this Master Plan is as follows:

Table 14-16 Required area for domestic coal-fired power station

Facility	Area
generation facility area	Approx. 210,000 m2（600MWx3）
coal stock and handling area	Approx. 50,000 m2（200,000 t、15 days）
ash handling area	(reference) for landfill Approx. 500,000 m2（1m of depth for 1 year）
other utility area	Approx. 200,000 m2
Total[1]	Approx. 460,000 m2 ＋ash area

Source: PSMP Study Team

Generation facility area include boiler building, turbine generator building, auxiliary equipment building, EP, desulfurization, denitrification, ash treatment, transformer.

The required area for the import coal-fired power station in this Master Plan is as follows:

[1] Residence area, co-existing area is also required.

Table 14-17 Required area for import coal-fired power station

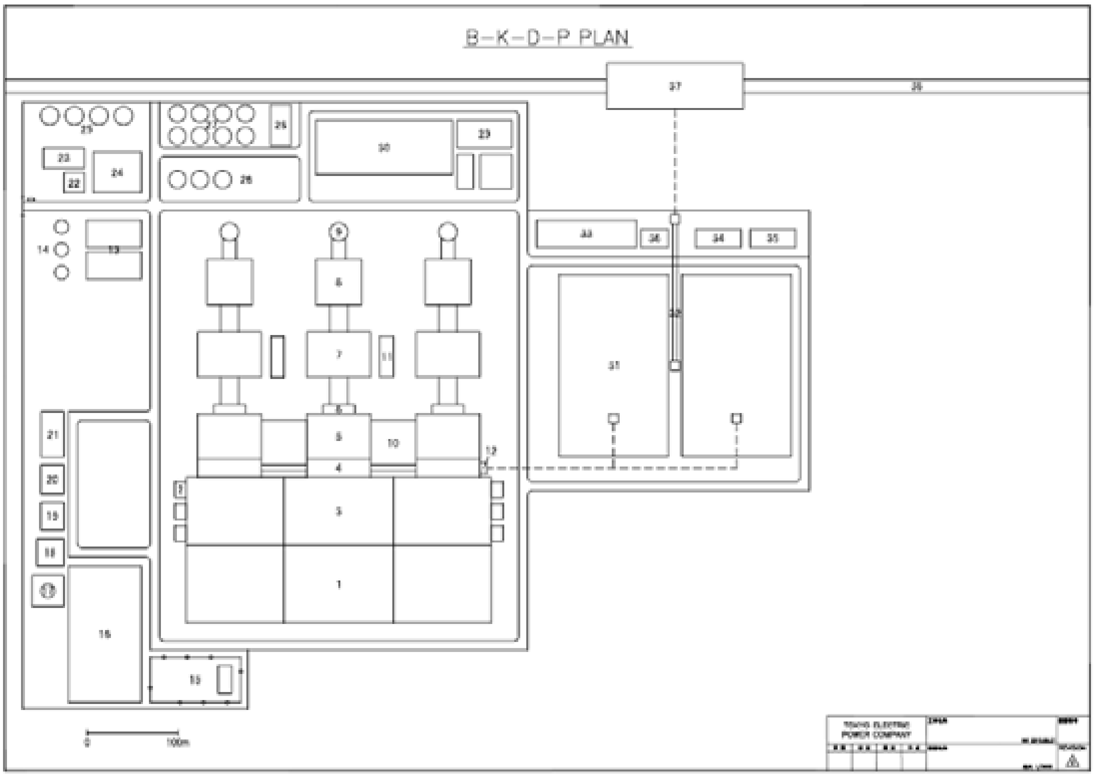
Location	Chittagong South	Meghnaghat
generation facility area	Approx. 140,000 m2 (600MWx2)	Approx. 140,000 m2 (600MWx2)
coal stock and handling area	Approx. 150,000 m2 (600,000 t)	Approx. 100,000 m2 (400,000 t)
ash handling area	(reference) for landfill Approx. 500,000 + 250,000 m2 (1m of depth for 1 year)	(reference) for landfill Approx. 500,000 m2 (1m of depth for 1 year)
other utility area	Approx. 200,000 m2	Approx. 200,000 m2
Total[1]	Approx. 490,000 m2 ＋ash area	Approx. 440,000 m2 ＋ash area

Source: PSMP Study Team

In this Master Plan, considering power development planning to 2030, 600MWx1 of facility would be installed for Chittagong South, however in the future both of power station is considered to expand to 600MWx2, the study is based on 600MWx2.

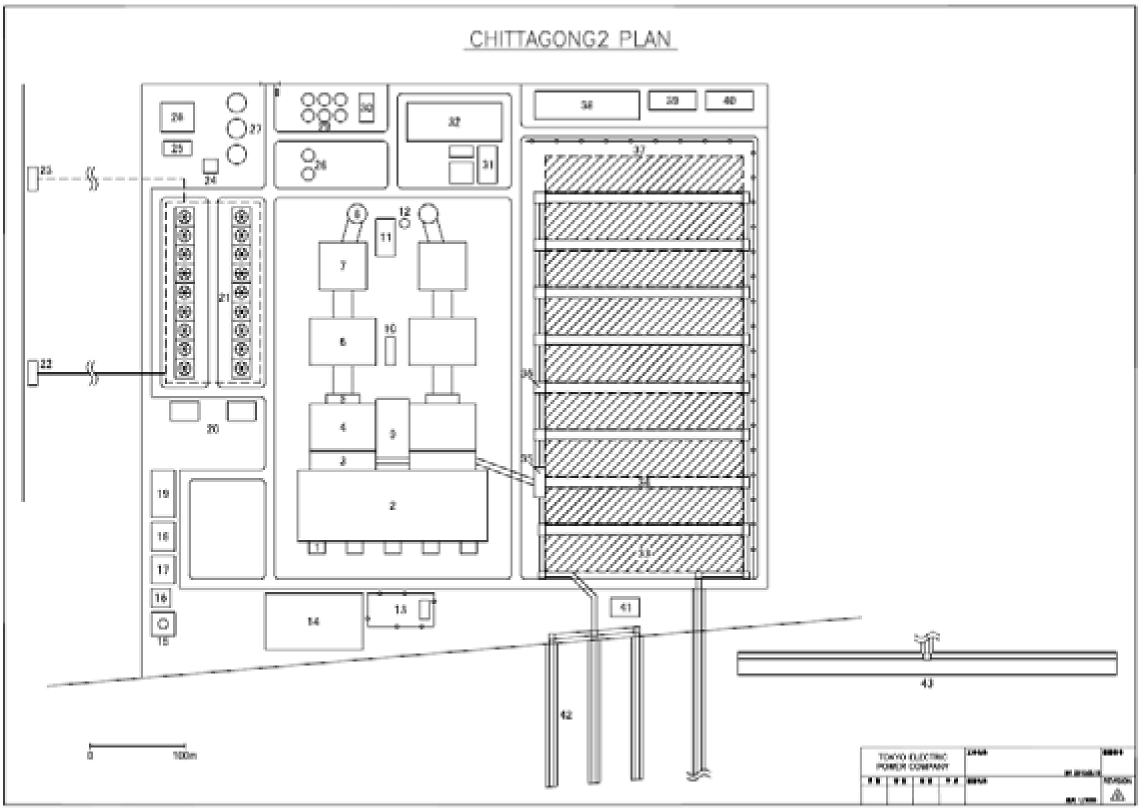
(2) Layout plan

Following shows the layout plan of B-K-D-P and Chittagong South.
The equipment layout plan of Meghnaghat is almost same as Chittagong South.



Source: PSMP Study Team

Fig. 14-21 Layout plan of domestic coal-fired power station (B-K-D-P)



Source: PSMP Study Team

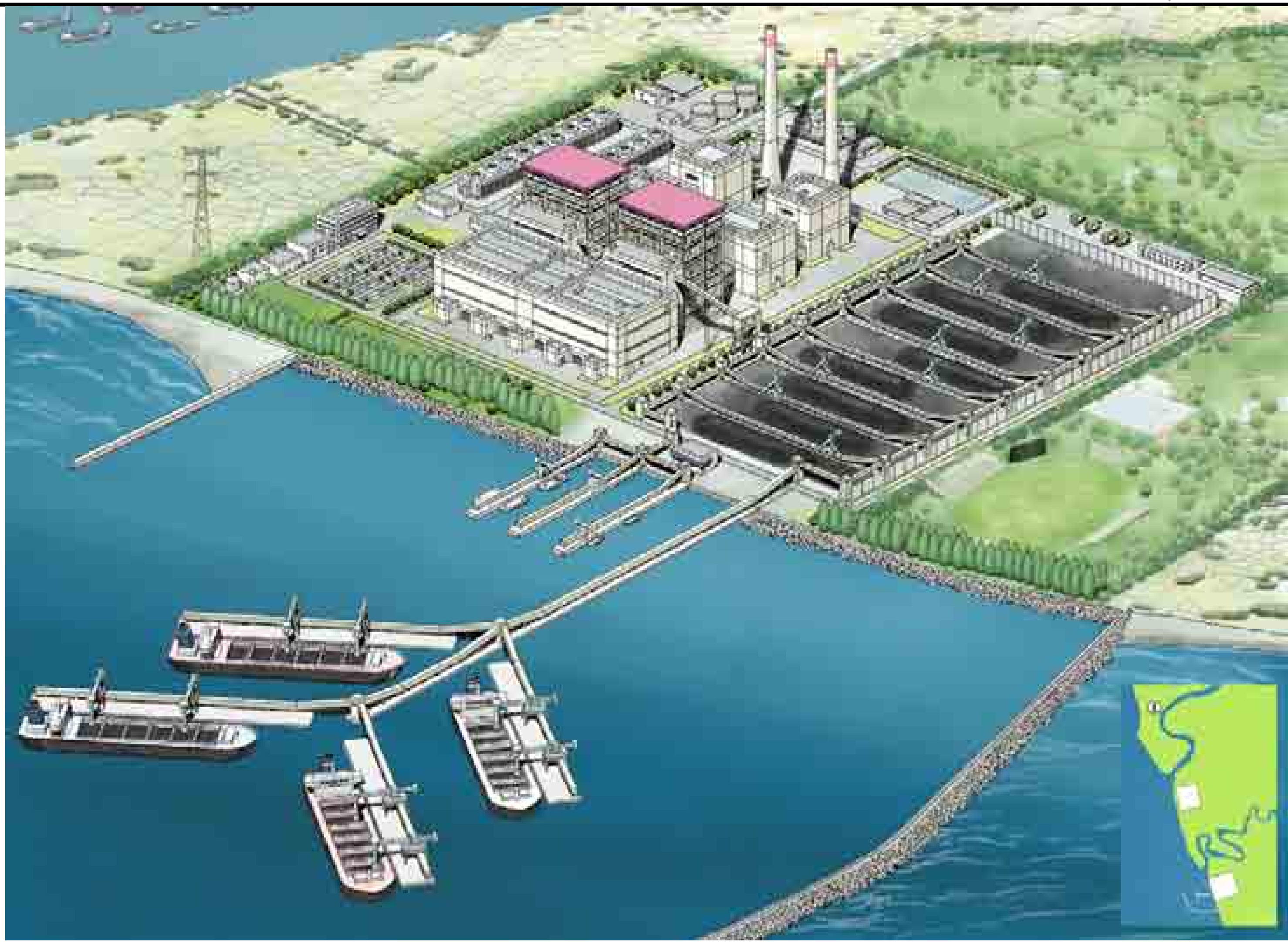
Fig. 14-22 Layout plan of import coal-fired power station (Chittagong South)

14.5.2 Bird-view image

Following shows the bird-view image of B-K-D-P and Chittagong South.
And image of Matarbari is added for reference.

Source: PSMP Study Team

Fig. 14-23 Bird-view image of B-K-D-P power station (600MW x 3)



Source: PSMP Study Team

Fig. 14-24 Bird-view image of Chittagong South power station (600MW x 2)

Source: PSMP Study Team

Fig. 14-25 Bird-view image of Matarbari power station and coal center (600MW x 4)

Chapter 15 Construction Schedule and Estimated Costs

15.1 Construction schedule

15.1.1 Summary

In planning the high prioritized project, the construction is broadly divided into two stages. The first stage comprises those things that need to be accomplished prior to project launch such as F/S, subsequent detail designs, election of contractors, and concluding contracts etcetera. This takes about 32 months. The second stage comprises the duties from the beginning of construction to operational commencement and takes about 48 months per each generator. The commencement work for the second generator is delayed six months and when the commencement for the first generator finally gets underway, it takes 54 months in total.

15.1.2 Procedures prior to construction launch

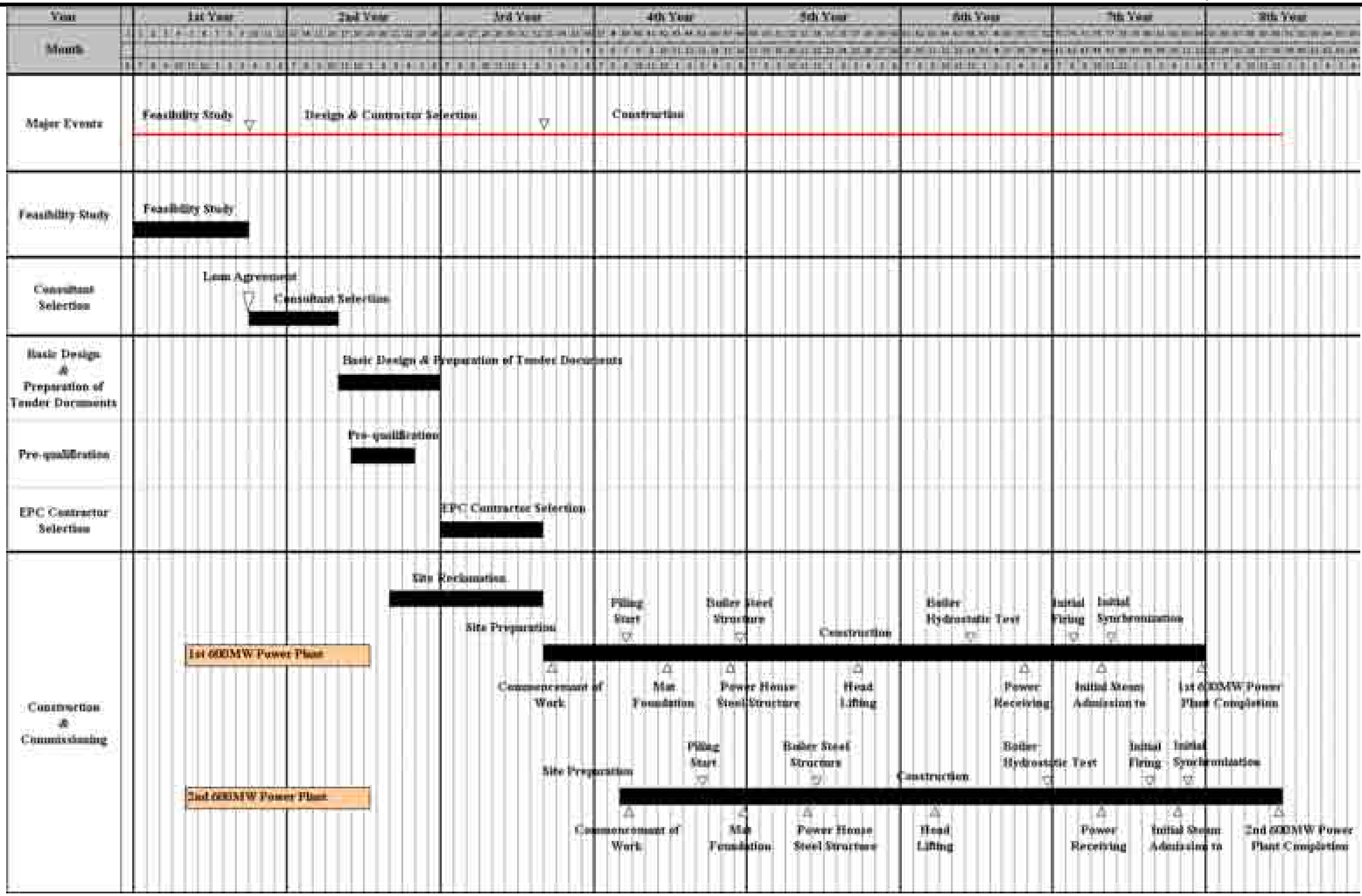
The following duties have to be accomplished prior to construction launch.

(1) Feasibility study (F/S)
(2) Site acquisition
(3) Capital Procurement and Financing approval
(4) Create a bid form
(5) Consultant selection
(6) Contractor selection

In order to initiate early implementation of this plan, out of the pre-construction procedures deemed necessary, the smooth implementation of the following is considered to be of vital importance. The first step is capital procurement. After the project feasibility via the F/S has been established, it is important that the government procure the necessary amount of capital financing as soon as possible. The second step is the selection of contractors. In order to ensure the smooth and swift execution of this plan, full-turn key implementation is non-negotiable prerequisite.

15.1.3 Construction process

After the contract(s) have been concluded, the construction schedule will be provided (attached).
This schedule will take into account both Japan's domestic and import coal fired power station project achievement record.



Source: PSMP Study Team

Fig. 15-1 Construction schedule

15.2 Estimated construction costs

15.2.1 Summary

The construction costs for this high prioritized project are based on past similar projects. A breakdown of the costs with estimated amounts is provided in Table 15-1 below:

Table 15-1 Estimated construction cost breakdown

(unit 1,000USD)

	Domestic Coal P/S 2x600MW			Import Coal P/S 2x600MW		
	Foreign	Local	Total	Foreign	Local	Total
Direct	1,430,026	252,920	1,682,946	1,508,856	285,636	1,794,492
Indirect	95,335	234,357	329,692	100,590	250,771	351,361
IDC	54,477	7,226	61,703	57,480	8,161	65,641
Total	1,579,838	494,503	2,074,341	1,666,927	544,568	2,211,494

Source: PSMP Study Team

Direct Expenses consist of costs connected to EPC contracts and consulting fees
Indirect Construction Expenses comprise reserve funds and import taxes, VAT

15.2.2 Construction expenses and calculation methodology

(1) Construction expenses can be divided into domestic and foreign currency. Domestic currency comprises domestic labor wages, domestically procured construction materials, value-added tax etcetera while everything else is allocated as foreign currency.

(2) Construction expenses are based on the value of prices in September of 2010 of which there is no fluctuation expected.

(3) Direct construction costs are those expenses deemed necessary to the construction of the power generating equipment and environmental countermeasure equipment etcetera. (However, fuel equipment (including port facilities) and ash disposal equipment are considered separate). The following conditions are based on EPC contract(s).

- The fuel costs for test run are not allocated as they are balanced out by electricity fees.
- Power and water used for construction is not included.
- Regarding transmission facilities, the point until the switchyard of the power station is taken into account.

(4) Consulting service costs are 5% of the EPC price for both foreign currency and domestic currency. These are consultant expenses hired to assist in the supervision of design implementation (manpower costs, miscellaneous overhead, technical fees, travel expenses, communication fees etcetera.)

(5) Regarding reserve funds and physical contingencies, from an engineering perspective, 5% of the EPC price applies to both foreign currency and domestic currency. The domestic currency amount is the same as the domestic currency amount of which each is allocated 5%. For price contingencies, the foreign currency portion is based on overseas market conditions of which the EPC foreign currency price is 2%, the domestic currency portion is based on CPI data and 5%, the same foreign currency portion.

(6) Import tax (VAT) adheres to the nation’s legal provisions, and as it shall be settled by the said business entity, the necessary tax rate shall be accounted for.

(7) Construction expense interest adheres to the payment plan applied to construction

term (period)

(8) The conditions governing construction expense payments are contingent on forecasted need on a year-by-year basis as follows:
1st year: 15%, 2nd year: 30%, 3rd year: 35%, Final Year: 20%

Further, in terms of primary generation facilities, in comparing domestic coal-fired power station with imported coal-fired power station, there is hardly any difference. However, since imported coal-fired power station involves the necessity of having port facilities, costs connected to fuel facilities (coal storage and handling) and ash treatment facilities will differ between domestic coal and imported coal.

Table 15-2 lists a breakdown of construction expenses.

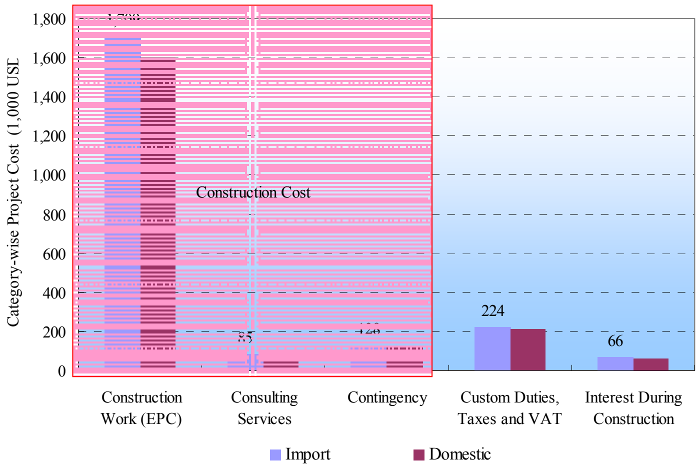
Table 15-2 Project cost detail (unit 1,000 USD)

Item	Domestic Coal Power Station (Minemouth)					Import Coal Power Station (with Port Facility)				
	Foreign Portion	Local Portion		Total		Foreign Portion	Local Portion		Total	
	(1,000 USD)	(1,000 TK)	(1,000 USD)	(1,000 TK)	(1,000 USD)	(1,000 USD)	(1,000 TK)	(1,000 USD)	(1,000 TK)	(1,000 USD)
A. Construction Work (EPC)										
A1.Power Station Installation & Related Works										
FOB Price of Imported Equipment										
1. Boiler Equipment	781,000			53,170,480	781,000	859,100			58,487,528	859,100
2. Turbine / Generator and its accessory	219,200			14,923,136	219,200	219,200			14,923,136	219,200
3. Environment Equipment	163,000			11,097,040	163,000	83,000			5,650,640	83,000
4. Coal,Ash Handling (Import: Port Facility)	0	0	0	0	0	147,000	4,289,040	63,000	14,296,800	210,000
5. Coal,Ash Handling (Domestic)	73,500	2,144,520	31,500	7,148,400	105,000	0	0	0	0	0
6. Construction, Erection, Commissioning & Insurance	90,148	14,254,318	209,376	20,391,594	299,524	90,001	14,231,035	209,034	20,358,286	299,035
Sub Total of A1	**1,326,848**	**16,398,838**	**240,876**	**106,730,650**	**1,567,724**	**1,398,301**	**18,520,075**	**272,034**	**113,716,390**	**1,670,335**
A2. Transmission Line	**35,081**			**2,388,342**	**35,081**	**38,705**			**2,635,043**	**38,705**
Sub Total of A	**1,361,929**	**16,398,838**	**240,876**	**109,118,992**	**1,602,805**	**1,437,006**	**18,520,075**	**272,034**	**116,351,433**	**1,709,040**
B. Consulting Services	**68,096**	**819,942**	**12,044**	**5,455,950**	**80,140**	**71,850**	**926,004**	**13,602**	**5,817,572**	**85,452**
C. Contingency										
Physical Contingency	68,096	819,942	12,044	5,455,950	80,140	71,850	926,004	13,602	5,817,572	85,452
Price Contingency	27,239	819,942	12,044	2,674,345	39,282	28,740	926,004	13,602	2,882,631	42,342
Sub Total of C	**95,335**	**1,639,884**	**24,088**	**8,130,295**	**119,423**	**100,590**	**1,852,007**	**27,203**	**8,700,203**	**127,794**
Total Construction Cost (A+B+C)	**1,525,361**	**18,858,664**	**277,007**	**122,705,236**	**1,802,368**	**1,609,447**	**21,298,086**	**312,839**	**130,869,207**	**1,922,286**
Per Unit Construction Cost (USD/kW)					**1,500**					**1,600**
D. Custom Duties, Taxes and VAT										
D1. Custom Duties & VAT (% of A1+A2 (Foreign) & C1)		12,169,520	178,753	12,169,520	178,753		12,840,366	188,607	12,840,366	188,607
D2. VAT & Income Tax on EPC Contractor (% on A1+A2 (local) & C2)		1,463,596	21,498	1,463,596	21,498		1,652,917	24,279	1,652,917	24,279
D3. VAT & Income Tax on Consultant (% of B)		681,994	10,018	681,994	10,018		727,196	10,681	727,196	10,681
Sub Total of D		**14,315,110**	**210,269**	**14,315,110**	**210,269**		**15,220,479**	**223,568**	**15,220,479**	**223,568**
E. Interest During Construction (IDC)	**54,477**	**491,965**	**7,226**	**4,200,771**	**61,703**	**57,480**	**555,602**	**8,161**	**4,468,857**	**65,641**
TOTAL PROJECT COST (A+B+C+D+E)	**1,579,838**	**33,665,739**	**494,503**	**141,221,117**	**2,074,341**	**1,666,927**	**37,074,167**	**544,568**	**150,558,543**	**2,211,494**

Source: PSMP Study Team

As shown in Table 15-2, the unit price of project cost is about 1,500USD/kW as domestic coal-fired power stations, 1,600USD/kW as import coal-fired power stations.

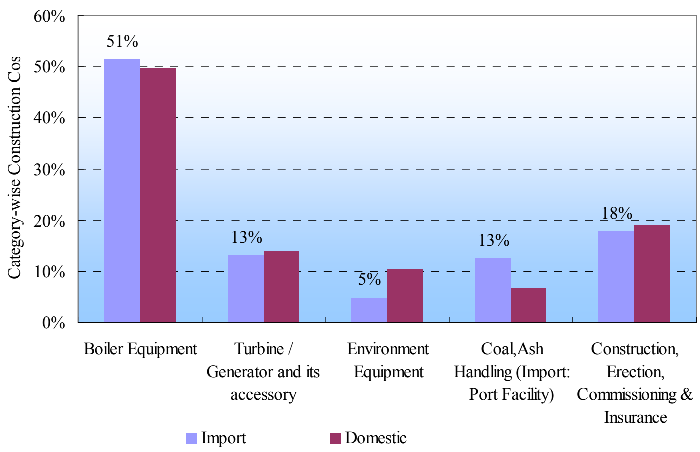
Each item rate of construction cost is shown as follows. Construction cost (EPC) has 70% of all. The remained cost is import tax, VAT(10%), contingency (6%), consultant cost (4%), interest during the construction (3%).



Source: PSMP Study Team

Fig. 15-2 Each item rate of construction rate

Each item rate of EPC cost is shown as follows. The boiler has 50%.



Source: PSMP Study Team

Fig. 15-3 Each item rate of EPC cost

15.2.3 Construction costs and adequacy evaluation

In order to conduct an adequacy evaluation of the aforementioned construction costs, a survey was conducted of the results of a similar project. According to a World Bank report titled, “Study of Equipment Prices in the Power Sector (2008), it was reported that in India 300MW～800MW of contracted coal power yielded 1,290～1,690 USD/kW. In reviewing the results of conditions connected to this area, in the said nation, 1,600 USD/kW was considered to be a reasonable level.

Table 15-3 Track record of coal-fired power station projects

Year/month	Country	Project name	Capacity	Type	Contract Price [Mil USD]	Unit Price [USD/kW]	Scope of contract
2010.6	Viet Nam	Nghi Son (1)	600MW (300MWx2)	Sub Critical	1,076	1,792	Overall construction
2009.11	Viet Nam	Van Phong	1320MW (660MWx2)	Super Critical	2,390	1,810	Investment
2007.5	Belgium	3 sites of Electrabel	2400MW (800MWx3)	Super Critical	3,586	1,494	Overall construction
2007.3	Canada	Keephills #3	450MW	Super Critical	598	1,328	Overall construction
2004.12	India	Bakreswar	420MW (210MWx2)	Sub Critical	478	1,138	Overall construction

Source: PSMP Study Team

Chapter 16 Economic and Financial Analysis of the Most Prioritized Projects

16.1 Economic analysis

16.1.1 Methodology

Whereas financial analysis focuses on the viability of the project from the perspective of the project sponsor, economic analysis considers and evaluates the optimal and/or efficient allocation of the resources utilized for the sake of the national economy. The methodology of the evaluation compares the economic benefits that will result from the resources input into the project under an environment of "With Project" as opposed to "Without Project" through which the economic internal return (EIRR) is to be drawn. The analysis verifies whether the EIRR is sufficient in covering the opportunity cost of the capital mobilized.

16.1.2 Assumptions

(1) Implementation schedule and period of the project

The implementation schedule and period of the project has been examined in the preceding Chapter. The economic analysis follows, in principle, the schedule that has been described but adjusts slightly to match the fiscal years of the country for the sake of simplifying the analysis. The schedule adjusted for the analysis assumes that the construction of the project shall commence in July 2014 and be commissioned in July 2018. The project is expected to operate for 30 years up till June 2030. The economic analysis has been applying a consistent price as of FY 2010.

(2) Inflation

Whenever it becomes necessary, the cost data that is expressed in terms of the constant prices of the fiscal years other than FY 2010 shall be used upon being converted to the constant prices of FY 2010 by the inflation indexes.

(3) Foreign exchange rate

For the data of various currencies, the conversions have been made utilizing the average exchange rates released by Bangladesh Bank for fiscal years. For future data, the forecast has been made by the Study Team, similar to what has been done for inflation, through which the past trend of foreign exchange rates has been reviewed to obtain future rates through extrapolation. It has been learnt that the past trends of the exchange rate between the U.S. Dollar and the Bangladeshi Taka is expressed by the linear function of $Y=-1.18547X + 53.03$ and the one for Japanese Yen and Taka is $Y=0.0335X + 0.4$, whereas Y represents the exchange rate and X represents the number of years that have elapsed starting from 1999. By using the functions, the analysis shall assume the exchange rates for the years to come.

(4) Fund raising

The analysis assumes that the project will be financed partly by donors and partly by the government of Bangladesh (GOB) through equity and loans. The loans from the donors will be lent to GOB and on-lent to the executing agency. The standard terms and conditions of on-lending within Bangladesh are established in the Guidelines issued by the Ministry of Finance[1] which prescribes that the GOB funds shall be provided in the combination of the equity and debt = 60:40; the terms of the loan are 25 years including a 5-year grace period; the rate of interest is to be 4.0% p.a. for the foreign currency and 3.0% p.a. for the domestic currency. The percentage of financing by the donors varies. The analysis assumes that 70% of the total costs shall be financed by the donors while the remaining 30% shall be provided by GOB.

[1] Ministry of Finance, "Lending and Relending Terms of Local Currency and Foreign Loans", March 2004

(5) Interest on loans

The interest accrued during construction shall be booked into the account of the capital project in progress and shall be capitalized at the time of the account transfer to the fixed assets upon completion of the project. The rate of interest to be applied during the construction is the same with the rates stated above. The interest during construction constitutes a part of the capital cost of the project and is counted as the economic cost whereas the interest to be paid during the operational phase shall not be counted as the economic cost.

(6) Revenue

The economic analysis adopts the quantified amount of the willingness-to-pay (WTP) as the measure of the economic value of the benefits instead of utilizing the actual tariff revenue from the project. The methodology for quantifying WTP will be elaborated on later.

(7) Useful life and depreciation

The analysis assumes the adoption of straight line depreciation while setting up the residual value of 10% and the useful life span of 30 years. The depreciation shall not be counted as the economic cost in the economic analysis.

(8) Contingencies

The project cost presented before contains both the physical and price contingencies. The price contingency shall be disregarded from the economic analysis whereas the physical contingency shall be included in the project cost because the physical contingency is to cover any of the project plan's shortcomings that has to be complemented with additional material, parts of works before the project could be completed as has been designed. Such parts of the project are found to be vital and indispensable to the project and, therefore, should be incorporated as an integral part of the project.

16.1.3 Cost

(1) Scope of project

The analysis focuses on typical coal-based thermal power stations that constitute the core parts of the Master Plan, out of which one of each plant of the generation projects based on imported coal and the one based on the mine mouth of a domestic coal mine. The project for the imported coal incorporated in the scope of the project the construction of a port importing the coal and a coal center for handling the imported coal. The generation plants are to be connected to a nearby transmission grid and the facilities for such connection shall be included within the scopes of both projects.

(2) Project cost

The costs of the projects are estimated in terms of the constant price of FY 2010 as enumerated below;

Table 16-1 Project cost for economic analysis（constant price of FY 2010）[1]

	Imported Coal P/S(2 X 600MW)			Domestic Coal P/S (2 X 600MW)		
	F.C. (US$ million)	L.C. (Tk million)	Total (Tk million)	F.C. (US$ million)	L.C. (Tk million)	Total (Tk million)
EPC Contract	1,437	19,042	119,043	1,362	16,861	111,636
Engineering	72	952	5,952	68	843	5,582
Contingencies						
Physical Contingency	72	952	5,952	68	843	5,582
Interest During Construction (IDC)						
Foreign Loan		5,852	5,852		5,546	5,546
GOB Loan		143	143		127	127
Total Cost	1,581	26,941	136,942	1,661	24,220	128,473

Source : PSMP Study Team

(3) Fuel price

The fuel prices have been reviewed earlier in Chapter 10. The economic analysis adopts the fuel prices described in the Chapter, as the prices that are based on the long term development plan of the Master Plan has been established to achieve the “least cost development” in meeting the forecasted demand. The analysis assumes that the fuel cost will remain constant after 2030 when the Master Plan ends and the years beyond are out of the scope of the Master Plan.

(4) Operation and maintenance cost

The operations and maintenance cost which has also been described in Chapter 10 has been adopted for the economic analysis.

(5) Taxes and fiscal levies

The taxes and fiscal levies have been deemed as the domestic unrequited transfer of revenues that plays no contributory function of the project to the national economy and are now disregarded in conducting the economic analysis.

16.1.4 Economic benefit

(1) Definition of economic benefit

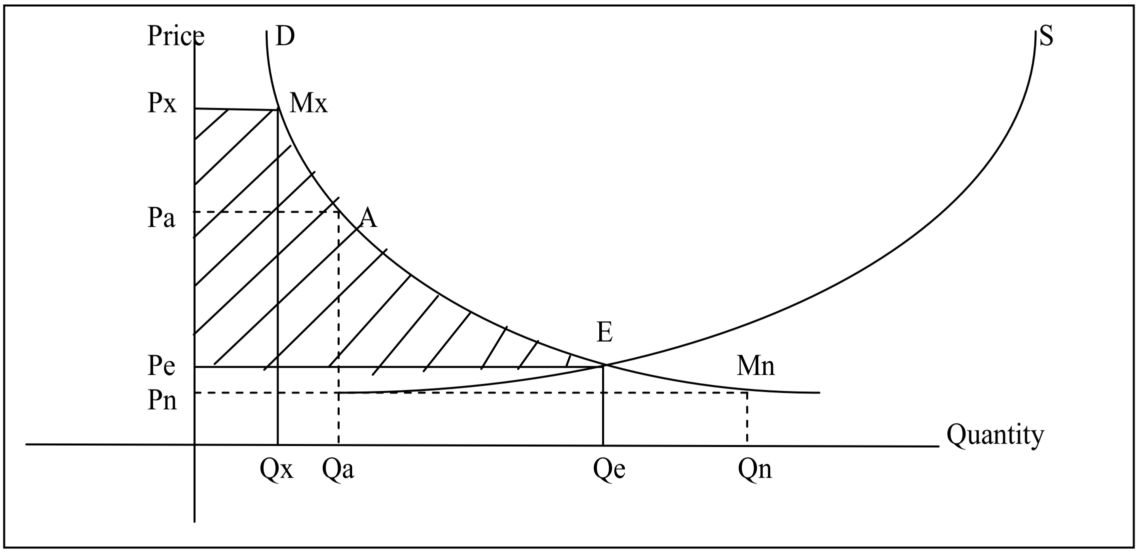
The economic analysis compares the economic costs and benefits in an environment with “With Project” versus “Without Project”. The parties to benefit from the project are defined as; (i) those who are not presently connected to electricity but will become electricity users owing to the implementation of the project; (ii) those who are connected to electricity but are not able to use the power as much as they need due to the supply constraints connected to expanded consumption. The benefit of the project will be composed of the incremental volume of power supplied to those beneficiaries.

[1] F.C. stands for Foreign Currency and L.C. stands for Local Currency. US$ 1 = Tk 69.59 (actual for fiscal year 2010)

The contemporary method of economic analysis is to define and quantify directly in monetary terms and evaluate the benefits arising from the project which is compared against the economic cost of the project in obtaining the economic internal rate of return. In those instances where the measurement and quantification of benefits are difficult, an analysis adopts an alternative method of assuming an alternative project which might generate the same quality and amount of benefit but could be constructed at the least cost next to the project under appraisal. Traditionally, in the power sector, the least cost alternative method used to be the predominant methodology but has changed during the past decade into adopting the direct method of quantifying benefits through the measurement of the Willingness-to-Pay (WTP) of the consumers for the purchase of electricity. The Study Team has delved into the pros and cons of the different methodologies to adopt. After reviewing the different methodologies, the Study Team has decided to adopt the direct quantification method.

(2) Willingness-to-Pay (WTP)

The Willingness-to-Pay (WTP) is the maximum amount consumers are prepared to pay for goods or services. WTP represents the economic value that consumers assess in their consumption pattern. The following figure illustrates the WTP in relation to the demand and supply curve;



Source: PSMP Study Team

Fig. 16-1 Willingness-to-Pay

In the above graph, the curve D represents the demand curve and the curve S the supply curve. At the crossing point of both curves, E represents the equilibrium where the supply and demand balances and Pe represents the level of electricity price that is currently paid, as the average billing price. The maximum price that consumers are willing to pay is represented by Px which should match with the long run marginal cost in the country. The area below the demand curve D and the line Px-Mx and above the line Pe-E represents the range of those consumers who are willing to pay in excess of the prevailing tariff and is called “Consumer surplus”. WTP is the aggregate of the total amounts that are currently paid by the consumers and the consumer surplus. WTP can be calculated by using the following formula. The curvature of the demand curve, which is the elasticity of demand, varies among different analysts and there is no standard number which has been theoretically established. General observation witnesses the curvature varying between 1/2 – 1/3. The analysis takes the conservative approach in adopting the curvature at 1/3.

WTP（average）＝ WTP minimum ＋ 1/3 X (WTP maximum － WTP minimum)

There exist different methodologies for calculating the maximum and minimum of WTP. With respect to the minimum value, most analysts rely on the average billing rate of electricity. The PSMP Study Team, too, follows and adopts the methodology as its own. The average billing rate is the price consumers are actually paying for electricity and the fact that it averages the amount that consumers are willing to pay is obvious. The rectangle with the corner points; Pe, E, Qe, 0 represents the aggregate amount consumers are paying at present. Should the price fall below Pe to Pn for example, the demand will expand so far as to Qn of which the supply cannot meet and no equilibrium is to be reached. For the analysis, the average bulk selling rate of BPDB in 2008-09 is known to be Tk 2.37/kWh[1] and is treated as the minimum value of WTP for FY 2009.

Contrary to the above, there exists a variety of methodologies for obtaining the maximum of WTP. The most solid but conservative approach is found to pick up the highest tariff to the consumers that is applied by any of the electricity providers at retail level. The price to be found there is the amount that is actually accepted by the consumers and can be deemed as a solid and reliable indicator although the methodology shall not be able to deny the probable existence of the higher level of WTP. In the above graph, the point Pa typically represents such a level. Pa is located at a higher level than Pe but consumers evidently expressing their readiness to pay through the actual purchasing of electricity. Other consumers are demonstrating their willingness to pay for the electricity at a much higher level such as Px by running the captive diesel generation at a much higher cost than the price of electricity at Pa. The efforts searching for the maximum is equivalent to ultimately determining the value of Px. The second of the methods to calculate the WTP maximum is to rely on the Long Run Marginal Cost (LRMC) for the supply of power theoretically established for the country. The general consensus of theory is that the LRMC can be deemed as the WTP maximum. Having no LRMC ever established for the country, it is not possible to adopt an alternative. In the absence of such, a second alternative is found in the consumers' behavior operating the captive diesel generation. The consumers who fail to obtain a sufficient volume of electricity turn to captive diesel generation. The consumers are paying for the captive cost, operating expenses as well as the fuel cost for such operations. Consumers' action for paying for them evidently demonstrates the willingness-to-pay.

The WTP maximum can be obtained in the operating cost of captive diesel generation plants through the following steps. It is assumed that consumers will resort to diesel generation, should they fail to obtain a sufficient supply of power from the grid. For such operations, they are paying for the capital costs, fuel costs, operation and maintenance of diesel equipment. There exists an evident case of consumer willingness to pay for such costs and expenses. The size of the captive generation plants varies from large to small; such as 1MW, 500kW, 100kW, 5kW, etc. The generation cost is generally understood to be following the economy of scale in which the larger ones are of smaller cost. The analysis follows the conservative approach in taking the case of smaller costs for analysis. To be a good example for such analysis, BPDB owns and operates small isolated diesel power stations running detached from the grid at Kutubudia, Sandip and Hatiya. Actual costs and expenses can be learnt from the operational records of those power stations as described below;

[1] Interviews with BPDB and BERC in October 2008 at the time of last bulk tariff adjustment

Table 16-2 Generation cost of isolated diesel plants of BPDB

	Actual for FY 2008-09
Capacity（MW）	6.5
Net Annual Output（kWh）	1,721,963
Fuel Consumption per 1kWh（lit/kWh）	0.403
Unit Price of Fuel（Tk/lit）	42.71
Fuel Cost（Taka/kWh）	17.21 (66.6%)
Variable Operational Expense（Taka/kWh）	0.79 (3.1%)
Fixed Expense incl. Administrative Overhead（Taka/kWh）	7.83 (30.3%)
Total Generation Cost (Taka/kWh)	25.83 (100%)

Source： BPDB, "BPDB Generation Cost for the Year 2009-10"

The examples referred to above are the three isolated power stations having a total capacity of 6.5 MW, in an average of 2 MW per station that can be deemed similar to the captive generation prevailing in the private sector and their operating cost is surmised to resemble that of captive generation. The predominant part of the generation cost of diesel generation is composed of the fuel costs occupying approximately 67%, in particular 80% at the Hatiya Power Station, of the total generation cost. The analysis takes into account the fuel cost and only disregards the capital cost and other expenses for the calculation of the WTP maximum in consideration of the following background and conditions;

(1) Many of the consumers have acknowledged that they have owned diesel generators for a considerable time prior to the present. The capital costs of the diesel generators vary depending upon the timing and scale of the investment;
(2) Consumers might have made investment decisions based on cheaper fuel and intend to operate the equipment while paying for the higher cost of fuel but have no intention to renew such investments, meaning that its owner has no intention of bearing the capital costs under the current environment; and
(3) Other expenses such as administrative expenses arise at large institutions but do not arise during small scale diesel generation.

Based on the above, the analysis treats the investment cost as the sunk cost and assumes expenses other than fuel as zero. From the table above, the fuel cost is referred to as the WTP minimum at the constant price of FY 2009. WTP has been obtained in the following equation;

WTP = Taka 2.37/kWh + 1/3 X (Taka 17.21/kWh – Taka 2.37/kWh) = Taka 7.32/kWh

The PSMP Study Team have now obtained WTP Tk 7.32/kWh in its hands at the constant price of FY 2009. The figure obtained is converted to the constant price of 2010 which turns out to be WTP=Tk 7.85/kWh. Using the figure obtained as the unit price of the economic benefit and multiplying the total volume of generation can quantify the value of the generated electricity. The quantified benefits are compared to the capital cost and the operational cost calculated by the international price of natural gas for the ultimate purpose of calculating EIRR.

(3) Economic evaluation

The Study Team has developed an analytical model incorporating the basic assumptions, inputs of cost and benefits through which the PSMP Study Team obtain the EIRR, the ultimate products of the analytical work. To begin with, the following table shows the EIRR for the Imported Coal Generation Plant;

Table 16-3 Economic internal rate of return (EIRR) <imported coal>

(Taka Million)

Fiscal Year	Economic Cost (A)			Economic Benefit (B)	(B) - (A)
	Capital	O&M	Total Cost		
2015	19,879		19,879		-19,879
2016	41,357		41,357		-41,357
2017	46,677		46,677		-46,677
2018	29,029		29,029		-29,029
2019		32,235	32,235	66,634	34,400
2020		33,007	33,007	66,634	33,627
2021		33,780	33,780	66,634	32,855
2022		34,552	34,552	66,634	32,082
2023		35,302	35,302	66,634	31,333
2024		36,027	36,027	66,634	30,607
2025		36,753	36,753	66,634	29,881
2026		37,479	37,479	66,634	29,155
2027		38,158	38,158	66,634	28,477
2028		38,860	38,860	66,634	27,774
2029		39,539	39,539	66,634	27,095
2030		40,218	40,218	66,634	26,416
2031		40,218	40,218	66,634	26,416
2032		40,218	40,218	66,634	26,416
2033		40,218	40,218	66,634	26,416
2034		40,218	40,218	66,634	26,416
2035		40,218	40,218	66,634	26,416
2036		40,218	40,218	66,634	26,416
2037		40,218	40,218	66,634	26,416
2038		40,218	40,218	66,634	26,416
2039		40,218	40,218	66,634	26,416
2040		40,218	40,218	66,634	26,416
2041		40,218	40,218	66,634	26,416
2042		40,218	40,218	66,634	26,416
2043		40,218	40,218	66,634	26,416
2044		40,218	40,218	66,634	26,416
2045		40,218	40,218	66,634	26,416
2046		40,218	40,218	66,634	26,416
2047		40,218	40,218	66,634	26,416
2048		40,218	40,218	80,328	40,111
EIRR	**17.69%**				

Source： PSMP Study Team

Similarly, EIRR has been calculated for the domestic coal-fired power plant as shown in the following table;

Table 16-4 Economic internal rate of return（EIRR）＜domestic coal-fired power plant＞

(Taka Million)

Fiscal Year	Economic Cost (A)			Economic Benefit (B)	(B) - (A)
	Capital	O&M	Total Cost		
2015	18,644		18,644		-18,644
2016	34,948		34,948		-34,948
2017	39,262		39,262		-39,262
2018	20,714		20,714		-20,714
2019		29,982	29,982	66,634	36,652
2020		30,601	30,601	66,634	36,034
2021		31,219	31,219	66,634	35,416
2022		31,837	31,837	66,634	34,798
2023		32,436	32,436	66,634	34,198
2024		33,017	33,017	66,634	33,618
2025		33,597	33,597	66,634	33,037
2026		34,178	34,178	66,634	32,456
2027		34,721	34,721	66,634	31,913
2028		35,283	35,283	66,634	31,351
2029		35,826	35,826	66,634	30,808
2030		36,369	36,369	66,634	30,265
2031		36,369	36,369	66,634	30,265
2032		36,369	36,369	66,634	30,265
2033		36,369	36,369	66,634	30,265
2034		36,369	36,369	66,634	30,265
2035		36,369	36,369	66,634	30,265
2036		36,369	36,369	66,634	30,265
2037		36,369	36,369	66,634	30,265
2038		36,369	36,369	66,634	30,265
2039		36,369	36,369	66,634	30,265
2040		36,369	36,369	66,634	30,265
2041		36,369	36,369	66,634	30,265
2042		36,369	36,369	66,634	30,265
2043		36,369	36,369	66,634	30,265
2044		36,369	36,369	66,634	30,265
2045		36,369	36,369	66,634	30,265
2046		36,369	36,369	66,634	30,265
2047		36,369	36,369	66,634	30,265
2048		36,369	36,369	80,328	43,959
EIRR	**22.10%**				

Source： PSMP Study Team

The above tables show the EIRRs at 17.69% for the Imported Coal Generation Plant and 22.10% for the domestic coal-fired power plant. The outputs obtained are not lower than any of the prevalent criteria for feasibility; the opportunity cost of capital typically represented by a long term government bond of the country, currently yielding 8-9% as of June 2010[1]; the threshold of feasibility perceived as common sense (10-12%); and the discount rate guided by GOB for preparation of the Development Project Proposal (12%). In particular, the EIRR turned out to be at a very high level of 22.09% at the domestic coal-fired power plant. PSMP Study Team now conclude that there are no existing doubts as to the economic viability of the two Projects selected.

(4) Sensitivity analysis

The analysis moves to the next task should any of the basic assumptions adopted for the project happen to change due to a significant extent, the extent of the impact to be felt by EIRR, is examined. The factors considered here are; (i) capital costs; (ii) operation and maintenance expenses; (iii) plant factors, (iv) fuel costs; and (v) WTP. The following table summarizes the impact on EIRR;

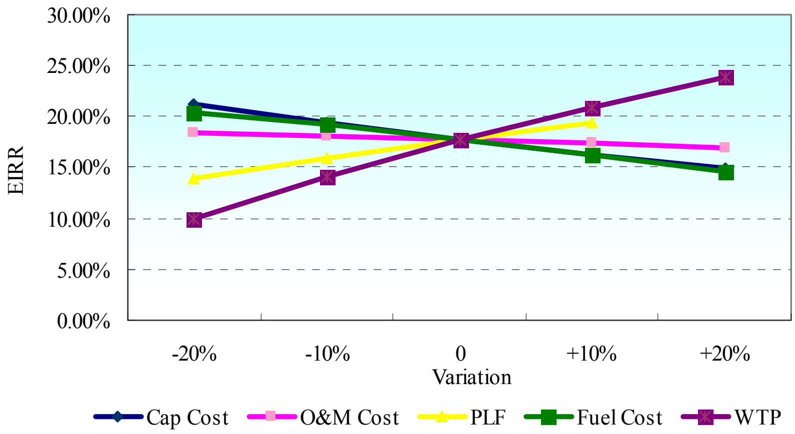
Table 16-5 Sensitivity test of EIRR

Parameter	Deviation	EIRR		Parameter	Deviation	EIRR	
		Imported Coal	Domestic Coal			Imported Coal	Domestic Coal
Capital Cost	▲20%	21.14%	26.36%	Fuel Expense	▲20%	20.45%	24.64%
	▲10%	19.39%	24.04%		▲10%	19.16%	23.40%
	0%	17.69%	22.10%		0%	17.69%	22.10%
	+10%	16.24%	20.44%		+10%	16.18%	20.73%
	+20%	14.99%	19.01%		+20%	14.56%	19.30%
O&M Exp.	▲20%	18.38%	22.81%	WTP	▲20%	9.95%	14.28%
	▲10%	18.04%	22.46%		▲10%	14.11%	18.43%
	0%	17.69%	22.10%		0%	17.69%	22.10%
	+10%	17.34%	21.73%		+10%	20.90%	25.42%
	+20%	16.98%	21.37%		+20%	23.84%	28.49%
PLF	▲20%	13.88%	17.79%				
	▲10%	15.84%	20.00%				
	0%	17.69%	22.10%				
	+10%	19.46%	24.09%				

Source： PSMP Study Team

Among the five parameters selected for analysis, there is no one whose changes deprive the projects of their economic viability, so long as the changes remain within 20% of the base case conditions. Viewing the Imported Coal Plant first, the fluctuation in WTP swings the EIRR to the most extent. The deterioration of WTP by 20% lowers EIRR to 9.95%, slightly undermining the 10% level but maintains a healthy level. The EIRR manages to stay at 14.11%, when the WTP falls by 10%. Next to WTP, the fluctuation of fuel cost affects EIRR. Should it increase by 20%, its EIRR goes down to 14%. The deterioration of the capital cost and the plant factor by 20% [2]lowers their EIRRs to 13-14%. The impact is found to be least from the fluctuation of O&M cost. Its changes of ±20% affects EIRRs only with a small margin of 1.4%. Moving to the domestic coal-fired power plant, for all of the selected parameters, the project maintains high EIRRs and a strong resilience against their fluctuations, endorsing lasting economic viability of the project. The movement of parameters and resultant EIRRs are illustrated in the following figure for easy reference;

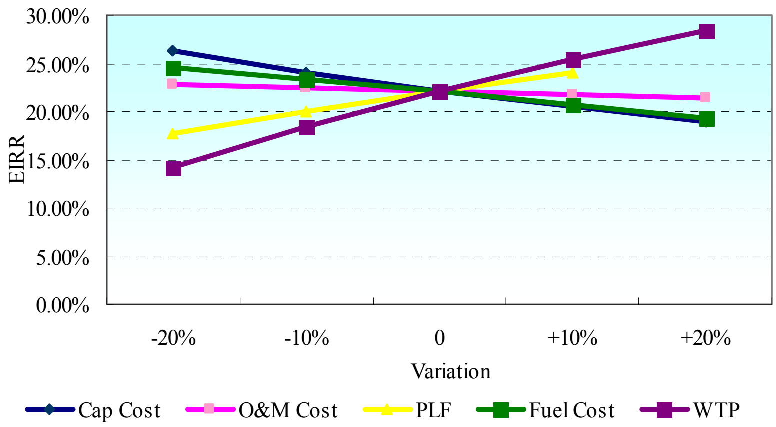
[1] Bangladesh Bank, “Major Economic Indicators: Monthly Update”, June 2010.
[2] The plant load factor assumes the basic rate of 80% and its deterioration by 20% means the PLF to be 64% (=80% X 0.8).



Source： PSMP Study Team

Fig. 16-2 Sensitivity test of EIRR ＜imported coal＞

At the Imported Coal Project, should the WTP fall by 20%, the EIRR will turn out to be slightly below 10% while maintaining a healthy level. For the deterioration of the parameter by 10% and other parameters by 20%, the EIRR manages to stay above 13%.



Source： PSMP Study Team

Fig. 16-3 Sensitivity of EIRR ＜domestic coal＞

At the domestic coal-fired power plant, the EIRR maintains a high level of EIRRs regardless of the parameter changes within 20% in any of the items. The project is evaluated to be sufficiently viable and resilient in all cases.

16.2 Financial analysis

16.2.1 Criteria for financial evaluation

The financial evaluation aims to assess project profitability from the points of project entity – BPDB. The financial costs include the capital costs and its relevant O&M costs (including fuel costs), while financial benefit/ values consist of the power generation portion of domestic retail tariffs. According to the study results, the following three power plants are the most prioritized projects:

Domestic coal-fired power plant: (1) B-K-D-P 1,600 MW #1&#2, COD of FY2019.

Import coal-fired power plant: (1) Chittagong South 600 MW #1&#2, COD of 2017,

(2) Meghnaghat 600MW #1&#2, COD of 2022.

The financial analysis here covers one case each from domestic and imported coal-fueled power plants. The financial viability of the Project is assessed by comparing the financial internal rate of return (FIRR) of the Project with the weighted average cost of capital (WACC), or the fee to finance the Project's cost. For this purpose, the WACC is set at 4.28%[1].

The following are the assumptions to estimate the FIRR of the Project.

(1) Both costs and benefits will be expressed in real terms valued at June 2010 constant prices.

(2) Like the economic analysis, the evaluation will be carried out for thirty four years in economic terms of the Project facilities, including detailed designing and the construction period of four years (FY 2015 to FY2018). All costs will be discounted to those as of June 2010. For reference, the fiscal year of Bangladesh starts in July and ends in June.

(3) The financial costs include:

- (a) The financial analysis of this study assumes the Ultra-super-critical type coal-fired thermal power plant which operates as a base load supplier of Bangladesh. The plant's land has been provided by BPDB's property. For the related facilities, power plants fueled by domestic coal would utilize coal mines next to its plants, while power plants fueled by imported coal would utilize port facilities. Electricity generated at the plants will be transmitted via the close electricity grid. This prioritized project covers the cost of transmission facilities necessary to connect with the existing grid.
- (b) The construction costs of this power generation project are the same as those estimated in Chapter 15 of "Construction Progress and Estimated Costs", including physical contingency. Different from economic analysis, the value of the local currency portion can be used without any adjustments.
- (c) The annual operation and maintenance costs of the Project facilities are estimated to be 5% of the investment costs.
- (d) Depreciation, interest charges, other taxes and duties are excluded
- (e) The fuel costs are cited from the values in the fuel scenario which are used in power development planning in the earlier section of this report. The value remains constant after the year 2030.

(4) The financial benefits include:

- (a) The financial benefits are defined as the incremental energy sales revenue obtained by the Project. The current domestic retail tariff (average retail tariff) is employed as the financial value of this evaluation. Because the Project covers only power generation facilities, the corresponding portion of the tariff is used as a financial value. This study used the Utility Tariff for this purpose. The total project benefit has been led by multiplying the average Utility Tariff with the annual power generation amount.
- (b) The annual power generation amount is calculated as 8,488GWh per power station (2 units, 1200 MW) based on the input such as the installed capacity, plant factor, and in-house use.
- (c) The average Utility Tariff is cited from that as of August 2010 ((2.73 Tk/kWh). The annual incremental rate is assumed to be zero in real terms, a similar approach as the recent World Bank's study[2]

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[1] The calculation of WACC

In general, WACC is led by the following equations:

WACC = {equity cost * equity / (equity + debt)}+{debt cost*debt / (equity + debt)}

The calculation assumes no tax involved because BPDB and the government – project investors – are exempt from tax.

The financing ratio of donors to the Government is set as 7 to 3. Among the amount from the Government, its 60 % (18% of the total cost) come as equity, while the rest come as loan from the Government. The dividend of the Government's equity is set as 6%, while the interest of donors' loan is set as 4%, and the one of the Government as 3%. From those assumption, the value of WACC is calculated as 4.28%.

[2] "Power Sector Financial Restructuring and Recovery Plan," IDA, August 2006.

16.2.2 Results of evaluation

The study team calculated the FIRR of the Project in accordance with the above premise to obtain the following results:

- Domestic coal) FIRR: not available. NPV: - 4,469 million USD (discount rate of 4.28%).
- Import coal) FIRR: not available. NPV: - 5,8212 million USD (discount rate of 4.28%)

The cash flow is shown in Table 16-6 for domestic coal and in Table 16-7 for imported coal. Both of the prioritized Projects are concluded to be financially not-viable under the assumed conditions, based on the fact that both FIRR values fall below its benchmark of WACC, 4.28.

Table 16-6 FIRR calculation for the most prioritized project (domestic coal)

(1,000US$)

Fiscal Year	Financial Cost (A)			Financial	Net
	Capital	O&M	Total Cost	Benefit (B)	(B)-(A)
2010					
2011					
2012					
2013					
2014					
2015	311,151		311,151		-311,151
2016	622,302		622,302		-622,302
2017	726,019		726,019		-726,019
2018	414,868		414,868		-414,868
2019		409,506	409,506	295,499	-114,007
2020		418,455	418,455	295,499	-122,956
2021		426,893	426,893	295,499	-131,393
2022		435,330	435,330	295,499	-139,830
2023		443,767	443,767	295,499	-148,268
2024		451,949	451,949	295,499	-156,449
2025		459,875	459,875	295,499	-164,375
2026		467,801	467,801	295,499	-172,301
2027		475,727	475,727	295,499	-180,227
2028		483,141	483,141	295,499	-187,642
2029		490,812	490,812	295,499	-195,312
2030		498,226	498,226	295,499	-202,727
2031		505,641	505,641	295,499	-210,142
2032		505,641	505,641	295,499	-210,142
2033		505,641	505,641	295,499	-210,142
2034		505,641	505,641	295,499	-210,142
2035		505,641	505,641	295,499	-210,142
2036		505,641	505,641	295,499	-210,142
2037		505,641	505,641	295,499	-210,142
2038		505,641	505,641	295,499	-210,142
2039		505,641	505,641	295,499	-210,142
2040		505,641	505,641	295,499	-210,142
2041		505,641	505,641	295,499	-210,142
2042		505,641	505,641	295,499	-210,142
2043		505,641	505,641	295,499	-210,142
2044		505,641	505,641	295,499	-210,142
2045		505,641	505,641	295,499	-210,142
2046		505,641	505,641	295,499	-210,142
2047		505,641	505,641	295,499	-210,142
2048		505,641	505,641	295,499	-210,142
Total	2,074,341	14,563,020	16,637,360	8,864,984	-7,772,377

Source: PSMP Study Team

Table 16-7 FIRR calculation for the most prioritized project (import coal)

(1,000US$)

Fiscal Year	Financial Cost (A)			Financial	Net
	Capital	O&M	Total Cost	Benefit (B)	(B)-(A)
2010					
2011					
2012					
2013					
2014					
2015	331,724		331,724		-331,724
2016	663,448		663,448		-663,448
2017	774,023		774,023		-774,023
2018	442,299		442,299		-442,299
2019		492,812	492,812	295,499	-197,312
2020		503,997	503,997	295,499	-208,498
2021		514,544	514,544	295,499	-219,045
2022		525,091	525,091	295,499	-229,591
2023		535,637	535,637	295,499	-240,138
2024		545,864	545,864	295,499	-250,365
2025		555,772	555,772	295,499	-260,273
2026		565,679	565,679	295,499	-270,180
2027		575,587	575,587	295,499	-280,087
2028		584,855	584,855	295,499	-289,356
2029		594,443	594,443	295,499	-298,944
2030		603,711	603,711	295,499	-308,212
2031		612,980	612,980	295,499	-317,480
2032		612,980	612,980	295,499	-317,480
2033		612,980	612,980	295,499	-317,480
2034		612,980	612,980	295,499	-317,480
2035		612,980	612,980	295,499	-317,480
2036		612,980	612,980	295,499	-317,480
2037		612,980	612,980	295,499	-317,480
2038		612,980	612,980	295,499	-317,480
2039		612,980	612,980	295,499	-317,480
2040		612,980	612,980	295,499	-317,480
2041		612,980	612,980	295,499	-317,480
2042		612,980	612,980	295,499	-317,480
2043		612,980	612,980	295,499	-317,480
2044		612,980	612,980	295,499	-317,480
2045		612,980	612,980	295,499	-317,480
2046		612,980	612,980	295,499	-317,480
2047		612,980	612,980	295,499	-317,480
2048		612,980	612,980	295,499	-317,480
Total	2,211,494	17,631,627	19,843,122	8,864,984	-10,978,138

Source: PSMP Study Team

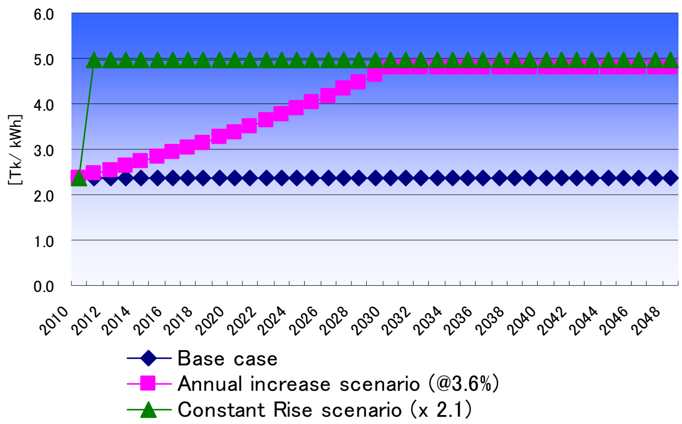
16.2.3 Sensitivity analysis

The financial viability of both prioritized projects would not be predicted under the above conditions (hereafter called the "current case"). This subsection aims to find the break-even conditions for the prioritized projects to be financially viable (hereafter called the breakeven case. Once the breakeven case is identified, its sensitivity analyses are followed. Like the economic evaluation above, the sensitivity analyses are to measure the impact caused by future uncertainties. The analyses examined four scenarios taking into account the variables of construction cost, fuel cost, O&M cost, and plant factors.

(1) New tariff case (breakeven case)

Following the previous results, revenue increase would be essential for the prioritized project to be financially viable, assuming that no more significant cost reduction can be expected. Because the plants are assumed to be operated as base load supplier, the increase of the annual generation amount is not to be expected. Therefore, the Study Team analyzed the project's breakeven point to set the average utility tariff, which is the unit value of the benefit, as a variable.

As a result, the project of the domestic coal-fired plant would be financially viable in either case that the average utility tariff increases at an annual rate of more or equal to 4.5 % since FY 2011, or that the tariff would become more than 2.1 times as high as the current tariff level (4.98 Tk/kWh). Fig. 16-4 shows the assumed future tariff projection. Like the case of fuel cost, the tariff stays constant after FY 2030. For the case of imported coal-fired plants, the project would be financially viable when the tariff-rise-rates would be equal to or more than 5.5 % or when the tariff level becomes more than 2.5 times as high as the current one.



Source: PSMP Study Team

Fig. 16-4 The projection of utility tariff used for this financial analysis (domestic coal)

The followings are the sensitivity analyses conducted that defines the base case as the breakeven case which raises the tariff at a constant annual rate.

(2) Capital cost increase scenario

The first scenario assumed that future capital investment, or construction costs, expands by 15% due to events such as global market fluctuations of construction material and the volatility of the currency exchange rate.

(3) Fuel cost increase scenario

The second scenario assumed that the procurement costs of fuel, coal, would be raised/ lowered by 10%.

(4) O&M cost increase scenario

The third scenario assumed that the O&M cost rises/ lowers by 50%, predicting the increase/ decrease of maintenance material costs and labor costs.

(5) Low plant factor scenario

The original case assumes the plant's annual plant factor to be 85%. This scenario examines the case of 60% and 95%.

Table 16-8 shows the result of those sensitivity analyses.

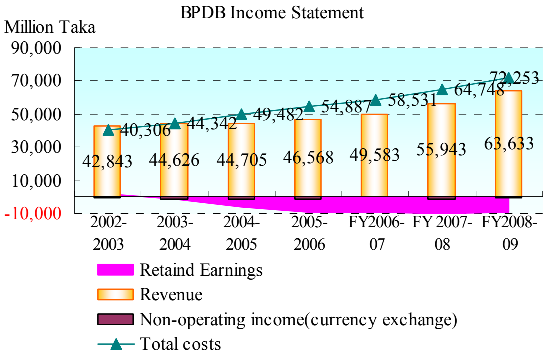
Table 16-8 Results of financial analyses[1]

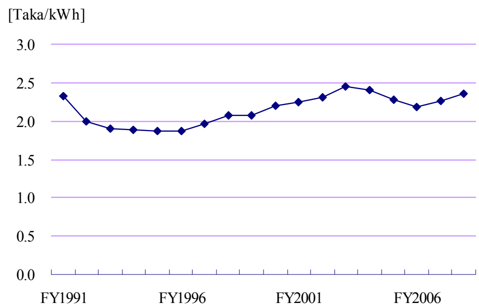
Scenario	FIRR (%)		NPV 2010 (Million USD) 4.28%	
	Domestic coal	Import coal	Domestic coal	Import coal
Current case	NA	NA	-3.907	-5,270
1) Breakeven case - Tariff incase by constant annual rate. (base case)	4.4	4.4	67	55
- Tariff increase at a time	5.1	5.7	175	297
2) Capital cost increase scenario	NA/6.2	NA/ 5.9	-374/ 509	-417/ 526
3) Fuel cost increase scenario	NA/ 6.0	NA/ 6.1	-400/ 534	-529/ 639
4) O&M cost increase scenario	NA/ 6.6	NA/ 6.4	-583/ 718	-640/ 749
5) Low Plant factor scenario	NA/ 5.9	NA/ 5.9	-2,194/ 519	-2,603/ 586

Source: PSMP Study Team

16.3 Financing plan of the most prioritized project

The Study Team concludes that an appropriate financing scheme for the Project is to receive long-term loans from overseas development agencies, taking into account the BPDB's financial status as well as the Government's policy to keep electricity tariffs low (Fig. 16-5).





Source: Developed by PSMP Study Team based on BPDB Annual Report

Fig. 16-5 The trend of revenues and expenses of BPDB (left), and the trend of the average billing rate.

[1] As for values divided by slash in the column of 2) to 4), the value in left stands for the result applying larger or positive figure as variable, while the one in right stands for the result applying smaller or negative figure as variable. All the cases of 2) to 4) result in "not available" in case of cost-increase. Likewise, the case of 5) returns "not available" results in case of lower plant factor as variable.

The following summarizes the necessary financing amount of these power plant projects:

- Total capital cost: 1) Import coal-fired plant: 2,211 million USD.
  2) Domestic coal-fired plant: 2,074 million USD.
- Financing amount to be procured (external source): over 70% of the total capital cost.
- Financing plan: 4 years (From June 2014 to July 2018)

This study assumes that the loan conditions will follow the standard conditions stated in the country's loan guidelines developed by the Ministry of Finance. Therefore, a Japanese Yen loan would cover 70 % of the total capital cost, while the rest, 30%, would be provided by the Government as mixture of loans and investments.

Table 16-9 summarizes the sub loan conditions:

Table 16-9 Sub-loan condition

	Undertaking Share	currency	Rate of interest	Repayment period	Grace period
Japanese Yen Loan	70%	JPY	4.00%	25 years	5 years
Government loan	12% (=30%X40%)	Taka	3.00%	25years	5years
Government investment	18% (30%X60%)	Taka	—	—	—

Source : Ministry of Finance, "Lending and Relending Terms of Local Currency and Foreign Loans", March 7, 2004

The rest of the total capital cost subtracting the Japanese Yen loan amount would be provided by the Government. Of the amount, 60 % would be as an investment, while the 40% would as a loan.

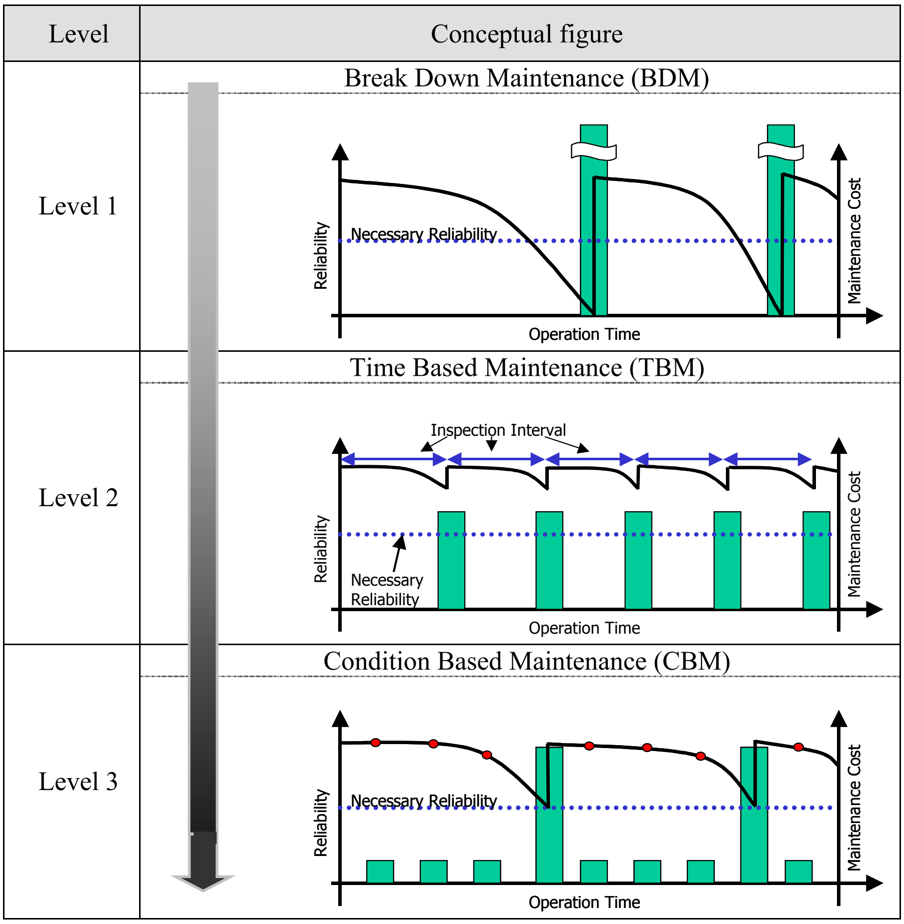
Chapter 17 Operational Execution System Analysis to the Most Prioritized Project

In this chapter, the operational execution system has been examined for the most prioritized project. When examining it, the problem of the current state of the maintenance system at the existing power generating plants in Bangladesh needs to be understood and remedial measures need to be examined while a proposal for the execution system of the most prioritized project needs to be newly set up. A proposal for the organizational structure that concerns environmental management and fuel procurement should be forthcoming.

17.1 Operation and maintenance control system

17.1.1 Selection of maintenance control level

In general, maintenance is categorized into the three levels shown in the following figure. Each character is described as follows:



Source: PSMP Study Team

Fig. 17-1 Concept of maintenance control

Level 1 breakdown maintenance: Method of repair after equipment breakdown. Because the repair period and cost cannot be predicted, it is impossible to arrange a plan beforehand.

Level 2 time-based maintenance: Method of regular inspection and repair regardless of the condition of the equipment. The operational efficiency is low because it needs to be renewed and repaired at the stage where the lifetime remains depending on the equipment's condition, while the calculation of the repair period and the cost are set up easily.

Level 3 condition-based maintenance: Method of repair at the appropriate time by monitoring the condition of the equipments. Maintenance engineer worker skill is required most in order to judge the equipment condition while the equipment is used most efficiently, and the repair period and cost calculations are relatively easy.

17.1.2 Current state at maintenance level in existing gas-fired station

This examination is for the service record of the main gas-fired station in Bangladesh during the past ten years. The result is shown as follows;

Table 17-1 Maintenance record of existing gas power station (last 10 years)

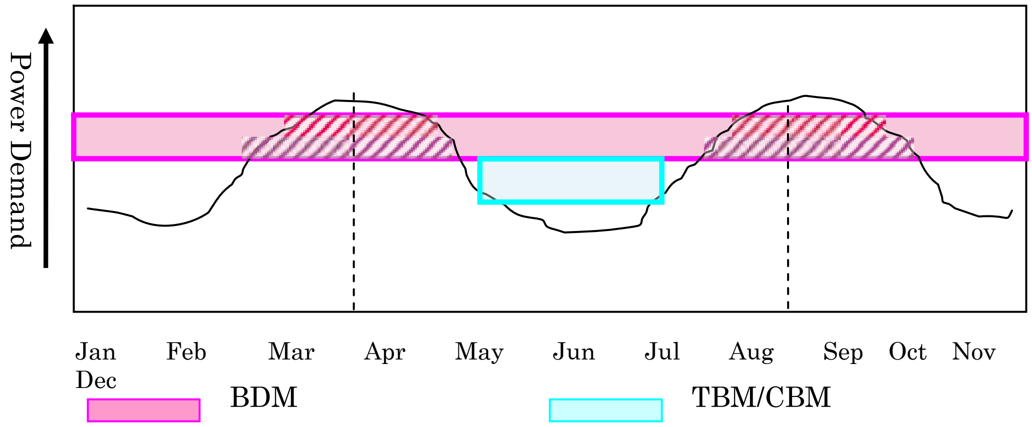
Power Station	Maintenance Record
Rauzan 210MW ST #1	2000.9 – 2001.2 (6 months)
Rauzan 210MW ST #2	2004.1 – 2004.5 (5 months)
Shikalbaha	2002.9 – 2003.9 (12 months)
Ghorasal 210MW ST #4	2002.6 – 2003.1 (7 months)
Ghorasal 210MW ST #6	2003.3 – 2003.5 (3 months)
Haripur 33MW GT #1	2005 5 – 2008.1 (32 months)
Haripur 33MW GT #2	2006.3 – 2007.5 (15 months)
Haripur 33MW GT #3	2005.5 – 2008.6 (37 months)
Ashuganj 150MW ST #3	2002.10 – 2003.10 (13 months)
Ashuganj 150MW ST #5	2007.7 – 2008.1 (7 months)
Baghabari 71MW GT	2005.11 – 2008.1 (27 months)

Source: BPDB Annual Report, PSMP Study Team

According to the result of the survey, it shows that service is not regularly executed, there are those which are not implemented at all even during the past decade, and some of them take about 60 days to three years or more.
It is apparent that a lot of power stations in Bangladesh operate under "operate until breakdown" philosophy without regular inspections. (Please refer to chapter 8 for details) It is categorized in the under the level 1 maintenance method or the so-called "Breakdown maintenance". The figure below shows the image of the difference between the BDM and the TBM/CBM at the regular service period. The mal-effect of the BDM might be to reach the maintenance scope wider than that assumed, so that the repair period will often be longer. It happens because it keeps operating without regular inspections, and when it breaks down, then inspection and repair begins. As a result, the maintenance period extends over the peak demand months of April and September, and influences supply capability.
On the other hand, it is possible for the TBM/CBM to match the regular service at a time when the demand is low, and to minimize the impact to low power supply, because the repair period is limited between the peak to peak period (about 60 days) which the maker recommends beforehand, and the possibility of the prospect for the repair scope and the cost within the expected range is high.

It is apparent that a lot of power stations in Bangladesh country operate under the "Operate until breakdown" minus regular service. (This is also stated in chapter 8) It is the so-called level 1 maintenance method "Breakdown maintenance ". The figure below shows the image difference between BDM and TBM/CBM during the regular service period. The bad effects of the BDM might be to reach the service range more than initially assumed, so that the repair period will be long. It happens because it keeps driving minus regular service, and when it breaks down, then it stops and begins service.
As the result, the regular service period reaches peak demand during the months of April and September, and it influences the supply capability.

On the other hand, it is possible for the TBM/CBM to match the regular service at a time when the demand is low, and to control the influence to low power supply, because the repair period is limited to the over haul period (about 60 days) which the maker recommends beforehand, and the possibility of the prospect for the repair range and cost is high.



Source: PSMP Study Team

Fig. 17-2 Maintenance period for BDM and TBM/CBM (Image)

17.1.3 Conclusion and proposal

In Japan, regular inspections are required by law, and it was a state of "Time-based Maintenance" (level 2) regularly inspected according to the law, However, it has improved to its present "Condition Based Maintenance" (level 3) that extends the regular inspection interval while monitoring the equipment condition as a result of vigorous discussion between the electric power utilities and the regulator in recent years.

It is preferable to shift from present breakdown maintenance to time-based maintenance first, and then condition-based maintenance in Bangladesh. To achieve those levels, the necessary steps are as follows;

- Development of legal systems that decide the regular inspection interval and scope
  In the current state in Bangladesh, there is no established law regarding regular inspections, so inspection is executed independently. However, it tends continue operations until break down due to the difficulty of a shut down in light of the supply and demand situation.
- Skill improvement of the maintenance work for monitoring equipment conditions adequately
  (Qualitative diagnosis (leakage, allophone, corrosion, transformation, discoloration, and expansion) by the working five senses (sight, aural, and sense of smell) at patrol.)
- Condition monitoring based on data
  (Not only is operational data and the maintenance data, etc., collected but also the operating condition and the standard condition (temperature, pressure, current, and vibration, etc.), are also compared and the condition is read from data by observing the tendency.)
- Quantitative diagnosis skill during the regular inspection

Prior capacity building is effective because it needs some lead time to obtain the skill for the setting of a regular inspection period and scope, the capability improvement of equipment conditions, and the method of observing and states of need of the knowhow respectively.

Moreover, there is nondestructive testing as a quantitative diagnosis technology that can judge the operating conditions adequately. The non-destructive testing is as follows;

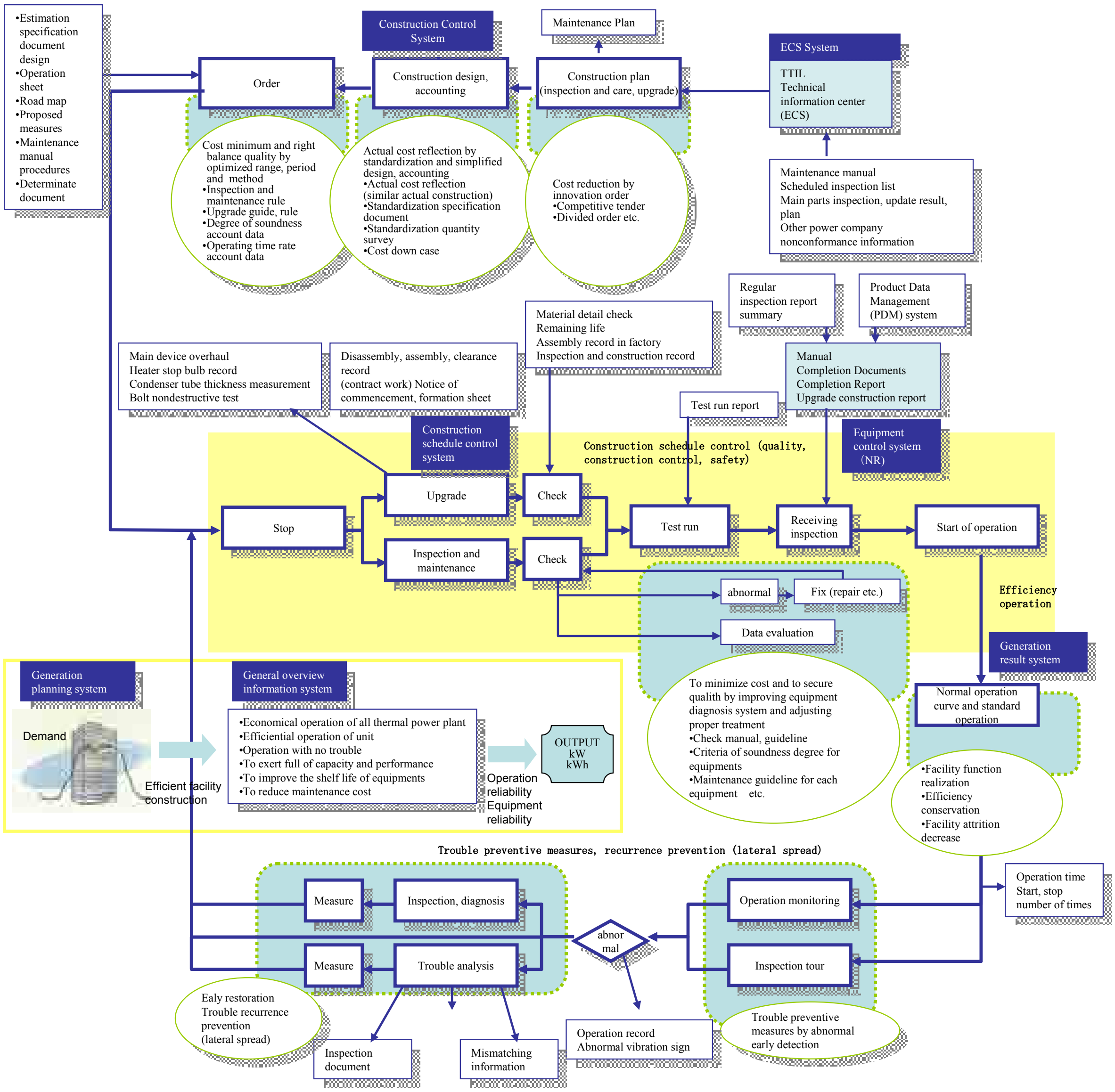
- Liquid penetrate test (Surface defect about 20μ detection limit)
- Magnetic Particle test (Depth about 0.5mm detection limit)
- Ultrasonic test (0.2 – 0.3mm immanence defect detection of thickness material)

At present, only the Liquid penetrate test is used frequently in Bangladesh among these. As for these nondestructive testing engineers, they have to take state examinations for each inspection technique, and in Japan all inspectors undergo certification.
It seems that a similar qualification system will be just as effective.

The figure below shows an example of the operational maintenance scheme in Japan.

At present, only the Liquid penetrate test is used frequently in Bangladesh among these.
As for these nondestructive testing engineers, they have to take state examinations for each inspection technique, and only certified persons are engaged in inspections in Japan.
It seems that a similar qualification system will be just as effective.

The figure below shows an example of the operation maintenance system in Japan.



Source: PSMP Study Team

Fig. 17-3 PDCA cycle for operational maintenance diagram

Before the regular inspection is executed, all work content should be executed when stopping, including the regular content works and the repair for the discovered abnormal equipment when operating, and when the elaborate work plan needs to be made, and arranging beforehand if there are necessary parts etc. (P: Plan).The inspection is executed according to schedule (D: Do). After the inspection, the settlement of abnormality which occurred before the inspection (C: Check) needs to be confirmed. Abnormalities found during the inspection is basically repaired during the regular inspection and repair time, however the measures (emergency measures or permanent measures) are decided with the estimation of the degree of severe abnormality and the lead time for parts procurement. The small-scale abnormality which carries over to the next regular inspection and the abnormality which is repaired by emergency measures are treated with a special measuring instrument by monitoring the condition of abnormality as pending issue management (A: Act). The execution record and the measurement result of the inspection are used for the remaining life assessment by using the prescribed format, and monitoring the trend at each inspection. The aforementioned PDCA cycle is utilized, and always aims at quality improvement.

Further, also, there is the TQM (Total Quality Management) method as a strategic tool to improve operations and maintenance quality improvement via daily inspection.
In the results executed by TQM as JICA technical projects, there is a case in the Bagabari power station where about 20MW output improves by repairing the heat insulator peeling off, and the output decrease was prevented by regular washing of the gas turbine air filter. These good cases illustrate that it is possible maintain performance minus excessive costs.

17.1.4 Proposal for operation and maintenance system for USC coal thermal power station

Because Bangladesh has minimum coal fired power station experience and severer control is required for USC plant operation, it is necessary to set up a fundamental operation and maintenance system.

17.1.5 Feature of coal thermal power station equipment

Because most of power stations in Bangladesh are gas fired power stations, it is necessary to understand how coal thermal power generation equipment is different from gas fired ones. Coal fired power station has different equipment from the gas fired one, since coal is a solid phase so that there are a lot of impurities (ash etc.), and it is burned as pulverized coal.
The main peculiar equipment in a coal fired power station is shown below.

Table 17-2 The main peculiar equipment of coal-fired power station

Equipment	Purpose	Peculiar points
coal transfer and stock system	to storage fuel (coal) and transfer to boiler	attention lake of coal storage at banker due to not continuous but intermittent supply
pulverizing mill	to pulverize the coal for boiler combustion	more frequent inspection required than other equipment due to severe wear and tear
soot blower	to blow the ash adhesive to boiler furnace	appropriate interval of soot blower for ash not to adhere to inside the boiler
ash treatment (boiler bottom)	scrape away bottom ash (clinker) from bottom of boiler (wet type is common)	to operate to prevent not to scrape away due to accumulation
electric precipitator	collect the ash in exhaust gas （fly ash）	necessary to manage the fly ash
ash treatment (storage, carry out)	storage and discharge of coal ash (fly ash, clinker) for utilization	enough capacity needed in the case of discharge delay

Source: PSMP Study Team

17.1.6 Notes for operational management

As coal fired power station normally operates a base load operation, it is basic to operate the plan within a standard operational range at all the times. In addition, the heating surface of the coal fired power station becomes dirty over time due to coal ash. A usual method to dealing with the dirt via regular operations of the soot blower (steam atomization), and partial dirt is dealt with a soot blower via temporary operation at the appropriate position and extending the operation time. In the case of low-grade coal and low melting point ash coal, there is a case where the water gun is used permanently. In particular, in order to prevent the growth of the adhesive at a boiler fire wall, there is also the case of dropping the clinker where the boiler load is lowered to the half loading on the weekend and causes temperature change.
As noted in the operation, the key points are to keep the fired condition, flame of the coal burner and proper maintenance of the angle of the frame steady. (The flame is neither a long flame, a short flame nor a wide angle flame.) In the case of changing the coal type and the coal mixed rate, combustion adjustment of the flame propriety maintenance is necessary.

Another subject of the combustion maintenance is to maintain the granularity of pulverized coal within the design range all the time.
In so doing, regular mill maintenance is executed on a per plan basis. (the inspection of maintenance parts by every fixed time according to the OEM recommendation, the repair of worn-out parts, and the parts replacement)
If the metal temperature of each pressure part material exceeds the design range, phenomenon such as high temperature creep deterioration, and high temperature corrosion, steam oxidation, and an increase of scale generation speed leads to accidents like the boiler tube leak.
Especially for the USC boiler, superior material with strength at elevated temperature is adopted, however, for the large-scale boiler, the design margin adoption by the boiler maker (concept of minimum thickness in the strength calculation) and the selection of boiler material will influence boiler performance since the imbalance of steam flow in the tube and the exhaust gas flow is unavoidable.

The material for the turbine adopted can be endured against the high temperature and high pressure. If the entrance steam temperature exceeds the design limitation, it will accelerate the high-temperature creep and the thermal fatigue, which influences the remaining lifetime.
To avoid them, it is necessary to completely maintain the various safety prevention devices and the protection instruments. The turbine type adopts one axis. Especially the axis and the bearing vibration management abide the turbine generator vibration protection device.

17.1.7 Difference between sub-critical equipment and ultra super-critical equipment

The main equipment difference between the USC (ultra super-critical) which is introduced in this master plan and the Barapukuria power station (sub-critical) is shown as follows.

Table 17-3 Major difference between Barapukuria power station (sub-critical) and USC

	Barapukuria (sub-critical)	USC (ultra super critical)
Capacity	125MW	600MW
Main Steam Pressure	16MPa	25MPa
Main Steam Temp.	538 degree	600 degree
Thermal Efficiency	31%	45%
Boiler Type	drum type	once-through type
De-SOx facility	none	equipped
De-NOx facility	none	equipped

Source: PSMP Study Team

From these differences, the following can be concluded.

- The boiler is not a drum type in the USC but a once through type. As for the once through type, the operating methodology and the characteristics are greatly different from the drum type. However, the burden to the operator can be mitigated by introducing an automated system. For the preparation for troubles, it is essential to acquire the operational characteristics of the once-through boiler, the purpose of each equipment, and the knowledge of the feature for the operator.

- Because the steam temperature/pressure condition is higher in USC, the material that endures high temperatures and high pressures such as the high Cr-Mo steel and the SUS material, etc is used for the boiler tube and other high temperature part. During construction, a special welding technique is necessary, however, because it is believed that a person who has advanced welding skill is limited in Bangladesh, it is necessary to secure a certain number of qualified welders. In addition, in order to maintain the quality and the safety of the welding point, the engineer who is able to conduct a non-destructive test and post-welding evaluation is needed.

- Because Bangladesh doesn't have any experience introducing desulphurization and denitration equipment as environmental equipment, the capacity building from construction to operations & maintenance is necessary.

As mentioned above, it is necessary to overcome some subjects to maintain and operate the USC coal thermal power generation facility proposed in this Master Plan. To build the necessary technical capacity, the following operations & maintenance system is proposed.

17.1.8 Proposal of concrete method

(1) The operation & maintenance engineer's training through construction work

During the construction period, it is necessary to organize a candidate engineer who will become a key person regarding operations & maintenance after commercial operation are allocated to the corresponding section for each engineer's occupation, and to establish a scheme which acquires the necessary professional skill. As Bangladesh doesn't have enough experience to introduce environmental equipment (the desulferization and denitration equipment), particular attention should be paid to it from an understanding of the basic mechanism to practical operation & maintenance skill to be fully obtained.

(2) Construction of operation historical data processing system by introduction of management system supported by computer

From the trial operation stage, the operator should gather operational data, such as operational conditions within the main standard range, the plant performance, water quality trend, and the performance test data. The data accumulated is used as operational management know-how.

(3) Capacity building for training advanced technological acquirer who has special welding skill

Because advanced welding skill talent of high temperature high-pressure parts and nondestructive testing is needed, the capacity building for the qualification system for such welding skill should be carried out.

17.2 Environmental management on existing coal-fired power station and recommendation

17.2.1 Current environmental management

Barapukuria's existing coal-fired power station's current coal-fire practices were examined in Bangladesh. BCFTPP operates with around 280 people, but there is no environmental manager in full service. Further, a safety manager serves concurrently to conduct the necessary plant technical work. Nevertheless, it can't be said the organization puts priority on safety issues. So, there are some non-conformances, especially in terms of environment and safety management. Table 17-4 shows concrete examples of such cases.

Table 17-4 Example of un-conformance in environmental and safety management

Example	Impact
Environmental management	
No ESP out let damper	Ash scattering with ESP hammering
No de-SOx and de-NOx	Large amount of pollutant emission compare with world standard
No cleaning of discharged ash under ESP hopper	Ash scattering
No cleaning of leaked ash such as boiler soot blower nozzle	Ash scattering
Large amount of under ground water pumping (around 32,000m3/day)	Decreasing under groundwater level, impact to water usage of local area
No analysis of effluent	Fear of pollutant effluent
Spillage of water containing coal dust (coal mine, coal storage yard)	Coal dust water spillage to local irrigation
Safety management	
Workers don't put helmets, safety shoes, work suit.	Fear of injury accident
Ash cleaning workers don't put dustproof musk.	Fear of arising heal problems

Source : PSMP Study Team

On the other hand, Meghnaghat gas combined power station (MPL) which is Malaysian capital IPP decides their own Occupational Health and Safety & Environmental (OHS&E) policies in addition to adopting the ISO14001 and OHSAS18001 system. There are no environmental and safety management problems because all employees comply with this policy. In terms of environmental and safety conditions, there is clearly a large difference between these two power stations due to management, though MPL uses fuel gas which is more environmental friendly than coal as fuel.

17.2.2 Objective of the Environmental Management Plan (EMP)

The Environmental Management Plan will be settled to implement mitigation measures that are described in the EIA. The EIA will be submitted to DOE when the entrepreneur acquires an Environmental Clearance Certificate (ECC). Concretely, it stipulates implementation of avoidance and mitigation measures, and plant monitoring to confirm implementation measures. The EMP should be a realistic plan that considers each site's conditions to conduct proper environmental measures. Further, in order to continue proper operations, it will adopt the ISO system.

17.2.3 OHS&E management organization and role of QHSE manager

The OHS&E management organization stipulates a concrete organizational structure, staff numbers , and job descriptions to conduct EMP which is submitted to DOE. In a coal-fired power station, the job description of each post is quite broad due to the various work duties involving environmental controls such as environmental monitoring during daily operations, operation of environmental facilities (FGD and ESP etc), coal handling, ash handling, and waste water treatment. The QHSE Manager unifies these environmental and safety works as his duty. Further, the QHSE manager has a responsibility to report the monitoring results to DOE. The Plant organization should be intent on realizing continuous improvement from the early stages of operation by adopting ISO14001, OHSAS18001system. Table 17-5 shows the necessary manuals needed to organize ISO1400 and OHSAS18001systems. The QHSE Manager has a responsibility to maintain the system and operate the Deming cycle smoothly which consists of the Plan (Management review by the plant manager, planning) – Do (implementation, operation) – Check (Data analysis, audit, nonconformance management) – Action (improvement, modification, prevention). Table 17-6 shows the main environmental related roles at each part that appear in Fig. 17-4. In the table, the bold letters refer to an important part of the environment management system. On the other hand, safety management will be conducted at all parts of the safety related manuals. The QHSE Manager and staff always monitor the conditions of safety management implementation to later be systematically reported to the Plant Manager.

Table 17-5 Example of environment and safety management manual

No.	Document title
ISO14001	
E-1	Environmental Management System Manual
E-2	Environmental Policy
E-3	Identification of environmental aspects and Impacts
E-4	Identification and follow up of legal and others requirements
E-5	Organization of the Environmental Management System
E-6	Environmental Communication (Internal communication / Awareness , External Communication)
E-7	Environmental Management System Operational control
E-8	Waste Management
E-9	Effluent Discharge Management
E-10	Emission Management
E-11	On-Site Emergency Response Procedure
E-12	Environmental Monitoring and measurement
E-13	Issuance and handling of non-conformance report
E-14	Environmental Management System Internal Auditing
E-15	Environmental Training
OHSAS18001	
S-1	OH&S Management Manual
S-2	OH&S Policy
S-3	Hazard identification and Risk Assessment
S-4	Identification and follow up of legal and others requirements
S-5	Organization of the OH&S Management System
S-6	OH&S Training and Awareness
S-7	OH&S Communication, Participation, and Consultation
S-8	OH&S Management System Operational Control
S-9	Fire Fighting Plan
S-10	Work Equipment Control
S-11	Monitoring, Evaluation, and Audit of Health & Safety Performance
S-12	On-Site Emergency Response Procedure
S-13	Typhoon and tropical storm preparedness procedure
S-14	Issuance and handling of non-conformance report
S-15	Incident / Accident Reporting and Investigation

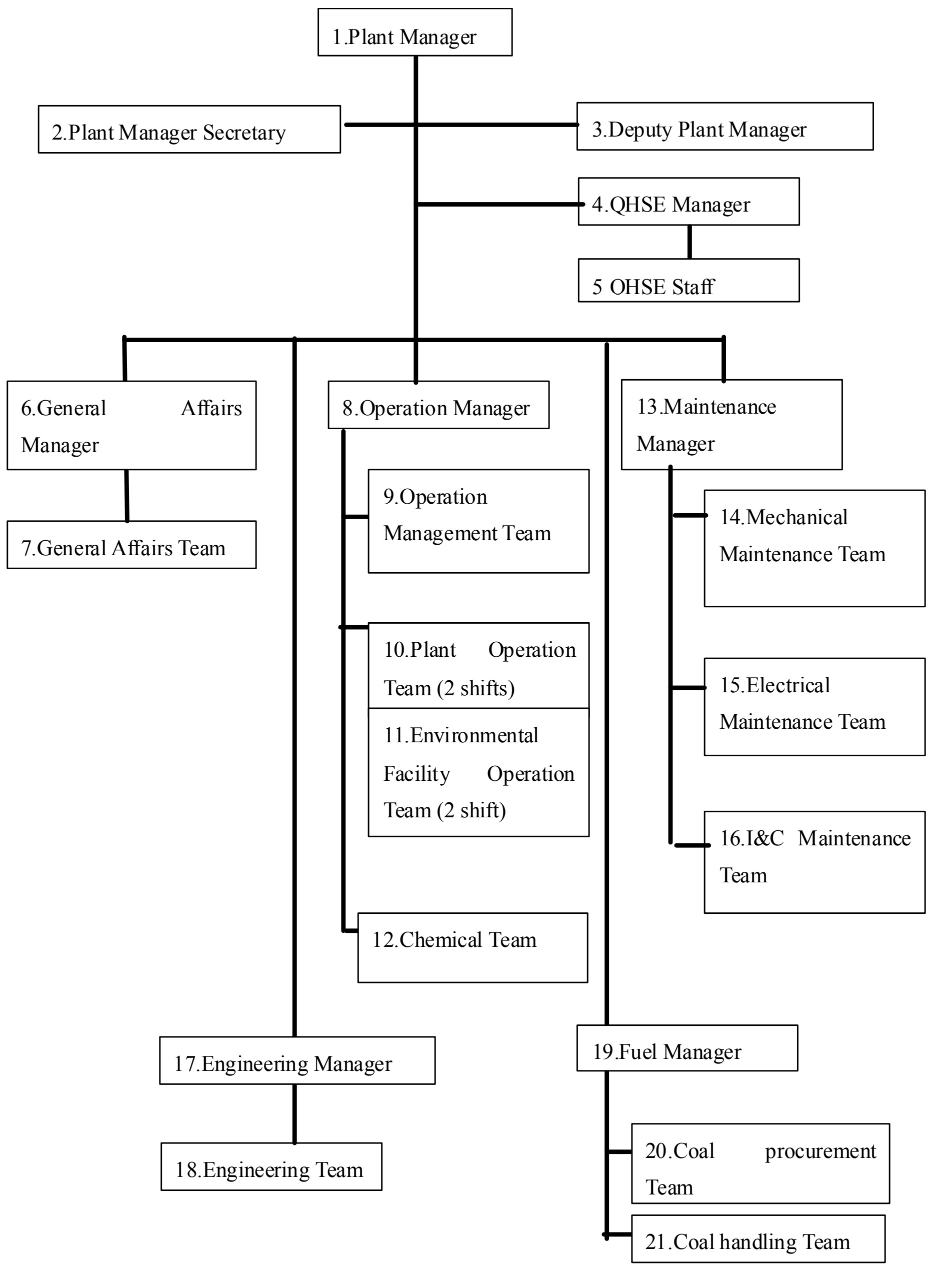
Source: PSMP Study Team

Table 17-6 Environmental related roles

No.	Position	Role
1	Plant Manager	Top management of environmental management system (EMS)
2	Plant Manager Secretary	-
3	Deputy Plant Manager	Depute the Plant Manager responsibility
4	QHSE Manager	Unify implementation of EMS
5	QHSE Staff	Supporter of QHSE Manager Implement EMS
6	General Affairs Manager	Budget management regarding environment issues. Public relations
7	General Affairs Team	
8	Operation Manager	Generation plant operation
9	Plant Operation Management Team	
10	Plant Operation Team	Monitor flue gas and waste water emission
11	Environmental Facility Operation Team	Environmental equipment operation(FGD, ESP etc). Monitor flue gas and waste water emission
12	Chemical Team	Chemical analysis flue gas, effluent, waste

No.	Position	Role
13	Maintenance Manager	Environmental facilities Maintenance
14	Mechanical Maintenance Team	
15	Electrical Maintenance Team	
16	I&C Maintenance Team	
17	Engineering Manager	Trouble shooting and measures study at environmental facility trouble
18	Engineering Team	
19	Fuel Manager	Environmental accident prevention when coal and oil handling
20	Coal procurement Team	
21	Coal handling Team	

Source: PSMP Study Team



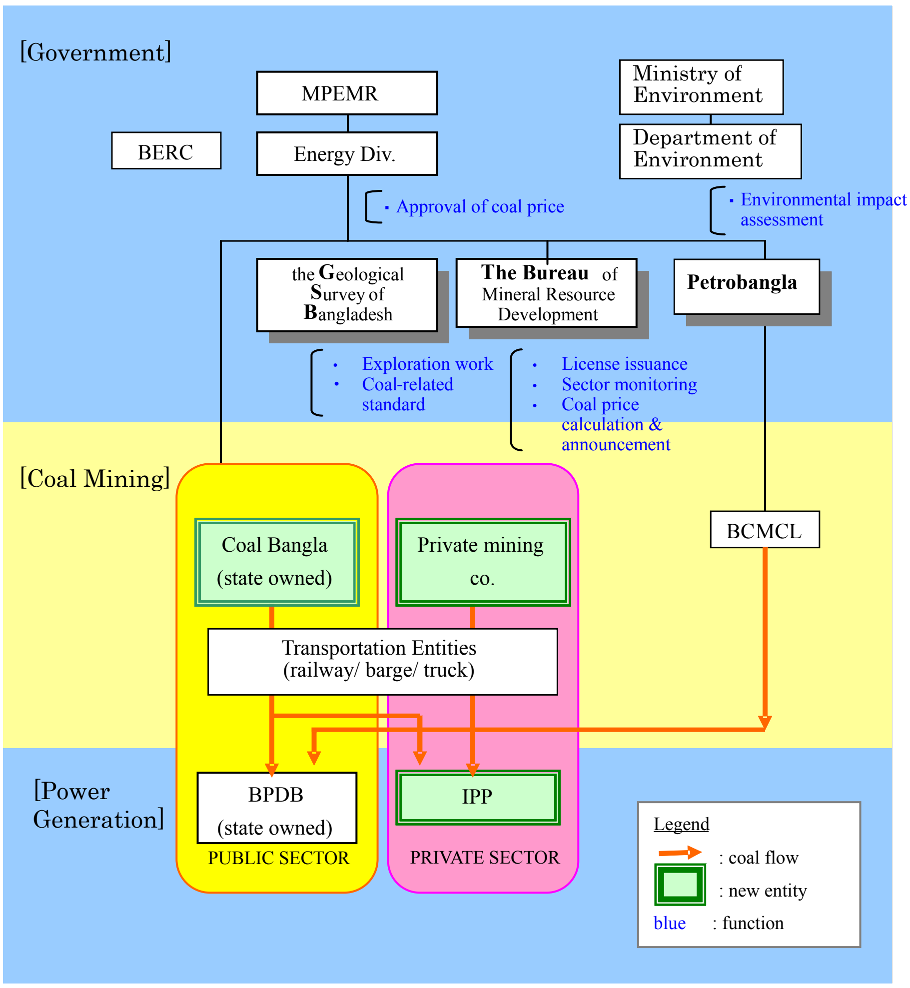
Source: PSMP Study Team

Fig. 17-4 O&M Organization (sample)

17.3 Institutional arrangement for coal procurement

17.3.1 Current situation and issues

This section studied the appropriate institutional arrangement to implement the master plan. It identified the current as well as the anticipated issues, and proposed the solutions. The master plan will cover the development of coal-fired thermal power plants which Bangladesh has had little experience with. To accomplish this goal, it is essential to restructure the current coal sector's institutional structure, e.g. the addition of new function/ role. The Study Team made some suggestion on the future image of the Bangladesh's coal sector like the degree of the government's involvement, taking into account the current and expected scale of the country's coal sector, and the sector's growth speed. Its basic approach is based on literature review – mainly the country's Draft Coal Policy, and interview with the JICA study's counterpart staff. Further, the Study Team made a visit to India's coal-fired thermal power sector in order to find out any international best practice which can be applicable to Bangladesh. Finally, the Study Team identified three major issues from institutional point of view and gave some recommendation to improve the situation. Fig. 17-5 shows the institutional arrangement and each organization's function, which is proposed in the Draft Coal Policy.



Source: Developed by the PSMP Study Team
Note: the Draft Coal Policy does not mention the institutional arrangement for power generation field by imported coal.

Fig. 17-5 Institutional arrangement in coal sector proposed in the Draft Coal Policy

Table 17-7 shows the fuel supply approach by public/ private and coal source.

Table 17-7 Fuel supply approach

	Domestic coal	Imported coal
State-owned power plant (BPDB)	Fuel supply agreement (FSA) between the government entities.	Procured by the power plant.
Privately owned power plant (IPP)	Fuel supply agreement (FSA) with state-owned mining companies. Or procured by the power plant.	Procured by the power plant.

Source: PSMP Study Team

For reference, the prioritized projects assume to be constructed and operated by public sector in both of domestic coal case and imported coal case. The Study Team identified the following three major institutional issues and proposed their countermeasure.

Issue 1: Procurement of imported coal for BPDB-owned power plants
Issue 2: Supply security of domestic coal
Issues 3: Government's implementation capability

Issue 1: Procurement of imported coal for BPDB-owned power plants

Currently, the government assumes that power companies which aim to operate power plants fueled by imported coal procure their fuel by themselves in principle. That is, it is not assumed that the government guarantees the fuel supply to the power companies – the scheme employed in the case of power plants fueled by domestic coal. The challenge, however, is that the country's state-owned-enterprise, BPDB has not imported coal for power generation. Because the Draft Coal Policy does not mention how to import coal from institutional perspective, the Study Team analyzed the issues based on the outcome obtained from the interview with relevant organizations to reach the following three solutions.

One solution would be for BPDB to procure coal by itself, same approach as that of IPP with power plants fueled by imported coal. There might be several options for this scheme. Taking into account that BPDB is the state-owned company, it might be the appropriate way to follow the case of Bangladesh Petroleum Corporation (BPC), the state-owned enterprise which has firm experience and knowledge in oil fuel import. BPC procures oil by floating international tender, calling not only for domestic but also for overseas procurement business entities. Regarding the concern about BPDB's credit on coal import, it would not be a significant matter because BPDB has accumulated its credit as a payer to IPPs based on power purchase agreement, proving little delay of payment. This fact would contribute to building the credit for coal import, too. In fact, according to BPC, they have rarely faced difficulties in procuring oil because they secure the payment to importers by issuing Letter of Credit. In order to realize this measure, BPDB would need to establish a coal procurement unit in their organization, providing capacity building and securing necessary human resources.

The second countermeasure would be similar to the first solution - to outsource the procurement task to external organization like trading companies under a long-term contract. Most Japanese and Indian power utilities adopt this approach to procure fuel, though the measure might not come true as long as BPDB stays as a state-owned enterprise. BPDB would need to float an international tender to procure imported coal because the Board is a state-owned-company. As anticipated, the whole procedure would consume a certain period of time, including a long appraisal time. Different from the tender scheme, it is expected that BPDB could save time in more efficient manner with this second solution. With this methodology, since there are few large-scale trading companies which have sound record of importing coal for power generation, BPDB would start building relationship with international trading companies which have experience in importing coal like MMTC of India.

The third measure would be that of Coal Bangla, which would be responsible for domestic coal handling, would also handle imported coal for power generation. This would enable BPDB to secure imported coal under FSA with Coal Bangla. In this case, it is recommended for Coal Bangla to provide capacity building in the procurement to its staff as well as to secure necessary human resources.
Table 17-8 summarizes the proposed recommendation.

Table 17-8 The major recommendation toward the issues on Procurement of imported coal for BPDB-owned power plants

- The creation of a unit responsible for the procurement of imported coal in BPDB. It is recommended for BPDB to implement capacity building on tender procedure of imported coal and to secure necessary human resources.
- The establishment of business relationship with international trading companies which handle coal. It is recommended that the government rules on international procurement by state-owned-enterprises would be operated flexibly.
- To add a task to procure imported coal to Coal Bangla. It is recommended for BPDB to implement capacity building on tender procedure of imported coal and to secure necessary human resources.

Those discussions are for cases when BPDB outsources the procurement task to external organizations. The other approach is the one that BPDB directly handles every stage of procurement by itself, such as negotiation with coal mining companies and shipping arrangement (DIY plan). For now, however, the outsourcing plan would be appropriate for BPDB because the plan would put less burden to BPDB than DIY plan (Table 17-9).

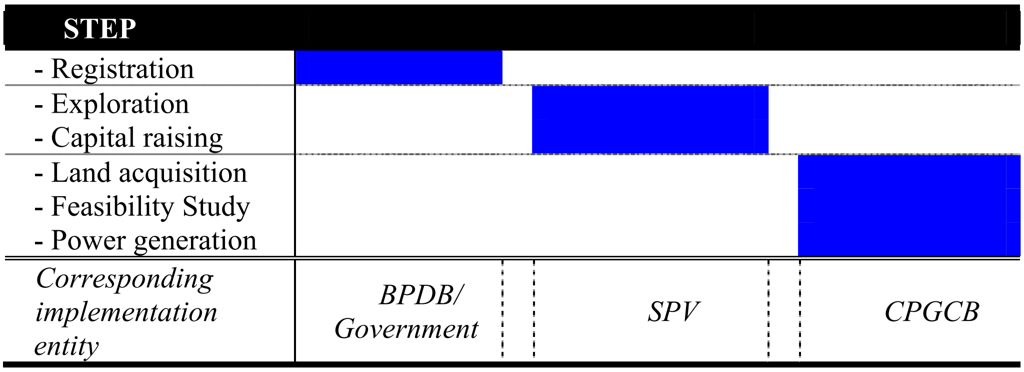
Table 17-9 Comparison of the plans

	Advantage	Disadvantage
1) Outsourcing plan	Comprehensive service including procurement of coal is attractive.	The plan requires commission charge.
2) DIY plan	No commission charge. IPPs can manage every step of the coal supply chain.	IPPs need to pay more transaction cost compared to Outsourcing plan.

Source: developed by PSMP Study Team

In case of imported coal base IPP (the case of Chittagong North Power station) as reference, BPDB has formed a joint venture (JV) with NTPC, the Indian state-owned-thermal power generation company. The JV plans to import coal through NTPC's resources. If this framework works smoothly, this would be likely to be the role model for Bangladesh's IPP with imported coal. The interview with NTPC found that NTPC has long procured imported coal through an external trading company like MMTC, while it plans to expand its procurement channels including its direct procurement. For the power company's direct fuel procurement, the company might need to invest in the upper fuel supply chain like the production right of coal mines in the exporting countries. Because such investment would costly, BPDB needs to investigate its cost performance when the Board plans for the direct procurement.
After the interview with BPDB as well as the scrutinized review of relevant literature, the PSMP Study Team found that a coal fired thermal power company exclusively for imported coal as fuel is scheduled to be established by the Government. The company's tentative name is Coal Power Generation Company of Bangladesh (CPGCB). Significant difference from the case of domestic coal is that the Government does not assume public sector participation in the power generation stage. Although the designed power company may be established as a subsidiary company of BPDB initially, the company is supposed to be owned and operated fully by private sector in future.
In order to assist the take-over process for potential investors of CPGCB, a shell company (SPV) is designed to be formed initially for preliminary work. The work would include appointment of

consultants for the project's feasibility study as well as an environmental impact assessment, land acquisition, and documentation related to RFP (request for proposal) and PPA (power purchase agreement). It is also recommended for the CPGCB's appraisal team of international tender to include knowledgeable sponsors which are familiar with technical aspects so that the team can eliminate non-eligible bidders. Fig. 17-6 shows the individual steps to establish CPGCB and corresponding entities.



Source: developed by PSMP Study Team

Fig. 17-6 The process toward the establishment of CPGCB.

Issue 2: Supply security of domestic coal

Domestic coal supply security depends on the sustainability of the domestic coal mining business. One of the major challenges is how to let the coal sector, currently only one company, grow from now on. There is only one state-owned-enterprise which runs coal mining business in Bangladesh, BCMCL. Taking the BCMCL case as reference, the Study Team analyzed the coal supply security in future of Bangladesh, identifying currently anticipated issues and making recommendations on the corresponding countermeasures.

First of all, coal mining business needs to be attractive from commercial aspects, if the Government wants its coal sector to develop further. After interviewing BCMCL, it turned out that there are large gap in the price of coal between the one for power generation and the one for the other use (the former is 85.5$/ metric-ton, and the latter is 111.37$/ metric-ton). In order to improve the profitability, further price raise of coal for power generation would be necessary, which means to raise electricity tariff further. This might have resulted from the national policy which has placed priority of the use of domestic coal on power generation. On the other hand, the interview with the relevant entities has found that there is more number of applicants of coal exploration/ marketing business license than expected now. This fact may implicate that the coal business in Bangladesh would be attractive. In fact, Petrobangla and some local enterprise have received new exploration license in KDP area according to the Bureau of Mineral Dept. (BMD). The Draft Coal Policy welcomes the participation not only from public sector but also from private sector. The Policy has proposed to establish Coal Bangla which imitates the function of Petrobangla in natural gas sector so that the Government shows the public sector commitment. In this case, several measures such as capacity building and securing human resource would be essential as the Coal Bangla would be the first state-owned coal company in addition to BCMCL. One concern is the outlook of the policy implementation. The policy had developed under the previous government regime, whole process related to the Draft Coal Policy have been delayed since the birth of new government regime in the end of 2008. Under such uncertain outlook, there still some possibility to show public sector commitment by expanding the business coverage of BCMCL, the only state-owned coal company. In summary, the Study Team recommends two points. Firstly, it would be effective to establish Coal Bangla to show public sector's commitment in the country's coal sector. Secondly, it is recommended to make regulated price of coal for power generation more attractive together with electricity tariff. This could be achieved by transferring the coal tariff setting task from Energy Division to Bangladesh Energy Regulatory Commission (BERC).

Besides the difficulty of commercial viability, the social and environmental matters are another challenge. It is said that compensation negotiation with local communities have been stacked for several years to explore coal mining areas not only Barapukuria area but also the adjacent Phulbari area. This kind of conflict can generally be solved by mutual understanding. BCMCL also acknowledges the importance to add an exclusive unit to promote communication with local community. They expect that building good relationship with local communities would result in smooth operation of coal mining business. Until now, there has been no exclusive unit for public communication in BCMCL and most relevant unit has treated matters case by case. Therefore, the Study Team recommends the creation of public communication unit in the above domestic coal supply organizations.

Finally about human resource aspects, it turned out that the capacity building of mine workers has achieved a certain level of success through OJT and in-house training center, while it is hard for the company to raise the skill of management level engineers through institutional arrangement only. BCMCL has studied on capacity building of their employees, whose plans include outsourcing to external entity. This is mainly because OJT would not be enough for higher level engineers to raise their capability. It will not be easy to solve this problem only by institutional approach. One possibility would be for the government to have a section which manages capacity building programs for domestic coal suppliers in the early days of the country's coal sector.

Table 17-10 summarizes the above recommendations.

Table 17-10 The major recommendation toward the issues on Supply security of domestic coal

- To develop a framework in order to make the regulated coal price more attractive. This could be efficiently achieved by transferring the coal tariff setting procedure from Energy Division to BERC. It is recommended to review the current regulatory framework on coal price setting.
- The establishment of Coal Bangla, or the government's approval on the expansion on the business coverage of existing state-owned-enterprises (BCMCL and Petrobangla) so that the government can show the commitment from public sector.
- The creation of a public communication unit in the aforementioned state-owned-enterprises, which will be responsible for social matters with the mines' surrounding community. It is recommended to secure necessary human resources and to have capacity building.
- Enhancing training program for management level engineers. This could be facilitated by the government's involvement, e.g. the creation of a unit for training program management. It is recommended to study the overseas best practices and/ or to import training program from overseas firms.

Issues 3: the Government's implementation capability

As the Draft Coal Policy mentions, one of the major institutional challenges to secure the future coal supply is capacity building of the existing government bodies such as the Geological Survey of Bangladesh (GSB) and BMD. The interview with relevant entities shows that there would be no need to establish new government organization for this purpose, while it is recommended to reinforce the existing government organizations. The major points are as follows:

(1) Strengthening of the implementation capability of the coal industry administration agencies: the Bureau of Mineral Dept. (BMD) supervises Bangladesh's coal sector, which is equivalent to the Ministry of Coal in India. The current issue is the size of the organization (14 members as of October 2010). The interview to BMD found that they do not plan to establish the Ministry of Coal, taking into account the scale of future coal industry in Bangladesh. Although BMD plans to expand its size to 40 members in near future, because BMD is responsible not only for coal

but also for other minerals, it is recommended that the organization increases its size more to prepare for future expanding coal sector.

(2) The agency of price regulation: Currently, Energy Division under MPEMR has been responsible for the approval of coal price. Some interviewees suggest that the independent energy price regulator, BERC, would be appropriate organization for this purpose because the bureau is responsible for tariff setting of other energy services such as electricity and gas. Considering that most developed coal would be used for power generation, it would be efficient that one administration body supervises both electricity and coal. In this case, it would need to provide capacity building to BERC and to secure essential human resources for this purpose.

Box. 17.1 International Best Practice

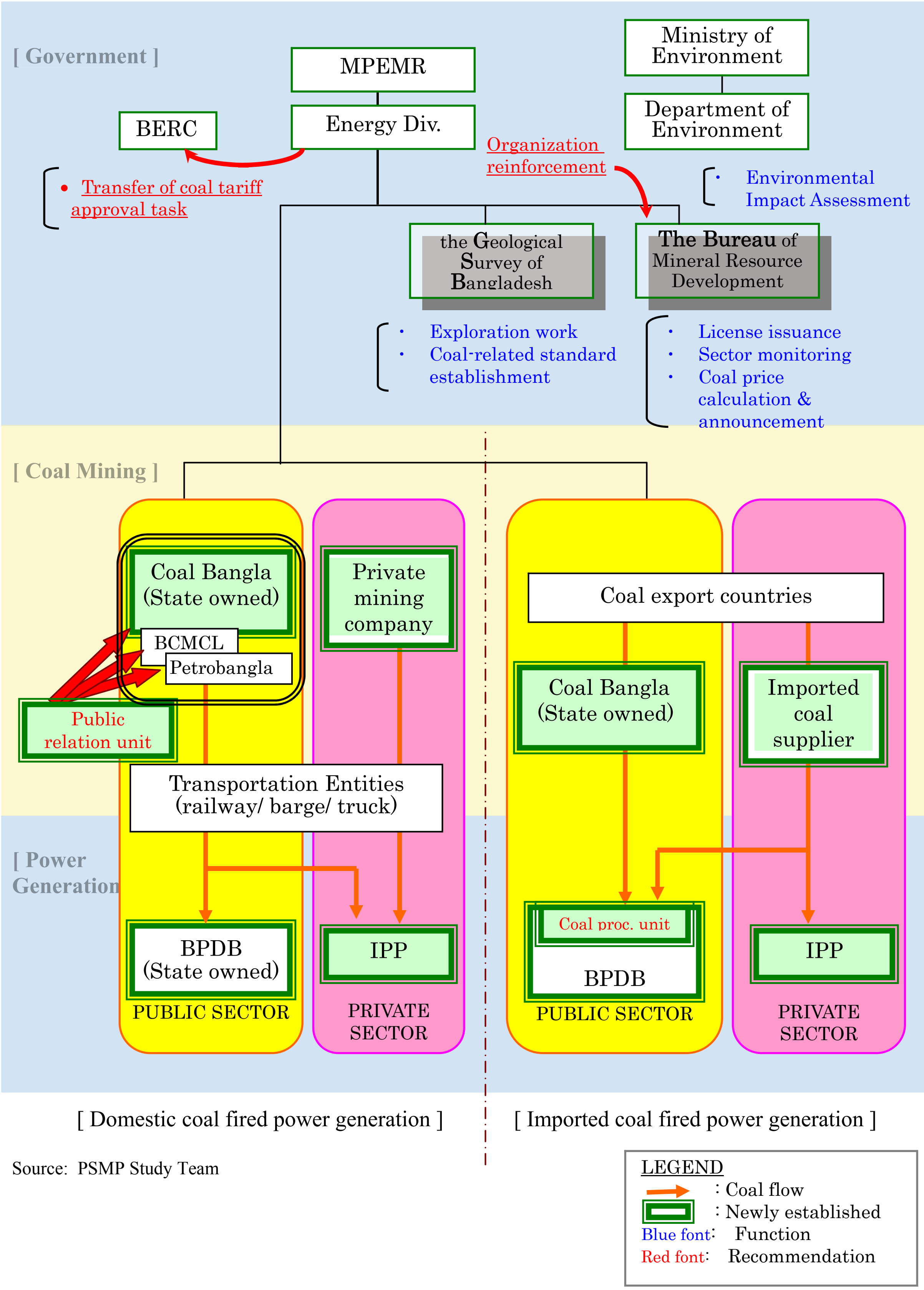
The best practice review tells that the degree of the Government intervention varies in accordance with the maturity of coal sector. For example, in India, because the coal development was implemented by small/ medium scale business entities in its early era, the development was the inefficient. Therefore, the Government has decided to aggregate those business entities, establishing a state-owned enterprise, Coal India Limited (CIL), to promote the sector's growth. The Government also established the Ministry of Coal in their body, too. Thanks to this decision, the nation's coal business has been streamlined and succeeded in increase of production. In UK after the World War II, then Government body, the National Coal Board (NCB) (currently the Coal Authority) had nationalized the coal industry taking into account the fact that coal business is national industry and the fact that the business had been less profitable for private sector to run. On the other hand, in Netherlands, the Government let private sector fully handle the coal business. Regarding Bangladesh, because the scale of its coal industry would not be as large as that of other nations like India, most interviewees answered that the significant degree of the Government intervention would not be necessary for Bangladesh's coal sector, the answer which the Study Team also agrees with.

Table 17-11 summarizes the above recommendation**.**

Table 17-11 The major recommendation toward the issues on the Government's implementation capability

- Capacity building to the government staff, e.g. GSB, BMD, and the Ministry of Environment, which are responsible for coal administration.
- The increase of members who will be in charge of coal sector administration in BMD.
- The transfer of the task related to coal price approval from Energy Division under MPEMR to BERC in near future. It is recommended for BERC to secure necessary human resources and to provide capacity building to its staff on matters related to coal.

Fig. 17-7 summarizes the recommended image of future coal sector in Bangladesh.



Source: PSMP Study Team

Fig. 17-7 The recommended institutional map of future coal sector in Bangladesh

Chapter 18 Environmental and Social Examination on the Most Prioritized Projects

18.1 Study methodology

18.1.1 Study objective

The objective of the environmental and social survey in this MP Study is to predict future adverse impacts caused by development projects that emerge from the Study and examine effective measures including examination of the alternatives to avoid or minimize such impact.

The Team has introduced in this Study the concept of strategic environmental assessment (SEA)[1]. SEA is conducted in the "strategic decision making stage", preceding individual projects in which wider variety of potential impacts on the environment are assessed from early stages of making policies, programs, plans and projects and the assessment outcome is reflected into the decision making to ensure that the said plan has taken the environment into appropriate consideration. The JICA's Guidelines for Environmental and Social Consideration endorse that JICA urges the host countries to introduce the concept of SEA when conducting MP studies and to address a wide range of environmental and social factors from an early stage[2]. Legislation in Bangladesh also requires that an initial environmental examination (IEE) be conducted for location clearance certificate (LCC), prior to conducting an environmental impact assessment (EIA).

18.1.2 Study method

The study team has assisted the Government of Bangladesh in examining the environmental and social viability of coal fired power projects among all potential sites, for power plant construction in order to short-list them by analyzing existing secondary data. The whole process of selecting the three most prioritized sites, among all others, taking viability of other aspects also into consideration, can be referred in the Chapter 12 and its APPENDIX.

Further, the future environmental and social impacts in the three most prioritized sites have been examined by conducting the IEE level studies. Local consultations were conducted to share the study outcome and collect their views on the construction of coal-fired power plant, project design and specifications[3]. Their opinions have been reflected in examining mitigation measures in this report.

Intensive discussions have been conducted, throughout this study, among government stakeholders by holding task team meetings in Dhaka. The task team has kept directing the above examination on the right track and contributed to its quality improvement. Specific assessment items (such as air pollution, resettlement and etc.) have been identified in the discussions which are to be more focused than the rest ('scoping'), and recommendations have been drawn in this report for further examination in future studies, such as feasibility study.

Relevant laws and regulations on environmental and social issues enacted in Bangladesh, outlines of each prioritized site and the summary of simple diffusion calculation can be found in the APPENDIX of this chapter.

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[1] SEA has been already introduced in the United States, Canada and 25 out of 27 EU countries. (Ministry of Environment, Japan. "Outlines of SEA Introductory Guidelines". January 2009)

[2] This MP Study has applied the JICA Guidelines for Environmental and Social Considerations issued as of April 2001.

[3] Local stakeholder meetings, focus group discussions among male groups and female groups, household interviews, and in-depth interviews with local authorities have been conducted.

18.2 Impact analysis for new power plant development

18.2.1 Situation analysis

First, the current situations of the three most prioritized sites are described below. The relevant data and further information are referred to in the APPENDIX to this chapter.

(1) B-K-D-P site

Nawabganj Upazila, where the B-K-D-P site is located, has 314.68 km^2 of area, in which there is a population of 204,351, composed of 46,435 households as of 2001. The literacy rate is rather low at 38.4 percent[1].

The majority of the Upazila population is involved in agriculture with the main staple products being rice, wheat, jute, mango, banana etc. Within a distance of 500m from the proposed power plant site, there are villages named Rahimapur (500 households); Nandanpur (350 households) and Joydebpur (400 households). These villages are within the agricultural zone and the proposed site maintains a certain distance from the important facilities, commercial centers or local communities. There is not even a hotel or restaurant in the area. There is a ruin named Seeta Kuthuri, which has been preserved by the Archaeological Department close but outside of the site. In and around the B-K-D-P site, there is a farming area and the ambient air condition is not severe in its totality.

The proposed site is situated in the middle of domestic coal mines: Barapukuria, Khalaspir, Dighipara, and Phulbari. In Barapukuria, the Barapukuria Coal Mine Company Limited and the Barapukuria Coal-fired Power Plant are already in operation. There are ground subsidence, mainly caused by the intake of underground water, which has brought damages on houses in the neighboring area. In addition, severe water shortage is observed due to the lower water level in their wells[2].

Source: PSMP Study Team

Fig. 18-1 Damages on houses in neighboring villages to Barapukuria coal mine

In the site survey, it has also been observed that ash from exhaust of the existing Barapukuria Power Plant has deposited on plant leaves[3]. The EIA for the Barapukuria Power Plant (implemented in 2000) estimated at that time that the NOx and SOx concentration would become higher than the current ambient air standard. Hence, exhaust gas concentration can still increase locally and adverse impact to the environment can be caused by the NOx and Sox from the proposed power station.

1 Bangladesh Bureau of Statistics, "the Area, Population and Literacy Rate by Upazila/Thana-2001" http://www.bbs.gov.bd/dataindex/census/ce_uzila.pdf (accessed in April 2010)

2 See detailed data in APPENDIX of this chapter.

3 It was also observed when PSMP Study Team visited the site in November 2009.

Source: PSMP Study Team

Fig. 18-2 Plant leaves with scattered dust from debris of power plant

The BCMCL has already taken actions to cope with such damages due to subsidence and ash deposit. They have spent 21 million Taka during five years up to 2010 to compensate for the damages on crops and houses, to build new houses, renovate the existing roads and to compensate by cash. They are now requesting allocation of government budget equivalent to 3.2 billion Taka for new land acquisition and resettlement, that will include new house construction, job creation and livelihood improvement activities[1].

In Phulbari, the Asia Energy Corporation (present GCM Resources) proposed an open pit coal mining development plan, which faced massive local resistance from anticipated 50,000 people to be involuntarily relocated and 300,000 indirectly affected by the project[2]. Three people died and 100 were injured in a protest gathering of over 50,000 people in 2006. The local resistance still remains up to present and there was a long march to Phulbari Coal Mine in October 2010 demanding proper utilization of natural resources for the development of the country[3].

(2) Chittagong site

Banskhali Upazila, where the Chittagong South site is located, has 376.9 km2 of area, consisting of a population of 391,320 comprised of 71,229 households as of 2001. The average size of one household is 5.5 people and the literacy rate is 29.5 percent[4]. There is no major industry in the Upazilla. As the Upazila is close to the center of Chittagong District and the Chittagong Port, not much population is involved in agriculture, except the service industry and the fishery industry. As the site is located close to the sea, the land is mainly used for non-agriculture purpose. The primary agricultural products are rice, potatoes, chilies and vegetables.

Two fertilizer factories located in the neighboring Anwara Upazilla are causing noise and air pollution. Respiratory illnesses, headaches, diarrhea and eye diseases are considered to be health hazards influenced by ammonia gas emitted from the fertilizer factories.

(3) Meghnaghat site

Sonargaon Upazila of Narayaganji District where the site is located has 171.66 km^2 of area. It has a population of 305,562 people comprised of 60,805 households as of 2001. The average size of one

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1 Information provided by the Barapukuria Coal Mine Company Limited staff (as of November 2009).

2 Information provided by the BCMCL staff.

3 http://www.demotix.com/news/484975/long-march-phulbari-coal-mine (accessed in December 2010)

4 Bangladesh Bureau of Statistics, “the Area, Population and Literacy Rate by Upazila/Thana-2001” http://www.bbs.gov.bd/dataindex/census/ce_uzila.pdf （accessed in April 2010）

household is 5.0 people, and the literacy rate is 47.0 percent[1]. The area is both agricultural and residential. There are few hotels and restaurants in the area. The tombs of Sultan Giasuddin and Shah Abdul Alla are situated in Sonargaon Upazilla, which is about 4 km away from the site. There are considerable number of factories in the Meghnaghat Newtown area, which causes noise and air pollution in the area.

Source: PSMP Study Team

Fig. 18-3 Meghnaghat industrialized area

There is a 450MW combined cycle power plant located near the proposed site[2]. They organized local stakeholder meetings prior to the power plant construction, held a well-received presentation on potential future pollution with prevention measures and land acquisition. Assistance for local residents has been continued even after the power plant launched its operation. They spend upward of US$ 30,000 to 40,000 annually for their corporate social responsibility (CSR) activities such as school construction, distribution of rice and blankets for the destitute during winter time. They have Health, Safety and Environmental Managers as permanent posts and they deal with any environmental or social issues which emerge during discussions. There have been no health or environmental problems reported so far and the local people do not have anxiety or perceive that there are any noise pollution and/or air pollution risks.

Source: PSMP Study Team

Fig. 18-4 Meghnaghat combined cycle power plant

[1] Bangladesh Bureau of Statistics, "the Area, Population and Literacy Rate by Upazila/Thana-2001" http://www.bbs.gov.bd/dataindex/census/ce_uzila.pdf (accessed in April 2010)

[2] Owned by the Power TEC, Malaysia. They launched the operation in November 2002.

When interviewed[1], the gas-turbine power plant staff showed their concern about noise and air pollution, which may be caused by the operation of coal-fired power plant, especially for clogging of gas turbine inlet air filters by fly ash. In addition, they are concerned that the local people may develop a negative impression about the power plant, if the environmental management of the coal-fired power plant is inadequate.

18.2.2 Problem analysis

A problem analysis has been carried out on the potential impact, that the 600 MW-class coal-fired power plant construction at the B-K-D-P, Chittagong and Meghnaghat sites can bring in terms of pollution and its effects on the natural and social environment. Items for analysis were identified in the preparatory study conducted by JICA in 2009[2]. Potential impacts during the construction and operation stages have been examined separately. For further detail, see AP Table 18-28 to 18-30, AP Table 18-45 to 18-47, and AP Table 18-62 to 18-64.

(1) Pollution and its effects on natural environment

- Common issues

  The common assessment result, among the three sites, of the problem analysis on pollution of natural environment is shown in Table 18-1. More attention should be paid to the noise, vibration and potential accidents that could occur during the construction period. Attention must also be paid to air pollution, water contamination, noise and vibration, waste, subsidence and water usage during the operation period.

Table 18-1 Problem analysis: assessment results on environmental impact (common issues)

No.	Item	Impact during Construction Stage	Impact during Operation Stage
1	Air Pollution	Air pollution can be caused by exhaust gas from transportation vehicles and construction machinery. And dust particles may be scattered near the construction site and road for construction vehicle.	Planned coal-fired power plant burns coal as the main fuel. And it burns light oil as auxiliary fuel (fuel for starting up). NO_X, SO_X and soot will be generated due to the combustion of these fuels.
2	Water Contamination	Drainage caused by rainfall, equipment washing and sewage will be generated during the work. And if waste management is not appropriately conducted, effluents from waste may be generated.	Thermal discharge will be produced when using river water for cooling. If cooling tower is used, effluent from condenser cooling water will be generated. Plant effluent and domestic waste water will be generated through plant operation. In case waste management methods aren't appropriately conducted, effluents from waste water may be generated.
3	Soil pollution	Soil pollution can occur due to lubrication oil or fuel oil spillage from transportation vehicles and construction machinery.	Soil pollution can occur due to lubrication oil or fuel oil spillage from unit operations.
4	Noise and vibration	Noise and vibration arise due to vibrations from transportation vehicles and construction machinery. AP Table 18-67 shows the list of the general noise level of transportation vehicles and construction machinery. Steam blowing during commissioning will also generate significant noise.	Noise and vibration will be generated through the operation of power facilities. If a cooling tower is used, there is significant noise and vibration from the cooling fan of the tower. For periodic inspections, noise and vibration may arise due to vibration from transportation vehicles and construction machinery. When using vehicles or conveyor for coal transportation, noise and vibration may occur.

[1] Interviewed with Plant Manager, February 2010.
[2] These are same items with the JICA's Guidelines for Environmental and Social Consideration.

No.	Item	Impact during Construction Stage	Impact during Operation Stage
5	Offensive Odor	If the domestic waste management isn't applicable at worker stations, offensive odor may be generated due to waste decomposition.	If ammonia which is used at Selective Catalytic Reduction (SCR) leaks, it may be a source of offensive odor. If the domestic waste management is not applied at worker stations for maintenance work etc., offensive odor may be generated due to waste decomposition.
6	Waste	Construction work will generate metal chips, waste plastic, wood shavings, waste glass and waste oil. Domestic wastes such as cans, bottles and food residue will be generated by construction workers at their work stations.	By-products generated through the operation of coal-fired power plant are coal ash, gypsum (if limestone-gypsum Flue Gas Desulfurization (FGD) is used), sludge from waste water treatment facility and cooling water canal fouling (if the river water or sea water is used for cooling purposes). These by-products will be wasted if they are discarded without recycling. Maintenance work will generate metal chips, waste plastic, wood shavings, waste glass and waste oil. And domestic waste such as cans, bottles, and food residue will be generated at the workers' stations.
7	Biota and Ecosystem	There is a possibility of endangered species existing in the site which is categorized as CR[1] in IUCN Red list.	There is a possibility of endangered species existing which is categorized as CR in IUCN Red list.
8	Accident	Construction accidents may be caused due to defects of health and safety management of construction work. It is necessary to pay attention especially to high altitude areas where accidents from falling may occur as well as construction vehicle road accidents and electricity accident.	There is possibility of accidents occurring such as fires due to oil spillage or instantaneous combustion of coal, accidents due to leakage or spillage of chemicals like caustic soda and sulfuric acid, accidents or incidents involving maintenance work.
9	Global Warming	-	It is estimated that approximately 3.54 to 3.79 million tons of CO_2 will be emitted from each 600MW unit per year through operation of coal-fired power plant.

Source: PSMP Study Team

- Specific issues to each site

  Taking specific features of each site into consideration, there are critical issues that need to be paid high attention for mitigation measures.

  (1) B-K-D-P Site
  - Long distance land transportation of domestic coal is needed during operation and it may generate coal dust and noise.
  - If underground water is used for cooling, there is a large possibility of ground subsidence, impact on water usage in surrounding area.
  - There is a possibility of Painted Roofed Turtle existing which is categorized as CR in IUCN Red List. Scattered reserved forests in Dinajpur District may be affected by power plant or transmission line.
  - As observed in Barapukuria Coal Mine, issues such as the i) decrease of the underground water level due to underground water usage, ii) ground subsidence caused by underground water usage and falling rocks, iii) noise and vibration caused by drilling and coal handling and iv) air pollution caused by coal transportation

[1] Critically endangered

vehicles are potential incidences that occur in domestic coal development prior to power plant construction.

(2) Chittagong Site

- There is a possibility of bottom sediment accumulation, if plant effluent and domestic waste water is discharged to Bay of Bengal and Sangu River after inadequate treatment.
- There is a possibility of Painted Roofed Turtle which is categorized as CR in IUCN Red List and Fishing Cat which is categorized EN[1] in IUCN Red List existing around the site. Around sea area, Ganges River dolphin and Blue Whale which are categorized as EN in IUCN Red List, may exist.

(3) Meghnaghat Site

- If there are no adequate measures taken for coal dust and fly ash, operation of adjacent Meghnaghat CCPP will be affected due to clogging of the gas turbine inlet filter.
- There is a possibility of bottom sediment accumulation if plant effluent and domestic waste water is discharged to Meghna river after inadequate treatment.
- There is a possibility of Red Headed Vulture and Painted Roofed Turtle categorized as CR in IUCN Red List and Fishing cat categorized as EN in IUCN Red List existing around the site.
-

(2) Social environment

- Common issues

The common assessment result among three sites of the problem analysis on social environment is shown in the Table 18-2.

[1] Endangered

Table 18-2 Problem analysis: assessment results on social impact (common issues)

No	Item	Impact during Construction Stage	Impact during Operation Stage
1	Involuntary Resettlement	Land acquisition is associated with involuntary resettlement.	Damage to houses and health hazards can be caused by smoke exhaustion, noise pollution, water pollution and land subsidence when the resettlement action plan is not appropriately planned and implemented. Political intervention and/or local movement against the operation of the power station can occur when adverse impacts on local residents' lives and livelihoods are severe.
2	Local Economy such as Employment, Livelihood etc.	Loss of employment and livelihood can be caused by temporary loss of agricultural lands during the construction period. Bangladesh regulations stipulate that displaced persons are entitled to compensation for loss of land, property and standing crops in monetary terms at fixed rates. It however does not compensate for loss of employment or livelihoods. The destitute, poor and landless farmers, agricultural laborers and wage laborers can therefore become further distressed if the construction period becomes too long.	Permanent loss of employment and livelihoods can be caused by land acquisition due to power station construction and surrounding areas. Bangladesh regulations stipulate that displaced persons are entitled to compensation for loss of land, property and standing crops in monetary terms at the fixed rates. It however does not compensate for loss of employment or livelihoods. The destitute, poor and landless farmers, agricultural laborers and wage laborers can become further distressed when job opportunities or at least skill training opportunities for them are not secured.
3	The Poor, Indigenous and Ethnic People	The destitute, poor and landless farmers can lose their jobs when agricultural land is temporarily lost due to the construction of power station. There are no ethnic minorities living on site grounds.	The destitute, poor and landless farmers can become further distressed when job opportunities or at least skill training opportunities for them are not secured. There are no ethnic minorities living on site grounds.
4	Misdistribution of Benefit and Loss	In case an ample number of job opportunities and skill training opportunities are not provided to meet the demand, the disparity between those with such opportunities and those without and that between the land owners and the rest (landless farmers, wage laborers etc.) can be widened.	Landless farmers and wage laborers can become further distressed and the disparity between the land owners and them can be widened if job opportunities and skill training opportunities are not given to them. Local livelihoods can be affected and health hazards can be caused by land subsidence, smoke exhaustion, noise pollution, water pollution and water shortage in case the environmental management plan is not appropriately planned and implemented.
5	Local Conflict of Interests	Local conflict can occur between the relocated people and the host community if there is a relocation required. Excessive interventions by various stakeholders can trigger local conflict among residents, and disruption of the local community.	Local conflict between the relocated people and the host community can continue during operation period also.
6	Gender	Appropriate information and knowledge may not be properly disseminated to the illiterate, particularly women. Gender gaps can occur in job opportunities.	Appropriate information and knowledge may not be properly disseminated to the illiterate, particularly women.

No	Item	Impact during Construction Stage	Impact during Operation Stage
7	Children's Rights	Child labor may occur due to their parents' loss of job. Children may lose education opportunities, and playgrounds for them may be lost. They may catch infectious diseases triggered by outsiders' entry into the community.	Child labor may occur due to their parents' loss of job. Children may lose education opportunities. They may catch infectious diseases triggered by outsiders' entry into the community and exhaustion of NO_x, SO_x.
8	Land Use and Utilization of Local Resources	Temporary loss of present land use pattern and/or economic infrastructure may occur.	Permanent loss of present land use pattern and/or economic infrastructure may occur.
9	Social Institutions such as Social Infrastructure and Local Decision Making Institutions	Disruption of local community can be caused via a conflict of interests among politicians, government offices, and residents. It might cause a delay in procedures of land acquisition and resettlement.	-
10	Existing Social Infrastructure	Temporary loss of existing social infrastructure can occur due to the construction works.	Traffic to/from power station may become heavier. Social services may become insufficient.
11	Cultural Heritage	There is no cultural heritage existing in the three sites.	-
12	Infectious Diseases such as HIV/AIDS	Infectious diseases may be spread via the construction workers into the community.	Infectious diseases may be spread via the operation workers into the community.

Source: PSMP Study Team

- Specific issues to each site
  Taking specific features of each site into consideration, there are critical issues that need to be paid high attention for mitigation measures.

(1) B-K-D-P Site

- 200 acres of land acquisition is anticipated that requires resettlement of population of approximately 1,250 households. Local residents and local government officers of B-K-D-P site are well aware of the incidences and social impacts caused by the operation of the Barapukuria Coal Mine and Power Plant. They are also aware of the social protest against the coal mine development in Phulbari. High attention should be paid to their genuine feeling toward not-well-planned development projects.
- Ground subsidence, noise and vibration, and air pollution may occur in case the domestic coal mine, which is to be established prior to the power plant, is not properly designed. Adverse impacts on lives of local residents can be immense in that case, which will lead to negative feeling toward the power plant development and its operation.
- Excessive interventions by various stakeholders and political people can trigger disruption of the local community and local residents can be influenced.
- The site is well known for its affluent rice production by farmers, who are the majority of its population. The local economy is poor and the adverse impact, on socially vulnerable people, caused by the loss of lands and cropping land can be immense. Equal distribution of benefits among the residents will therefore be essential.
- The present potential site is away from the city center, residential areas, local markets and protected forests. Land use and utilization of local resources, however, may be affected by the selected location and transmission line route.

(2) Chittagong Site

- Acquisition of government land and private land is anticipated with small-scale involuntary resettlement. Entry of illegal squatters should be prevented until the construction is complete.
- The present potential site, that has been selected, is away from the city center, residential area, local market and the protected forest.
- Warm effluent water, plant effluent and sewage according to plant operations and domestic effluent water can adversely affect local fishery industry and their livelihoods, in case they are not properly treated.

(3) Meghnaghat Site

- Involuntary resettlement due to the land acquisition can occur. The potential site is however located in the sandbank of Meghna River, which can minimize the number of directly affected people.
- Waste water from construction work, plant effluent and sewage according to plant operations and domestic effluent water can adversely affect local fishery industry and their livelihoods, in case they are not properly treated.

18.3 Local consultation

18.3.1 First meetings with local stakeholders

Household interviews and focus group discussions (FGD) targeting local residents and in-depth interview (IDI) with the Upazila local officers were conducted at B-K-D-P site, Chittagong site and Meghnaghat site in order to acquire snapshots of life quality there. As the study team saw severe time constraints and the fact-finding and collection of local information was the primary objective of this first consultation, the local consultants commissioned by PSMP Study Team organized the meetings.

(1) Local consultation at B-K-D-P site

(a) Overview

The following table shows facts of interviews with fifteen male and female local residents, focus group discussions with male group and female group and in-depth interviews with local officers in Nawabganj Upazila. Further details of participants are referred to in the APPENDIX to this chapter.

Table 18-3 Facts of first local consultations (B-K-D-P Site)

Mode of Consultation		Number of Interviewees	Date	Venue
Household Interview				
	Male interviewees	7	4-7 Jan 2010	Rahimapur and Nandanpur Villages under Nawabganj Upazilla
	Female interviewees	8	4-7 Jan 2010	
Focus Group Discussion				
	Male Group	12	4 Jan 2010	Rahimapur village, Nawabganj Upazila
	Female Group	8	5 Jan 2010	Nandanpur Village, Nawabganj Upazila
In-Depth Interview				
	Upazila Nirbahi Officer	1	6 Jan 2010	Nawabganj Upazila Nirbahi Office
	Upazila Nirbahi Officer	1	7 Jan 2010	Phulbari Upazila Nirbahi Office
	Agriculture Officer	1	4 Jan 2010	Office of Agriculture Officer, Nawabganj
	Fisheries Officer	1	4 Jan 2010	Office of Fisheries Officer, Nawabganj
	Education Officer	1	5 Jan 2010	Office of Education Officer, Nawabganj

Source: Household interview, focus group discussions and in-depth interviews

(b) Discussion points

- Expectations for New Power Plant Construction (Electrification)
  The proposed site and surrounding areas are electrified, but the power supply does not yet meet the demands. Only half of the areas of male FGD participants have been electrified, and the other half could not be electrified although they are ready to pay for the connection. Female FGD participants believe that electricity is absolutely essential for the better education of their children and development of agriculture and industries. They urged local public representatives to take necessary actions for electrification, but no subsequent actions were taken. All of them appreciated the initiative for establishing a new power plant at the proposed site as the electricity shortage could be overcome by its construction.

- Concerns for New Power Plant Construction
  Participants are well conversant with the existing ground subsidence, cracking of houses and crop damages etc. in the villages adjoining Barapukuria, caused by the coal-fired power plant and the coal mine. They are afraid that similar adverse environmental impacts might occur, although they are interested in a new power plant in their area.

  The participants emphasized on appropriate mitigation measures for the environmental and social impacts if the new power plant is constructed at the proposed site. They also strongly recommended that the affected people be properly compensated. They feel that housing damage due to ground subsidence is a terrible social loss and think that the local authority should be careful in this regard and the affected landowners must be properly compensated.

  Local officers interviewed were all well aware that people nearby the coal-fired power plant and coal mine in Barapukuria are suffering from noise pollution, ground subsidence, cracks in houses, and damage to the paddy fields which have been drowned by water. They mentioned that the local people in Barapukuria believe they had been attacked with asthma, diarrhea, etc. because of the flying ashes from the power plant although no statistical health data was available to buttress such a claim. For this reason, the local people were against the extraction of coal from the upcoming Phulbari coal mine as they knew the entire Phulbari town had to be resettled. As it is the local government who should take initiatives in land acquisition and resettlement, they suggested the construction period should be shortened to minimize affects to the local people and that all affected people must be properly compensated.

Source: PSMP Study Team

Fig. 18-5 Local consultations in B-K-D-P Site

(2) Local consultation at Chittagong site

(a) Overview

Fifteen local residents were interviewed in Anwara Upazila, which is a neighboring Upazila to Banskhali. Focus group discussions (FGD) and an in-depth interview (IDI) with local officers were also conducted. Facts on each consultation are described below. Further details of participants are referred to in the APPENDIX to this chapter.

Table 18-4 Facts of first local consultations (Anwara)

Mode of Consultation	Number of Interviewees	Date	Venue
Household Interview			
Male interviewees	8	28-30 Dec 2009	Gobadia and Dudhkumra Villages, Anowara Upazila
Female interviewees	7	29-30 Dec 2009	
Focus Group Discussion			
Male Group	8	29 Dec 2009	Gobadia Village, Anowara Thana
Female Group	6	28 Dec 2009	Dudh Kumra Village, Anowara Thana
In-Depth Interview			
Upazila Nirbahi Officer	1	29 Dec 2009	Anowara Upazila Nirbahi Office
Fisheries Officer	1	28 Dec 2009	Office of Upazila Fisheries Officer, Anowara
Agriculture Officer	1	28 Dec 2009	Office of Upazila Agriculture Officer, Anowara
Educational Officer	1	28 Dec 2009	Office of Upazila Education Officer, Anowara
AC Land	1	28 Dec 2009	Office of AC Lands, Anowara
Public Health Engineering Officer	1	28 Dec 2009	Office of Upazila PHE Officer, Anowara

Source: Household interview, focus group discussions and in-depth interviews

(b) Local views on power plant development

- Expectations toward New Power Plant
  Although they have no idea what a power plant is like, male participants were very interested in the new power plant as they believe it would be useful for agriculture, industry, household and securing employment. Female participants also welcomed the idea as they thought local people would find employment while local electricity demands would be met resulting in the town's enhanced development.

  Local government officers extremely welcomed the idea of these lands being used for coal-fired power plant construction, as they thought electrification is essential for the national interest of the country, as economic and national development would be impossible without electric power. They said that the country's industries, offices, educational institutions and irrigation facilities will all come to standstill without electricity. They also pointed out that importing coal through waterways could save fuel cost.

Source: PSMP Study Team

Fig. 18-6 Local Consultations in Chittagong Site (Anwara)

- Low Knowledge on Power Plant
  Both male and female participants had no knowledge about the environmental effects caused by a coal-fired power plant and health hazards which these pollutions may ultimately cause. They suggested planting a lot of trees and neat and clean living, when asked how they should conserve the environment.

- Concerns for New Power Plant
  Local government officers opined that the environmental aspects should be put on an agenda by the Government and investment companies, when building a coal-fired power plant. A power plant can cause noise, smoke, waste, etc. and might bring various damages to crops, river water and human health. They said everything must be protected from such damage and standard guidelines must be followed. All participants opined that scientific methods should be used for environmental preservation. Besides, landowners must obtain proper compensation and should also have access to advantageous employment opportunities at the power plant.

(3) Local consultation at Meghnaghat site

(a) Overview

Fifteen local residents were interviewed regarding their livelihoods and accompanying life quality in Sonargaon Upazila. Focus group discussions (FGD) and an in-depth interview (IDI) with local officers were also conducted. Facts on each consultation are described below. Further details of participants are referred to in the APPENDIX to this chapter.

Table 18-5 Facts of First Local Consultations (Meghnaghat Site)

Meeting		Number of Interviewees	Date	Venue
Household Interview				
	Male interviewees	15	17-19 Dec 2009	Ganga Nagar Village and Islampur Village, Sonargaon Upazila
	Female Interviewees	-	-	
Focus Group Discussion				
	Male Group	6	18 Dec 2009	Islampur Village, Sonargaon Upazila
	Female Group	8	19 Dec 2009	Islampur Village, Sonargaon Upazila
In-Depth Interview				
	Upazilla Nirbahi Officer	1	17 Dec 2009	Sonargaon Upazila Nirbahi Office
	Social welfare Officer	1	20 Dec 2009	Office of Upazila Social Welfare Officer, Sonargaon
	Agriculture Officer	1	21 Dec 2009	Office of Upazila Agriculture Officer, Sonargaon
	Senior Fisheries Officer	1	22 Dec 2009	Office of Upazila Fisheries Officer, Sonargaon
	Education Officer	1	18 Dec 2009	Office of Upazila Education Officer, Sonargaon
	Chairman and Members of Sonargaon	2	19 Dec 2009	Office of Upazila Chairman, Sonargaon

Source: Household interview, focus group discussions and in-depth interviews

(b) Local views on power plant development

- Expectations toward New Power Plant

Participants did not believe that new power plants would cause any harm, such as smoke and noise to the environment, as the existing combined cycle power plant of 450MW did not create any such disturbances. Male participants thought that a new power plant would help in solving the scarcity of electricity. The combined cycle power plant nearby led to the employment of some people from surrounding villages and female participants, therefore, welcome the new initiative as their husbands or children may find jobs at the new power plant.

Most of local government officers opined that it would be better if a new power plant was constructed just beside the existing power plant. There are no specific diseases caused by the existing power plant, and they expect that the new power plant will also be a pollution-free one.

Source: PSMP Study Team

Fig. 18-7 Local consultation at Meghnaghat site

- Awareness toward Environmental Conservation
  Villagers is just aware that they should keep the surrounding area clean.

18.3.2 Second meetings with local stakeholders

In addition to the first local consultations conducted in December 2009 and January 2010 as described above, another round of local consultation was organized in October and November 2010, after the project design of power plants became more specific. It was the Power Division that organized the meeting and PSMP Study Team supported the same.

The venue for the meeting with B-K-D-P local stakeholders was Dhaka in consideration of the security situation in Dinajpur. For the meeting with Chittagong local stakeholders, the venue was also Dhaka for the same reason. Land acquisition was one of the crucial issues raised in the Chittagong program. The facts about local stakeholder meetings at each site are as described in the following table. Further details of participants are referred to in the APPENDIX to this chapter.

Table 18-6 Facts of second local consultations (all sites)

Date and Time	Venue	Participants		
		Local Stakeholders	GOB	PSMP Study Team
B-K-D-P Site				
11-30AM to 2PM, 14 November 2010	Power Division (Bidyut Bhaban), Ministry of Power Energy & Mineral Resources	9 males: (Union Chairman, Union staff, Professor, Imam (religious leader), farmers, merchants etc.)	2 males (Joint Chief and Assistant Chief)	7 (out of whom 6 are local consultants)
Chittagong Site				
11-30AM to 1-30PM, 7 November 2010	Power Division (Bidyut Bhaban), Ministry of Power Energy & Mineral Resources	10 males (Upazila Chairman, Upazila Nirbahi Office staff, Agriculture Officer, Forestry Officer, Principal, Union Chairman, villagers etc.)	4 males (Additional Secretary, Assistant Chief and task team members from EGCB and BPDB)	7 (out of whom 5 are local consultants)
Meghnaghat Site				
11-30AM to 1-30PM, 3 November 2010	Conference Room, Sonargaon Upazila Nirbahi Office	31 males (Assistant Commissioner [Land], Upazila Chairman, Statistical Officer, Union Vice Chairman, Fishery Officer, Credit Officer, teacher, Education Officer, Resettlement Officer, Imam [religious leader], villagers etc.)	3 males (Assistant Chief and task team members from EGCB and BPDB)	9 (out of whom 7 are local consultants)

Source: Minutes of local stakeholder meetings

(1) Main points of discussion at B-K-D-P local stakeholders' meeting

Power Division, who chaired the meeting, introduced the background of the MP Study, and explained that no more new gas fields are expected to be discovered and that the GOB was thinking of coal as fuel for power generation. He requested that the participants provide opinions without hesitation, which would be reflected into the study report, and to request others, who were unable to join the meeting, to extend their cooperation. Power Division also stressed that the MP Study has been developed for the benefit of the entire nation.

(a) Environmental Issues

Participants asked questions regarding ash treatment and the PSMP Study Team replied that there are many precedents in recycling of fly ash and landfilling by bottom ash in Japan.

(b) Social Issues

Participants mentioned that the situation in Phulbari was still not good. It must be fully explained to the local people about the necessity of developing another coal-fired power plant there. It should also be explained that there will not be other health hazards, such as those the local people faced in Barapukuria. The payment process of compensation would be easy and simplified and payment will be made to the right people. Job opportunities would be created for those who are to be involuntarily relocated.

The Chairman of Daudpur Union mentioned that he would welcome establishment of the coal-fired power plant in Bhagabanpur, which is almost at the center of the surrounding coal deposits and close to Barapukuria, Phulbari, Dighipara and Khalaspir coal fields and also Madhypara Hard Rock Mine. He said that his people would not object to the project if Bhagabanpur was selected as the site and they would extend their cooperation.

Participants welcomed the opportunity to attend the local stakeholder meeting in Dhaka.

Source: PSMP Study Team

Fig. 18-8 Second local consultation with B-K-D-P local stakeholders

(2) Main points of discussion at Chittagong local stakeholders' meeting

Power Division chaired the meeting. A visual presentation was made by the local consultant: EAL. It was the Additional Secretary who answered most of the questions raised by the participants.

(a) Environmental Issues

Participants proposed that construction of the embankment against Cyclones is desirable before the power plant. Participants also said that warm draining water will be cooled naturally if it remains in a pond for a certain period of time. The Power Division replied that he welcomed the proposal and he wanted understanding that there was the possibility of inevitable air pollution.

Source: PSMP Study Team

Fig. 18-9 Second local consultation with Chittagong local stakeholders

(b) Social Issues

The participants welcomed the initiative of power plant construction, since there was no other major industry in Banshkhali Upazila. They requested that certain benefits be given to the local people such as construction of school and hospital. They mentioned that there are people residing in the proposed site (both government land and private land). The Power Division mentioned that proactive efforts should be to ensure that the local people are gainfully employed. To this end, the livelihood recovery will be considered and examined at the implementation stage of the project.

(3) Main points of discussion at Meghnaghat local stakeholders' meeting

The meeting was presided over by the AC Land of Sonargaon Upazilla. BPDB, one of the task team members, made visual presentation. The GOB representative answered to all the questions raised by the participants.

(a) Environmental Issues

Participants pointed out the warm effluent's impact to river fish and the possibility of spontaneous ignition at the coal stock pile. In response, the BPDB replied that proper environmental protection measures such as cooling tower usage or coal stockpile sprinkling could solve these problems.


Source: PSMP Study Team

Fig. 18-10 Second local consultation with Meghnaghat local stakeholders

(b) Social Issues

Participants requested that acquired land should be used correctly, the officers in charge of redress of grievances should be identified, the land price should be evaluated correctly and job opportunities should be created for the local people. They mentioned that local people lost their jobs when the gas turbine combined cycle power plant acquired their private land and no proper compensation was paid.

Participants did not deny the necessity of developing power generation facilities, but they stressed that land to be acquired should be at a minimum, proper compensation should be paid, and there should be no in-between broker. They also requested establishment of schools to improve the education level of the local people.

GOB representative explained that recommendations, such as organizing a committee for transparency, providing positions of non-technical staff at the new power plant for the local people, acquiring a minimum amount of land and contributing to local benefits via power plant construction, would be incorporated into the Master Plan Study Report.

18.4 Problem solution for the new coal power plant construction and operation

Measures have been examined for solving likely specific items of critical problems raised above, based on the primary and secondary data collection and analysis and the outcome of local consultations.

18.4.1 Examination for problem solution: environmental pollution and natural environment

(1) Common issues

Table 18-7 shows the possible solutions commonly identified for all three sites during construction and operation.

Table 18-7 Mitigation measures for environmental impact (all sites)

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
1	Air pollution	As for the reduction of exhaust gas from transportation vehicles and construction machinery, idling stops and keeping proper exhaust condition by routine inspection of vehicles are to be applied. As for countermeasures for dust scattering, load cover, periodical vehicle washing and periodic peripheral road cleaning are to be applied.	Conducting flue gas treatment by system including FGD, SCR, Electrostatic precipitator (ESP) etc., attention will be paid to mitigation of coal dust scattering. It is desirable to apply covered conveyer to prevent coal dust with coal transfer.
2	Water contamination	Countermeasure for water contamination due to excavation waste soil outflow is suitable via a fence installation utilizing sandbags etc. As for the effluent due to equipment washing, it is suitable to install a temporary precipitation tank and to drain the supernatant water. As for sewage, it is suitable to put up septic tanks. In addition, as for waste, water contamination can be prevented if waste treatment is conducted promptly and the waste is not left for long time.	There will be no warm effluent water generation since cooling tower or air cooled condenser will be adopted as cooling system. Plant effluent and sewage according to plant operations will be discharged after waste water treatment, including coagulating sedimentation, neutralization and oil separation. Appropriate capacity design for waste water treatment is needed, especially if air cooling tower is adopted as condensed cooling water blow a large amount of effluent.
3	Soil pollution	Periodic maintenance of transportation vehicles and construction machinery and conducting pre-operational machinery checks are judged important.	Oil and grease treatment procedures are important to prevent the spillage of lubrication oil or fuel oil. In addition, management organization has to be established to implement works according to designated procedures. And action procedures should be prepared in order to not to spread the adverse impact in case of an oil spillage occurrence. An oil dike has to be set around oil storage tanks. It is necessary to dump ash only in dumping sites with water proof seal to prevent bottom sediment leakage out of the ash pond.
4	Noise and vibration	Streamlining the construction process, using low-noise machinery and lowering vehicle speed in residential areas are judged to be proper countermeasures. As for countermeasures for noise due to steam blowing during commissioning, the establishment of a work schedule, not to blow steam during the night time is judged to be applied.	Developing a green belt along the site border is a lowcost and effective way to mitigate noise and vibrational impact. To avoid noise and vibration due to coal transportation, use of covered conveyor is desirable. If the boundary noise simulated in the detail EIA exceeds the noise regulations which is decided on each category, introduction of a green belt, sound insulating material and a sound insulating wall will be examined.
5	Offensive odor	Offensive odor caused by domestic waste decomposition from workers camps can be prevented by separate collection and periodic disposal of waste.	NOx mitigation without SCR which uses ammonia is effective measure against offensive odor. When using ammonia, storage tanks, pipes, and valves must be inspected periodically. In addition to preventing operational mishaps, operation of ammonia facilities are to be managed by the person in charge. With regards to garbage treatment, it is suitable to dump it periodically and not have it in storage for a long time.

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
6	Waste	Reduction of waste amount can be conducted by establishing a waste management program including reduction, reuse and recycling (3R). Introduction of a separate procedure for collection of waste, especially for paint sludge and batteries will be required. These items should be collected separately and disposed of only in designated areas.	Reduction of waste amount can be conducted by establishing a waste management program including reduction, reuse, and recycling (3R). Because amount of by-products due to plant operations are large, they should be recycled as much as possible (AP Table 18-77 shows examples of by-products recycling). A separate collection of industrial waste should be thoroughly conducted. Especially paint sludge and batteries should be suitably collected separately and disposed of in designated areas, since they have potentially large impact on the environment. Domestic waste from the workers camp must also be collected separately and garbage should be dumped immediately to prevent the source of odour and contaminated effluent.
7	Biota and Ecosystem	Nest building by endangered species should be examined in detail EIA. Nest relocation should be conducted if there are any. Careful attention should be paid to existence of each endangered species during construction stage and necessary protective action should be conducted, if there are any.	Careful attention should be paid to each existing endangered species during operation stage and necessary protective action should be conducted, if there are any.
8	Accidents	A suitable OHS organization (policy, manual, announcement of policy, safety training and safety patrol) should be established to prevent accidents. It is also important to conduct quality control in construction work to prevent accidents during commissioning and operation period.	A suitable OHS organization (policy, manual, announcement of the policy and manuals, safety training, safety patrols) should be established for accident prevention. It is also important to conduct quality control in maintenance work in order to prevent accidents.
9	Global warming	-	Due to introduction of an ultra-super critical boiler with high efficiency unit, emission of CO_2 will be reduced by 1.07 million tons to 1.15 million tons for each 600MW unit per year compared to the case of Barapukuria class unit. These figures are calculated based on designed values. It is important to keep designed output and efficiency from adequate O&M.

Source： PSMP Study Team

(2) Specific issues to each site

Taking specific features of each site into consideration, possible problem solutions for critical issues are as the following:

(1) B-K-D-P Site

- It is desirable to apply covered conveyer for long distance land transportation of domestic coal to prevent air pollution and noise.
- Air cooled condenser or cooling tower will be adopted as cooling system. Underground water drawdown for power plant operation should be prevented by

using river water even by adopting cooling tower. At the time of pilot mining, mitigation measures for ground water drawdown should be confirmed by reinjection of drainage,

- In order to avoid protected forests, attention should be paid to selection of site location and transmission line route.
- It is desirable to conduct proper environmental control in domestic coal mine development. For environmental control, it is also desirable to apply EIA Guideline for Coal Mining issued by Department of Environment (DOE) in 2009.

(2) Chittagong Site

- Measures for water contamination described in Table 18-7 are to be implemented to prevent bottom sediment accumulation.
- The embankment against Cyclones may be constructed along plant border.

(3) Meghnaghat Site

- It is needed to be studied whether construction of wind break fence is necessary to prevent spreading of coal dust.
- Bottom Sediment: Same as Chittagong.

18.4.2 Examination for problem solution: socio-economic and cultural aspects

(1) Common issues

Possible mitigation measures against social impacts common for all sites, which may be caused by the proposed power plant are given in Table 18-8. In relation to environmental management, prevention measures for health hazards caused by the environmental impact are also referred here. Responsible agencies and monitoring agencies are also mentioned in the table, as clear definition and identification of responsible organizations can contribute to the smooth construction and operation of power plants.

Table 18-8 Mitigation measures for social impact (all sites)

Impact	Mitigation Measures	Responsible Agency	Monitoring Agency
Pre-Construction			
Occupational health hazards from dismantling of existing facilities and equipment	- Proper safety measures should be examined to raise awareness and take required actions - Safety education should be provided to all for proper knowledge and risk perception toward potential risks, which may be caused by the project	- Planning and Design Section of BPDB - Consultants	- Project Director (PD)
Land acquisition and involuntary resettlement[1]	- Proper Land Acquisition Plan (LAP) and Resettlement Action Plan (RAP) must be developed and examined prior to the construction - Prompt procedures for application and approval of site clearance certificate (SCC) followed by land acquisition. - Betterment of living condition, livelihood and job opportunity creation should be examined in LAP and RAP	- Planning and Design Section of BPDB - Consultants - Ministry of Land - DOE - Upazilla Nirbahi Office	- PD - BPDB - Consultants - Upazilla Nirbahi Office
Construction phase			
Unhygienic condition created at solid waste disposal site	- Use safe waste disposal techniques and land filling by waste may applied be	- Contractor	- PD - BPDB - Consultants
Deterioration of hygienic condition due to workers' careless behaviors	- Forewarn workers from roaming around - Proper health and sanitation facilities and education	- Contractor	- PD - BPDB - Consultants
Deterioration of local environment caused by wastes from construction works	- Safe disposal of construction wastes - Proper health and sanitation education for local people	- Contractor	- PD - BPDB - Consultants
Possibilities of accidental events during construction	- Place adequate warning signs and posts and training for people's awareness raising - Announcements to make communities understand the risks of accidental events (using microphones and loud speakers etc. for effective announcement) and training	- Contractor	- PD - BPDB - Consultants
Fire hazards	- Fire fighters and adequate equipment should be kept as stand-by and periodic drill	- Contractor	- PD - BPDB - Consultants

[1] The land prices are indicative only. The actual land prices may be estimated based on the actual requirement of land for the project. According to the Bangladesh regulation, displaced persons are entitled only to compensation for loss of land, property and standing crops in monetary terms at the rates fixed by GOB. According to JICA guidelines, compensation for losses must be based on the amount that require for re-purchase.

Impact	Mitigation Measures	Responsible Agency	Monitoring Agency
Possibilities of accidents from hazardous materials and non-use of personal protective equipment (PPE)	- Make the workers aware of the hazardous materials and proper handling methods - Set-up warning signs, labels and signals - Provide helmets, safety shoes and other PPE for workers in accordance with accident prevention and work safety procedures and make them use these	- Contractor	- PD - BPDB - Consultants
Post-construction/ Operation phase			
Degradation of air quality	- Gaseous pollutant emission control measures should be adopted to reduce air pollution - Periodic measurement of air quality - Air quality information should be properly delivered to the local community	- Plant Owner	- PD - BPDB - Consultant - Department of Environment (DOE)
Deterioration of water quality	- Proper wastewater treatment measures should be ensured to reduce adverse effects on river water quality - Water quality information should be properly delivered to the local community	- Plant Owner	- PD - BPDB - Consultant - DOE
Increase of Sound/ Noise	- Efficient sound control system should be ensured to reduce noise levels at the power plant site - The progress of sound control should be well informed to the local community	- Plant Owner	- PD - BPDB - Consultant - DOE
Pilferage	- Proper security measures and monitoring - Patrol for prevention of security deterioration	- Plant Owner	- BPDB

Source: PSMP Study Team

In addition to the issues raised in the above table, there are some other social components to be considered for the benefit of the local people as given in Table 18-9.

Table 18-9 Measures for improvement of local situation (all sites)

Social Components likely to be Impacted	Areas for Improvement	Mitigation Measures / Enhancement
Information, Education and Communication	- Low education - Limited access to information due to low literacy rate - Female low literacy	- Awareness program for raising proper knowledge on power plant construction - Visual aids (posters, leaflets, fliers with pictures and signs) are to be developed to deliver proper information - A team comprised of communication officer, rural development officer and engineer should be organized to prepare and implement action plans for local livelihood development
Health and Living Condition	- Poor housing conditions - Poor sanitary conditions	- Proper Land Acquisition Plan (LAP) and Resettlement Action Plan (RAP) must be examined and prepared prior to the construction - Betterment of living condition and livelihood, and job opportunity creation should be examined in LAP/RAP - Awareness program for improving health and sanitation condition should be implemented
Employment	- Increasing unemployment - Limited job opportunities - Low skill	- Skill development should be examined in RAP - Local people should be affirmatively employed in the power plant
Income Level	- Lower income than rural average	- Advanced agricultural methods can be introduced to further income generation - Ensure stable power supply to local offices, factories and irrigation facilities for effective work which helps increase local income

Source: PSMP Study Team

(2) Specific issues to each site

Taking specific features of each site into consideration, possible problem solutions for critical issues are as following:

(1) B-K-D-P Site

- There can remain particular residents who are too cautious and skeptical toward development projects. Communication tools should be well designed to prevent them from being misguided. The tools should be informative even for the illiterate to deliver proper knowledge on environmental mitigation measures.
- Amusement facilities open to the local residents can be allocated along with the power plant construction. Equal distribution of benefits to the local community should be well designed. Information on the new power plant should be kept open to the public, keep transparent and accountable not to cause any doubts.
- As the local awareness on diseases and their prevention measures is low, detailed program for improving health and sanitation condition should be carefully designed. Contribution to securing safe and sufficient water supply can be considered through providing safe wells.

(2) Chittagong Site

- There seems to be no prior knowledge on power plant among local residents. Awareness raising program should be developed very carefully in order to convey proper knowledge and acquire good understandings from them.

- Currently people in Anwara Upazila (next Upazila to the site) suffer from diseases which are likely caused by the nearby fertilizer factories. Detailed program for improving health and sanitation conditions should be carefully designed to create awareness of local residents and their behavior change.

(3) Meghnaghat Site

- Local residents are too optimistic toward power plant construction without knowing difference between combined cycle and coal-fired power plants. The possible environmental impacts and potential risks such as health hazards likely to be caused by the coal-fired power plant must be fully addressed and environmental mitigation measures be fully explained. As the local residents are not advanced in terms of education opportunities, the communication tools should be well designed even for the illiterate.
- Taking good practices and lessons learnt from CSR activities conducted by the combined cycle power plant into consideration, the new power plant should keep itself transparent and accountable to the local community.

18.5 Study items with high priority in future F/S

18.5.1 Environmental management and consideration

(1) Common issues among three sites

(a) Construction stage

- Noise and Vibration
  Streamlining of the construction process, usage of low-noise machinery, and lower vehicle speed in residential areas are the measures to be taken.

- Accident
  Establish suitable OHS organization (policy, manual, announcement of policy, safety training and safety patrol), and conduct quality control of construction work.

(b) Operation stage

- Air pollution
  <u>Measures for SOx emission</u>
  The Environmental Conservation Rules of Bangladesh stipulates the stack height according to the generation capacity, as the SOx emission regulation. It stipulates 275m of stack height above the 500MW class thermal power plant. However SOx emissions concentration can be reduced by FGD and it is not always necessary to use a very high stack. It is recommended that Bangladesh formulate regulations governing SOx emissions for both the effective stack height and the total amount of SOx emissions.

  <u>Measures for NOx emission</u>
  The reduction over-rich-air ratio, low NO_X burner, two-stage combustion, and flue gas recirculation have been adopted in many large-scale boilers as a combustion improvement technology. There are many precedents of the use of SCR as denitrification equipment for power plan boilers. However, NOx concentration can be reduced to around 300mg/Nm3 without SCR which uses ammonia. Mitigation measures for NOx emission should be decided when considering the risk and cost of handling ammonia.

  <u>Measures for soot emissions</u>
  A low temperature ESP or a low-low temperature ESP is suitable for the mitigation of soot emissions during the operation stage. The high temperature ESP has been designed at

around 350 °C of the gas temperature (upstream of the air heater), low temperature ESP is designed at around 140 °C of the gas temperature (downstream of air heater), and the low-low temperature ESP is designed at around 80 °C of the gas temperature (intermediate of each gas-gas heater of the limestone gypsum FGD). The selection of the flue gas treatment system is carefully conducted for the whole system, including desulfurization and denitrification. AP Fig.18-14 shows an example of the flue gas treatment system. Further, the evaluation items for flue gas treatment system selection may be found in AP Table 18-71.

Measures for coal dust

The adoption of sprinkler equipment is effective for coal dust scattering. To reduce water usage and prevent water contamination, it is necessary that the effluent form coal storage yard be collected and reused after sedimentation.

- Water contamination

  Equip the plant with waste water treatment facilities (coagulating sedimentation, neutralization, and oil separation).

- Noise and Vibration

  Develop green belt along the site border.

- Waste

  Establish waste management program (reduction, reuse and recycling: 3R)

(2) Specific issues at B-K-D-P

- Air pollution

  If the Sulphur content of coal is under 0.4%, it is possible to achieve world environmental standards with a planned stack height of 275m as stipulated in the Environmental Conservation Rules of Bangladesh for coal-fired power plants exceeding 500MW. Further, it is possible to reduce the stack height to around 140m[1] with an FGD installation.

- Ground subsidence, Water usage

  Ground water pumping won't be conducted in order to prevent subsidence and impact to water usage. If cooling tower make up water cannot be supplied from river in detail EIA, air cooled condenser is planned to be installed. There are precedents of installing air cooled condenser to 600MW class thermal power plants. AP Table 18-78 shows example of air cooled condenser precedents to 600MW class thermal power plants in China. Study of possibility for recycling discharged water from coal mine to plant service water is recommended.

- Environmental consideration in domestic coal development

  Furthermore, environmental and social considerations for domestic coal mine development which precedes power plant construction is indicated in EIA Guideline for Coal Mining. AP Table 18-79 shows the environmental consideration for mine development. Reinjection of the prior drainage of the aquifer is recommended to be examined, as a countermeasure for ground subsidence via ground water pumping.

[1] Local stakeholder's requirement

(3) Specific issues at Chittagong and Meghnaghat

- Air pollution

  Chittagong site is located 12 km away from Chittagong Airport. Even if it is outside the height regulation area from the airport, it is not suitable for high structure construction from the perspective of aviation security. The Meghnaghat site is located near Dhaka and it is not suitable either to construct a very high structure in view of aviation security (see AP Fig.18-13). A detailed confirmation of the EIA is required because the stack height can be reduced to around 140m[1] via FGD installation.

  However, the sulfur content of the imported coal is estimated to be quite high. It is necessary to set both the FGD and 275m height stack which is stipulated in the ECR. If a low height stack is used, the performance of the FGD should be at its highest and a higher gas temperature and a faster gas flow rate at a stack outlet is needed. The best solution should be examined in the detailed EIA in consideration of cost and efficiency.

- Water contamination, Ground subsidence, Water usage

  In order to prevent adverse impact on local fishery, ground subsidence and underground water level decrease, cooling tower is needed to be adopted as a cooling system, while makeup water will be supplied from rivers. Further, the cooling water effluent needs to be discharged after proper waste water treatment (coagulating sedimentation, neutralization and oil separation).

- Coal dust

  Mitigation of coal dust impact during the operation stage is important in the Meghnaghat site which is next to the combined cycle power plant. The application of a windbreak fence is desirable to be examined in the EIA in detail, even if the installation cost is large.

18.5.2 Social consideration

- Environmental mitigation and prevention measures should be thoroughly taken up and reflected in the project design, which will also lead to mitigation of social impacts

  Land acquisition and involuntary resettlement will be the only major social issues that cannot be avoided even in case environmental consideration is properly reflected into the project design, i.e., mitigation facilities to prevent air pollution, noise, vibration, ground subsidence etc.

  In other words, it is recommended that the Government of Bangladesh fully recognizes the importance of installing such environmental protection measures, in order to mitigate (or reduce) the degree of social adverse impact caused by the power plant construction and operation.

  It is also recommended that such prudent actions be legalized as the responsibility of the project proponents to synchronize the national environmental arrangements with international ones.

- Appropriate actions should be taken for land acquisition and involuntary resettlement in a timely manner

  Proper LAP/RAP must be fully examined and prepared prior to start of construction work. Upon issuance of the SCC, after careful consideration on the site selection, it is strongly recommended that the Project Owner work intensively on the application procedure of

[1] Local stakeholder's requirement

land acquisition along with the implementation of EIA followed by ECC issuance and approval of development project proposal (DPP). It will help to minimize time until the operation of the power plant starts.

- Resettlement action plan (RAP) should be thoroughly examined and elaborated from mid-term and long-term perspective.

  Legislation on resettlement has not been promulgated in Bangladesh as of November 2010. Donors' guidelines on environmental and social safeguards are, instead, applied when the GOB receive finance provided by them.

  Not only additional land acquisition for people's relocation and construction of their houses, it is essential that education on hygiene, sanitation, and environment, measures for betterment of livelihoods and living environment and skill training program should be incorporated in the RAP for the benefit of the affected people. Since these will involve additional cost, these should be incorporated in the DPP also. Job opportunities should be affirmatively offered for the affected people at the newly constructed power plant. It not only helps them generate their income but increase their understanding toward the power plant operation.

- Awareness raising and knowledge sharing is the key element for proper risk communication

  Incidences occurring in Barapukuria have been well known at national level in Bangladesh. People of local communities in Barapukuria and Phulbari may have strong skepticism toward coal-fired power plant construction and coal mine development and protests against such development activities might be faced.

  It is recommended to spend time and budget for information sharing on new power plant construction and local consultations in order to achieve understanding from the local people. Environmental protection measures should be examined, reflected into the project design and explained to the local people, which will help ease their feelings.

  Formal public consultations should be conducted in the EIA study in order to disclose detailed project activity and the potential impact and to obtain public opinions. Public consultations and disclosures should also be conducted during the construction phase to raise local awareness. Project information and impact should be disclosed to the public through all kinds of media: newspapers, announcements via microphones or loud speakers at the project site, posters, leaflets and cards with visual messages. Well-experienced environmental management specialist should work closely with social development specialist to develop the best tools that interpret complex technical issues into plain expression for the local people to understand well.

- Supports and collaboration from civil society organizations, local NGOs, government institutions and administrative bodies are essential.
  It is desirable that the opinions of NGOs such as BRAC, ASA, CCDB, CARITAS, UDP, TMSS and Pallibandhu Parishad should be collected in Barapukuria, BRAC, ASA, Grameen Bank and Proshika in Chittagong, and BRAC, ASA, Proshika, VARC and VOSD in Meghnaghat. These NGOs have profound local experiences in the areas and can contribute as facilitators to active dialogues with local people, and can promote an awareness-raising campaign together with the project owner. Their support is essential to implement the comprehensive RAP.
  **ITALICS part will increase cost.*
  Since the official procedures for land acquisition are handled mainly by the Deputy

Commissioner's Office, Upazila Nirbahi Office and Union Parishad Office, it is strongly recommended to work closely with these offices in order to promote further understandings in local community.

- It is recommended that the Project Owner creates an environmental and social unit and allocate experienced personnel
  The application for the approval of land acquisition can be submitted before having the approval of EIA (ECC) and the DPP. In order to avoid effects on the project implementation schedule, such approval process should be started as soon as the project site is finally identified. It is recommended that the Project Owner establishes a unit exclusively dealing with environmental and social safeguards to promote the procurement procedures for consultancy contract and other official procedures required according to the Bangladeshi legislations.

18.6 Environmental management plan, resettlement action plan and indigenous people plan

The Terms of reference (TOR) for the resettlement action plan has been drafted in the APPENDIX. The RAP will be elaborated on when the detailed EIA is formulated.

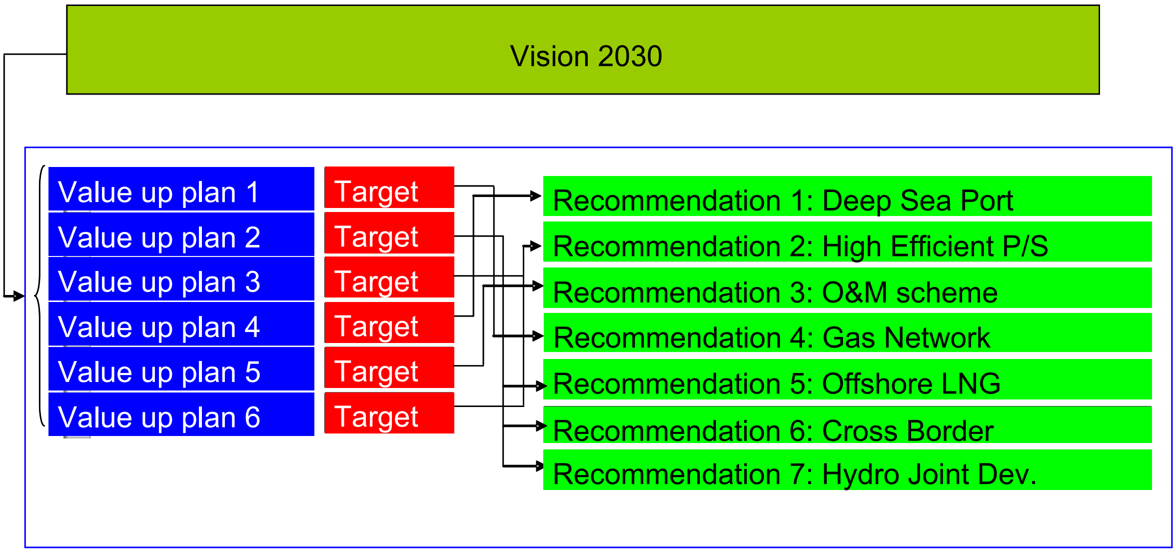
Environmental Management Plan has been drafted in the chapter 17.2 and the TOR for EIA has been drafted in the APPENDIX. Indigenous and ethnic people plan is not drafted in this Master Plan since there are no such people identified in the three most prioritized sites.

Volume 3 Recommendations for Future Support Measures

Chapter 19 Recommendations

In this chapter, the recommendations have been submitted based on knowledge acquired by investigation so far.

As mentioned in Chapter 2, this MP has developed the vision of the MP as the prioritized goal, and has set the value-up plans and targets in order to achieve the goal. The following describes the detailed recommendation to attain those targets. The following figure summarizes the target with the corresponding recommendations.

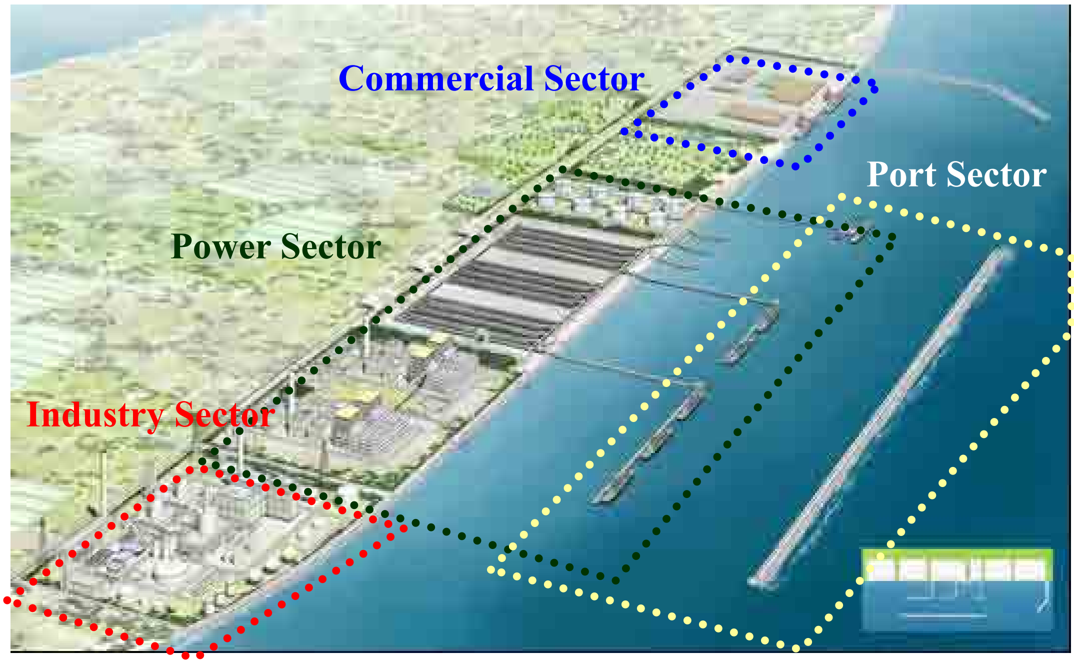


Source: PSMP Study Team

Fig. 19-1 Relationship between each target and recommendations

19.1 Study for basic design regarding deep sea port development (F/S, D/D)

In order to receive import coal ships, and for the industrial structural development of Bangladesh towards processed exportation and to export products, the necessity for a deep sea port continues to grow the economy. Because it needs a huge amount of investment for the development of deep seaports, it is difficult for the power sector to proceed alone. Hence, it should proceed with the coordination of other sectors such as commercial sector, industry sector and other financing from international organizations. The PSMP Study Team recommends a study for deep sea ports and the related conditions of import coal, oil, and gas.



Source: PSMP Study Team

Fig. 19-2 Image of deep sea port development by multi-sector in Matarbari

19.2 Study for the basic design of coal-fired power plant applied high efficiency generation technology (F/S, D/D)

In this study, from the optimum power generation plan and transmission network development plan which were formulated based on the results of the investigation in the 2nd year, after proceeding with the technical, economic, environmental and social analyses, to prioritize projects with high development possibility and create a short list with three sites and proceed to a rough technical study.

For the construction of a power station, based on the aforementioned technical study, the feasibility study (F/S), detailed design (D/D) reflecting the local characteristics is needed. The main study contents are; securing of ground, generation facilities, cooling water and fuel, transportation, capacity of fuel, treatment of coal ash, methods for the prevention of air pollution, methods of environmental conservation, the selection of the main equipment, water systems for the power station, coal handling facility, port infrastructure, ash treatment facility, heavy equipment and material during construction, packing for transportation, transportation restrictions, transportation methods for heavy equipment during maintenance etc.

Through application of the USC coal-fired power plant equipments, enhanced generation efficiency becomes possible and reduction of CO_2 emission is also realized in order to contribute to adaptation of climate change problems. Further, although coal-fired power plants generally emit more NOx, SOx and dust than gas-fired ones, emissions can be reduced drastically by applying state-of-the-art denitrification, desulphurization and dust collection facilities or technology. This also means that the construction of environmental-friendly coal-fired power plants can also be attained. As the next step, the PSMP Study Team recommends conducting a feasibility study based on the needs of Bangladesh and the donor.

Source: PSMP Study Team

Fig. 19-3 Bird-view plan of power plants (L: Domestic coal: Import coal)

19.3 Support project for the enhancement of O&M organization and human education in thermal power generation (Technical support)

Based on the results of investigations of existing gas-fired power plants, it became clear that a majority of the plants are incapable of reaching designated performance levels of capacity and efficiency. The main reason is that these inspections are more restorative than preventive which means most repairs take place after something breaks down.

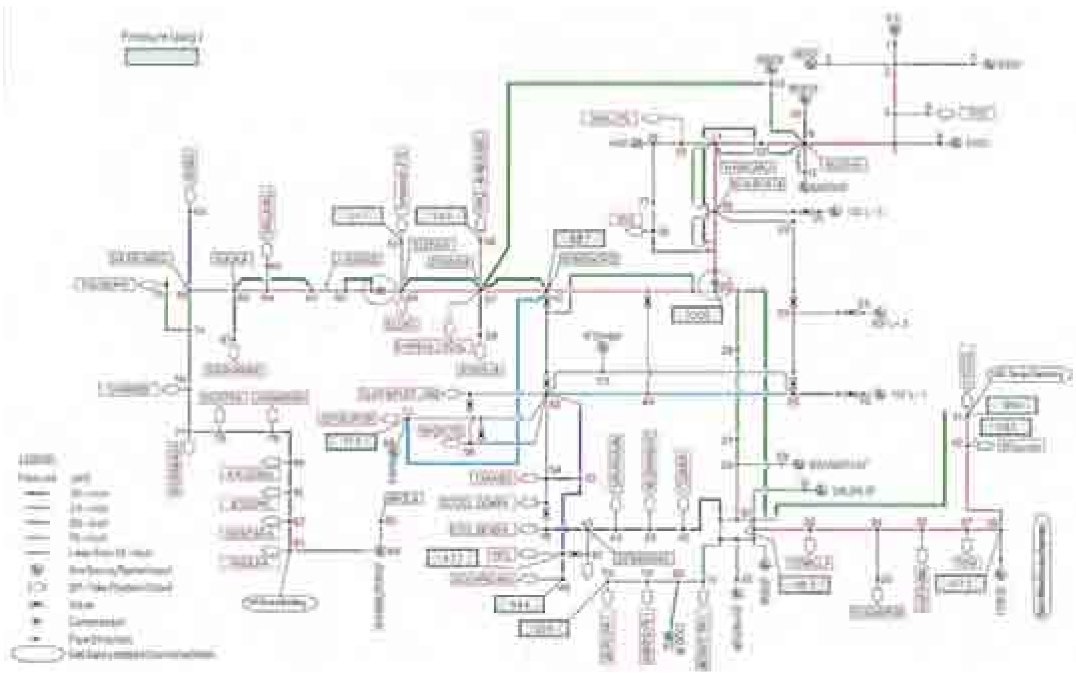
Since power demand will increase in the future, ensuring a stable power supply will require that generation facilities perform according to original specifications. In order to meet these requirements, it is important to change over to the concept of “take care before break down” instead of the current “repair after break down”. In other words, proceed with regular inspection regardless of whether something is broken or not such as (Time Based Maintenance (TBM))” or heeding to equipment predictors during monitoring (Condition Based Maintenance (CBM)”.

In order to taking root of TBM and CBM in Bangladesh, it is possible to teach by incorporating CP training into Japan to transfer maintenance know-how, etc. Moreover, one other effective means is to provide technical assistance in proceeding with the equipment diagnosis for individual plants which carries out aged deterioration together with the CP in order to judge the validity to proceed with rehabilitation.

19.4 Support project for enhancement of gas network (F/S, D/D)

The reason underlying the gas shortage in Bangladesh is the shortage of supply from the gas fields. In addition, the combined factor of the weakness of the existing gas pipeline does not make things better. On the other hand, in order to improve the gas network, a huge amount of investment is needed. It is difficult for Bangladesh given that support from international organizations like ADB is not sufficient.

One more purpose would be to make a promise to supply gas for Haripur P/S and Bheramara P/S for which Japan would provide financing, maintenance or upgrades for gas networks would be necessary in the future, the PSMP Study Team recommends in proceeding with the development study to secure gas supplies especially in the west side.



Source: PSMP Study Team

Fig. 19-4 Map of major gas network

19.5 Project for offshore re-gasification facilities (F/S)

Since natural gas demand is already larger than its supply, the introduction of LNG would be the practical option to fulfill this demand-supply gap. Establishing the LNG chain is essential for the introduction of LNG. The LNG receiving facilities must be constructed in Bangladesh. The constructions of proven onshore facilities require a great amount of cost and time. As the offshore gas receiving facility technique has developed and does not need so much cost and time, the offshore gas receiving facility has attracted attention. The PSMP Study Team recommends a study in order to stabilize the supply of LNG in the future.

Source: NIKKISO CO., LTD study data (2010)

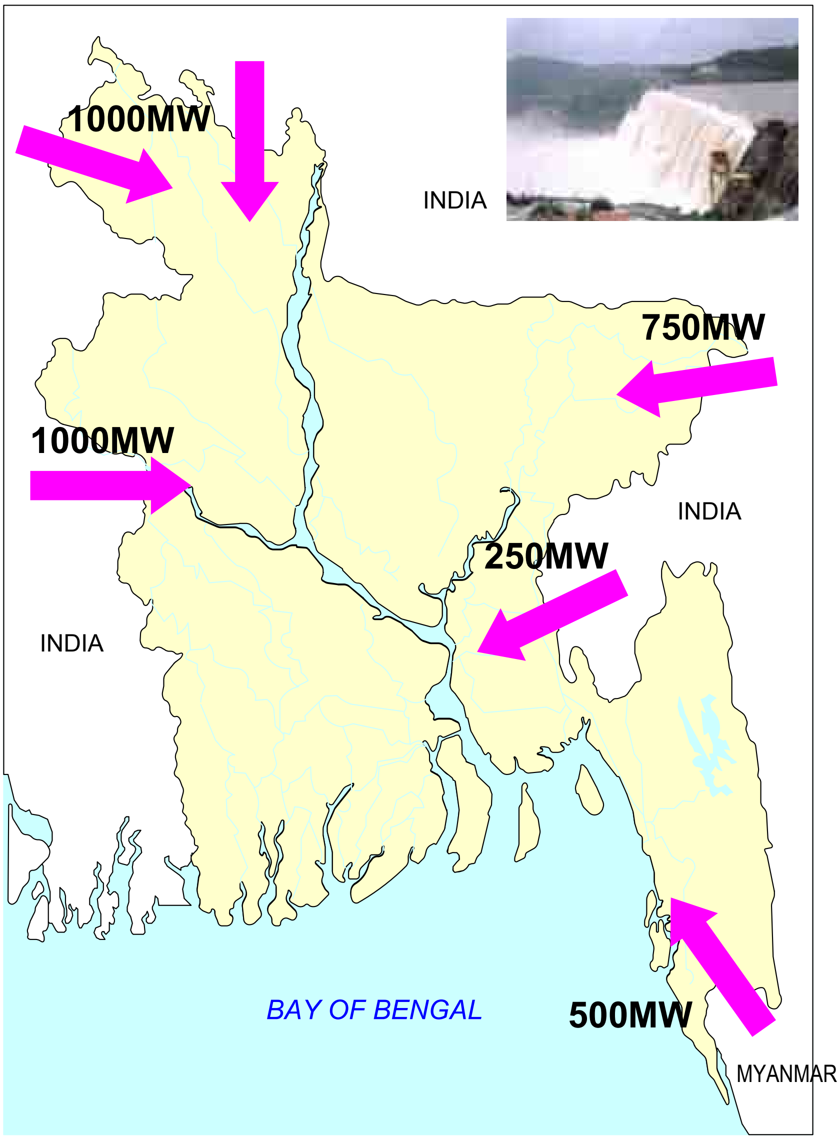
Fig. 19-5 Type of mooring（Left: Jetty type, right: Buoy type）

19.6 Technical support project towards the realization of cross border trading of electric power as a target (F/S)

The country surrounding Bangladesh, India, Nepal, and Bhutan possesses a vast potential of hydro power resource capability (assuming that potential hydro power is set in India at 148,700MW, Nepal at 44,000MW, and Bhutan at 30,000MW). It not only contributes to the development of these regions, but by using these abundant resources effectively within the countries in South Asia including Bangladesh, it also contributes to alleviating climate change via renewable energy conversion and large-scale CDM (Clean Development Mechanism) project development is also expected in the future. Moreover, hydro-power generation is excellent in load following capability since it is rich in frequency adjustment functions; there are various advantages for countries in South Asia to establish a firm electric power network in the future.

The South Asia broadband electric power network basic study is mainly implemented by USAID (SARI=South Asia Regional Initiative). Cross border trading has already been implemented between India and Bhutan and India and Nepal.

As for the possibility of cross border trading between India and Bangladesh, the cross border trading between the Bengal province in India and West Bangladesh is recommended by USAID in its basic study. In the short term, the power flow in Bangladesh is from east to west. Since power flow is mitigated by cross border trading, this cross border trading is efficient. But in the mid and long term, since power flow has changed from west to east, the cross border trading at East and North-east Bangladesh would became efficient. In addition, existing hydro-power resources are especially abundant in Bangladesh and in the border of the Eastern or North-east Indian area. Hence, for a certain period of time, this area will be targeted for development. The potential for cross boarder trading has been determined for the following reasons; a good supply-demand balance when surplus hydro power is off-peak during the rainy season is expected to be supplied to Bangladesh where there are power shortages. On the contrary, during the dry season, the electricity from Bangladesh to India and electric power accommodation is based on the time difference between both countries as well as holiday differences etcetera. Since the reinforcement of the power system in India is required, in order to proceed with electric power trading, it should be determined whether or not there is any interest between the countries, in alignment with expectations that these activities will be conducted by an international organization. The PSMP Study Team recommends to conduct a developmental study in order to search for an efficient potential electric power trading scheme from the perspective of the power development plan and power system plan.



Source: PSMP Study Team

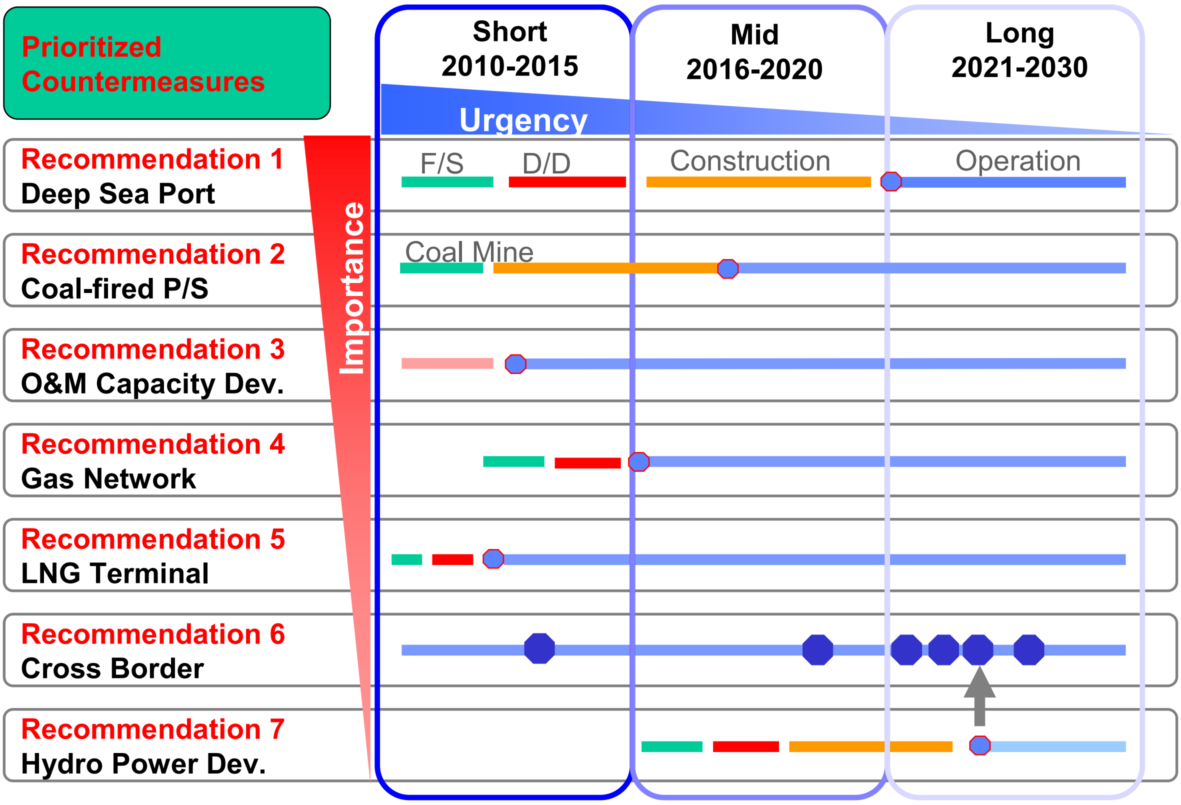
Fig. 19-6 Cross border trading of electric power plan

19.7 Support project for the joint development of a hydro power station with neighboring countries (F/S)

Although there is some possibility of an interconnected system between Bangladesh, Nepal or Bhutan, in order to realize such an interconnection that will have a network pass through India, there are some political difficulties that must be surmounted. It is clear that priority should be given to an interconnection system with India first. There is another possibility to develop not only an interconnection system but the joint development of the hydro power station in Assam State, Northeast India. On the stage of joint development, PSMP Study Team recommends proceeding with an investigation of the concerned technical, environmental and social, economic issues.

19.8 Priority of recommendations

The following figure shows the importance and urgency of recommendations.



Source: PSMP Study Team

Fig. 19-7 Priority of recommendations

In order to implement the development of coal-fired power stations which are the core of this Master Plan smoothly, it is essential to secure fuel supply, prioritizing the development of port facilities for import coal and the development of domestic coal mines. The PSMP Study Team recommends the Bangladesh government to implement some measures to strengthen the O&M ability of power companies so that the increasing newly developed power stations would keep them full performance for long time.

People's Republic of Bangladesh
Ministry of Power, Energy and Meneral Resources

THE STUDY FOR MASTER PLAN ON COAL POWER DEVELOPMENT IN THE PEOPLE'S REPUBLIC OF BANGLADESH

Power System Master Plan 2010 (PSMP2010)

FINAL REPORT

Appendix

February 2011

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company, Inc.

Volume 1 Power System Master Plan 2010

Volume 2 Technical Study for the construction of Coal-Fired Power Station

Volume 1 Power System Master Plan 2010, Figure and Table List

Volume 2 Technical Study for the construction of Coal-Fired Power Station, Figure and Table List

Chapter 4 Coal Sector APPENDIX

4.1 APPENDIX – 1 Brief summary of Coal Policy

(1) Introduction (Energy condition of Bangladesh)

About 73% of Bangladesh's commercial energy needs are met by natural gas. On the other hand, about 50% of this gas produced is used for power generation and 12% for the production of fertilizer. Further, approximately 90% of the country's power generation is presently dependent on gas. According to recent projections, the quantity of proven and probable remaining gas reserves till 2006 is 13.75 Tcf. If no new gas fields are discovered, according to demand, it is apparent that a shortage of gas will become a problem during the periods subsequent to the year 2011.

Apart from power generation, gas is the main ingredient of Urea fertilizer and CNG. Moreover, as a result of utilization of CNG in the transports, as a fuel alternative to imported oil, on the one hand, foreign currency is being saved and on the other, the number of CNG-driven vehicles is increasing fast, which is playing an important part in creating an environment free from pollution. If the GDP of the country becomes 7% or more, according to projections, at least an additional 26 Tcf gas will be required by the year 2025, which is equivalent to about 1,000 million tons of coal, according to heat value.

Under this situation, it is extremely necessary to preserve gas in order to supply it on a long term basis for fertilizer production, CNG, domestic fuel and for the existing power plants. Therefore, in order to ensure long term energy security in the country, the coal usage has to be gradually increased by limiting gas usage by the power and other sectors. It may be mentioned that, among the coal fields so far discovered in the country, since the depth of the other four fields is more than Jamalgonj field, the in-situ proven geological reserves in the four fields (Barapukuria, Khalashpir, Phulbari and Dighipara) is 1,168 million tons.

(2) Background and current status[1]

Power System Master Plan (Nexant) in 2006 states that if the GDP is 5.2%, 19,312 MW of power generation will be required and if the GDP is 8%, 41,899 MW of power generation will be required by 2025. In 2025 out of a total electricity generation of 41,899 MW, 32,837 MW will be generated with coal; for this purpose 75 million tons of coal will be required. 825 (= 450 +375) million tons will be required during 2005 and 2030 and 1,200 million tons will be required during 2005 and 2035.

On the other hand, the Gas Sector Minster Plan (Wood and Mackenzie) in 2006 states that natural gas can't supply enough energy if it is a high case of GDP. It will be necessary to initiate planning and construction of coal-based power plants on an urgent basis from now on, keeping in mind the country's energy security.

(a) Aims and objectives of the coal sector

The "Coal Policy" shall be guided by the Mine and Mineral Resources (Control and Development) Act-1992 and Mine and Mineral Resources Rules-1968 (revised up to date).

(b) Ensure energy security by development the coal sector[2]

- If it is possible to extract a maximum of 90% of coal from these mines with open mining method, about 1,050 million tons of coal may be available. According to Nexant projection, if required 75 million tons of coal in the year 2025 is considered as stable for

[1] In case of an 8% GDP, domestic coal supply will be over 30 million tons/year in 2019 and 75 million tons/year in 2025. These numbers are only attributable to power generation excluding other industries and coming from only four fields. If there are no new shallow coal fields, the achievement of this amount of domestic coal supply will be difficult because of technical and social hurdles needing to be surmounted.

[2] Present coal recovery ratio by O/C is over 90% in many cases in the world and almost mines start production from outcrop lines or sub-outcrop lines in shallow area. In deep area U/G is adopted because of no-economic method by O/C. In Bangladesh limited depth of O/C is not clear for economical mining, in case of the geological condition of Bangladesh

power generation and if no new coal-based power plant is established, it will be possible to generate electricity up to the year 2033 only from coal-based power plants.

- If it is possible to extract a maximum of 20% of coal with underground mining method, about 235 million tons of coal may be available. According to Nexant projection, with this amount of coal, only power can be generated up to 2022.
- It may be possible to extract 788 million tons of coal with open mining method from shallow coal fields. On the other hand, only 60 million tons coal may be available, if coal is extracted with underground mining method from medium deep (from 250 meters to 500 meters) coal fields. This means that a total of 848 million tons of coal may be available from the 4 mines. According to the projection of the same study, it will be possible to generate power up to 2030 with this coal (if no new coal-based power plant is established after the year 2025 and this estimate has been prepared considering 75 million tons to be used in the year 2025 as steady).

(3) Use of coal as commercial fuel for energy security

(a) Coal as commercial energy

Coal will be developed as an alternative commercial energy in order to reduce the growing demand on natural gas and reliance on imported fuel for power generation, other industrial and commercial uses.

Many countries in the world generate between 40% and 60% of electricity with coal. Considering this fact, after 2010 power generation in the country, have to be coal based, in the interest of enhancing the energy security. The domestic use of coal is to be encouraged to replace fuel wood and imported fuels such as kerosene and LPG.

(b) Coal sector master plan

Considering increasing demand of energy in the country and in order to ensure energy security in the country for 50 years, a Coal Sector Master Plan is to be prepared for development of this industry through Coal-Bangla (proposed)/BMD, according to use of coal in coal-based power plants and in other sectors. The Coal Sector Master Plan is to produce a long term coal sector development strategy with due clarity on the following:

(1) Roles of various parties (including GoB and institutions) to be involved in coal regulation, mining, financing, environmental and social protection,
(2) Profitability analysis of coal showing various cost to each party and the benefits,
(3) Nature of involvement of each,
(4) Country benefit including economic rent GoB can extract,
(5) Regional development in north-western Bangladesh that can take place,
(6) GoB investment needs.

The Energy Division is to initiate developing and implementing such a Master Plan keeping consistency with local demand of coal for power generation.

(c) Regulation of coal production

Considering the present recoverable coal resources of Bangladesh and fixing the target of energy requirement for the next 50 years, GSB has to be strengthened and modernized for boosting up its exploration, since coal discovery is a profitable sector. In order to achieve the target of rapid development of coal sector, the Bureau will issue Exploration Licenses and Mining Leases in such a way that coal production is consistent with energy demand projected in the Energy Policy.

(d) Other coal uses

Under the Coal Sector Master Plan, all kinds of coal use will be encouraged in all other sectors, apart from power sector

(1) Coal as an Alternative Fuel

(2) Small Scale Power Plants
(3) Coal Dust
(4) Support Services
(5) Steel and Re-rolling Mills
(6) Coal Gas.
(7) Coal to Liquid, Fuel Oil and Other Matters

(e) Regulation of coal export

In case of GDP 8 %, 825 million tons of coal will be required only for power generation till the year 2030 and 1,200 million tons till the year 2035. As a result, it will be difficult to keep even the existing power plants in the country in operation. Under such circumstances, it appears that there will remain no opportunity to use coal for any other purpose or to export coal.

However, as a result of discovery of new coal/gas fields in the country, opportunities for export of coal, in excess of obligatory coal-based power generation, may be given on the basis of recommendations of Sector Development Committee and on approval of the government, after keeping provision of energy security for 50 years and after formulation of Coal Sector Master Plan on the basis of determination of overall energy requirement. Quantities of this export shall, under no circumstances, exceed the quantity to be used in obligatory power plants in a year.

The Lessee will have to take leading roles for assisting other entrepreneurs in establishing coal-based power plants, apart from obligatory power plants, considering demand for industrial development, for marketing Bangladesh coal locally.

(4) Infrastructure development

(a) Coal Zone

The coal basins discovered in the north-western area of Bangladesh and the areas with potential basins of coal will be declared as Coal Zone. Government can alter, extend and refine the limits of this map, as required.

The following matters of the region will be taken into consideration, after reviewing the entire socio-economic structure in the Coal Zone**:**

(1) Physical infrastructure e.g. railway, roads, power transmission, ports, waterways, water reservoir etc.
(2) Social infrastructure e.g. villages, towns, educational institutions, industries, commerce and service organizations
(3) Agricultural land use patterns
(4) Water bodies, underground aquifer movements
(5) Matters relating to bio-diversity of the proposed zone.

(b) Coal Zone Report

Government organizations (Coal-Bangla/BMD) will prepare a Coal Zone Report for overall development of the entire Coal Zone. The study is to be supported by other Government organizations.

For development of the coal sector, transportation sector in Coal Zones will be developed. In this respect, other ministries and executing agencies will ensure timely construction and operation of Coal Related Infrastructure.

The Coal Zone will be developed as a major power producing block in Bangladesh based on mine mouth coal fired power generation and from here different load centers of the country will be directly connected by transmission lines.

The Coal Related Infrastructure will be developed in the public and private sectors with assistance from development partners on conditions of a long term business plan and realization of appropriate price from those who will use the facilities.

(5) Consideration of coal related technical aspect

(a) Extraction of coal

The long-term energy security in the country will be ensured through extraction of justified quantity of coal considering energy security of the country and consistent with Energy Policy projection. Established and proven technologies suitable in the context of socio-economic condition of Bangladesh, considering geological structure, nature and condition soil, are to be employed.

Mines are to be planned and developed for achieving targets of coal extraction, complying with health, safety and environmental regulations and keeping coal prices at reasonable rates. The feasibility study is to include a detailed economic analysis that will provide the Government with the costs and benefits of coal extraction on different methods of mining.

(b) Method of mining

The investors will have to propose the mining method based on geological structure, hydro-geological level, soil/rock mechanics, environmental impact study etc., to be included in the techno-economic report. While approving such proposal, the Bureau will keep in mind the energy security of the country. U/G planned for development in Bangladesh is to take cognizance of the earlier experiences and adopt proper pre-cautionary measures during the exploitation phase. Coal extraction from Open mines is to be under strict surveillance for mitigation measures relating to techno-economic, social, environmental and land reclamation issues.

Since there is no experience on open mining in Bangladesh and if coal is to be extracted with this method, experience has first to be gained on the following matters through development of one mine with this method and if the results are found satisfactory, arrangements for commercial extraction may be made from other mines:

(1) Order to extract coal.
(2) Determination of effects on underground water level through Computer Simulation and study the results of its recharge through water Injection method.
(3) Mitigation of environmental pollution.
(4) Effect on environment as a result of pumping out water for keeping the mine dry, in Land reclamation and study of its fertility.
(5) Rehabilitation of displaced persons and their income restoration.
(6) Socio-economic condition
(7) Increase in public awareness.

(c) Coal reserves

GSB is to set standard procedures, compatible with international standards, such as JORC (Joint Ore Reserve Committee)/ASTM to define various types of coal reserves, such as measured reserve, indicated reserve and inferred reserve. [1]

(d) Quality gradation of coal

For commercial purposes, the Bureau, in association with BSTI/GSB with the support of specialists from Institute of Fuel Research and Development (IFRD) of BCSIR and BUET is to establish standards for quality gradation of both Steam Coal and Coking Coal, following as much as possible, international standards. For being followed by the Lessee, the Bureau will decide the coal gradation for meeting the demands of customers.

[1] Khalashpir and Dighipara in the 4 coal fields are not enough for exploration boring. More exploration works are required to catch detailed geological conditions,

(6) Environmental aspects for considerations

(a) Environmental safeguards

In the light of relevant law and rules, Department of Environment (DOE) will take all necessary actions for minimizing the impact to the environment, while mining, beneficiation, coal-based power generation or any other related work is performed.

The Equator Principles/ World Bank Guidelines on environmental safeguards will be applicable on an interim basis. These guidelines will be rigorously followed while mining, storing, transporting and utilizing coal.

The Government may seek guarantees from the Lessees on critical environmental impact items, @ 1.5% of the estimated cost of the project, in the light of Environmental Impact Assessment and the Environmental Management Plan. [This will be in addition to 3% mentioned in clause 39(c) of Mines and Minerals Rules-1968 (amended up to date)].

(b) Environmental impact assessment (EIA)

The Licensee/Lessee is to undertake an Environmental Impact Assessment (EIA) in accordance with guidelines provided in the Equator Principles/World Bank Environmental Guidelines and DOE regulations. The EIA Report will be considered as a document open to all.

Decision on leasing of mine will be taken in accordance with Mines and Minerals Rules-1968 (amended up to date), after scrutiny of all documents submitted by the bidder and, if necessary, after taking assistance from experts.

(c) Social impact assessment (SIA)

The Licensee or Lessee is to prepare a comprehensive Social Impact Assessment (SIA) through community and stakeholders participation. Opportunities have to be provided to the local communities to participate, through complete disclosure of EIA and Environmental Management Plan (EMP), in the consultative process, in order to enable them to have greater control over the environments in which they live.

(d) Environmental management plan (EMP)

The Licensee/Lessee is to prepare an Environment Management Plan (EMP), along with EIA, following Equator Principles/ World Bank Environmental and DoE guidelines. A set of mitigation management, monitoring and institutional measures to be taken during the implementation and operation of the project, in order to eliminate adverse environmental and social impacts, offset or reduce them to minimum acceptable levels, will be included in the EMP.

(e) Ground water management and aquifer structure

In order to keep the mine pits dry, while working on underground or open mining, some operations involve dewatering of ground water in a large scale from the pits. As a result of large scale dewatering from the pits, the cone of depression may extend over several kilometers. The influence on underground water table during mine development has to be determined even before such development through Computer Modeling/Simulation.

Large scale extraction of ground water for a prolonged period may cause surface subsidence. As a result of the above situation and in order to protect the houses, buildings, reservoirs, railway lines, canals and land drainage around the mine, mitigate measures have to be included in the mining design, while selecting mining process.[1]

[1] There is very thick Upper Dupi Tila formation saturated by water over coal seams in Coal Zone and this formation becomes big obstacle. So maybe this clause is mentioned especially. Before O/C operation, conducting not only simulations via computors but also field tests of bench slope stability and other measures are desirable for control of the Upper Dupi Tila formation. Therefore, it is better to conduct trial mining or test mining in order to maintain safety and stable production

(f) Environmental preservation costs

The Licensee/Lessee is to bear all Environmental Costs associated with the implementation of the Project.

(g) Environmental impact research

Long-term impact to the environment arising from mining operations will be assessed by engaging a research team consisting of appropriate experts (which is not a committee), on payment of appropriate remuneration. The Government will realize compensation from the Lessee, in accordance with Mine and Mineral Resources Control and Development Law 1992 and Mines and Minerals Rules-1968 (amended up to date).

(7) Land reclamation, rehabilitation and utilization

(a) Reclamation and Rehabilitation of Land

As most of the coal resources of Bangladesh have been discovered under populated and high-grade agricultural land, the Lessee is to undertake phased reclamation and rehabilitation of lands affected by exploration/mining operations and is to complete this work before the abandonment of the area/mine.

(b) land utilization

The Licensee and Lessee are to prepare, even before start of mining works, a special plan for achieving desired targets and an EMP in accordance with Equator Principles/ World Bank Environmental and DOE guidelines, along with details of steps to be taken for land re-use, at the end of different stages of exploration and mining activities.

An action plan of land use for minimizing adverse environmental impacts from the proposed mining activities is to be prepared for different phases of mining. The best safety measure of international standard has to be taken so that no harm occurs to lives and properties in and around the mine

(c) Overview of land reclamation

Mining and civil engineers, architects, soil scientists, hydro-geologist etc., will be formed under the Bureau, which will carry out close technical supervision of gradual rehabilitation and reclamation of pits created by mining activities by the Lessee.

(d) Compensation for resettlement of inhabitants and structures

In accordance with Equator Principles/ World Bank Environmental and DOE guidelines, compensation acceptable to the owners, for rehabilitation, land and structural losses will paid.

Mine and Mineral (Control and Development) Rules 1968 and the kinds of laws will be properly adhered to during development of mine and production.

(8) Investments in the coal sector

(a) Physical & institutional infrastructure development

Apart from coal exploration, Development and Production, investment will be done in the following sectors:

(1) GSB activities on initial exploration and discovery of coal basins, exploration data management, technical standards;

(2) Establishment of Coal-Bangla and improvement of efficiency (if required) for overall development of coal sector;

(3) Enhancement of Coal R&D activities;

(4) Institutional development and capacity building for Bureau, GSB, BCMCL, Petrobangla, Energy Division, DOE, Ministry of Agriculture, Ministry of Water Resources; Ministry of

Land, Ministry of Communications, Ministry of Shipping, Bangladesh Railway, Port Authority and Land Acquisition offices of proposed coal mine area;

(5) Coal Related Infrastructure;

(6) New technologies such as coal bed methane, peat development, coal gasification (underground and surface);

(7) Rural and domestic use of coal for poverty alleviation, rural based power generation.

(b) Investment

Priority will be given to Government sector for coal exploration, development, production and marketing. But private investment will be encouraged on urgent basis if required for ensuring adequate supply of energy taking into consideration of energy security.

The licensee or Lessee cannot transfer license or lease or assign to those persons or organizations that are inexperienced in mining, bankrupt or financially insolvent.

(c) Exploration of Coal basin

1) Exploration of new areas by the Private Sector

Bureau of Mineral Resource development will invite proposal/Expression of Interest (EOI) from interested firms through international advertisement for exploration of coal in the new areas. Bureau is to assess the qualifications of the tendered to ensure that the tendered has sufficient experience in mining, is solvent and is able to carry out the planned exploration activities.

But statutory organization or authority will get priority in this case.

2) Discovered coal basins

Coal basins are to be released to the private sector for investment or retained by the Government for public sector investment. But the applicant/tendered may collect data/information from GSB on payment before issuance of license or lease for coal basins discovered by GSB.

(d) Process of investor selection for GSB discovered coal basins

The selection is to be done through tendering by invitation of proposals through press media, other websites including websites under CPTU**.**

(e) Other awards for Mining

1) Peat Coal Blocks
2) Coal Bed Methane
3) Other Precious Minerals
4) Underground Coal Gasification

(f) Coal field development program and budget

(9) Coal-fired power generation

(a) Establishment of coal based power station

In accordance with Power System Master Plan-200 (Nexant), if the GDP growth rate is 5.2%, power generation will be required 9,786MW in 2015, 13,993MW in 2020 and 19,312MW in 2025. If GDP 8%, power generation will be required 13,408MW in 2015, 24,445MW in 2020, 41,899MW in 2025. In 2025 out of a total generation of 41,899 MW of electricity, 32,837 MW will be generated with coal; for this purpose 75 million tons of coal will be required.

There will be shortage in supplying gas to the existing running power stations and fertilizer industries in 2011 onwards. So, planning of coal based power generation as alternative source of energy should be undertaken right now.

The proven underground geological reserve is 1168 million tons in Bangladesh except Jamalgonj. 90% of reserve by open mining method is about 1,050 million metric tons. On the other hand, 20% of reserve by U/G is about 235 million metric tons. Refer to Table 3-2-1, Table 3-2-2.

(b) Mandatory power station

It is to be a condition of the Mining Lease that all Lessees will construct one mine mouth power station as a Mandatory Power Station, operate the station and sell electricity to the grid, under a long-tern power purchase agreement.

The broad Parameters of a Mandatory Power Station are to be:

(1) The commercial operations date for the station is to be within one year forcibly of the date of commercial operation of the mine. But the priority will be given to award lease to the proposer / investor who will go for commercial operation of stations from the date of commercial operation of mine forcibly. Priority will be given to the proposer who will produce the highest power for mandatory power station.

(2) The lessee must establish Mandatory Power Station of capacity at least 500MW for extraction of 3 million tons coal annually from the mine during development of coal field.

(c) Coal-fired IPP

Public sector power generation agencies alone would not be able to cope up with the huge mine produce in Coal Zone. Private sector power generation must be encouraged as coal-fired independent power producers (IPPs) to set up coal based power plants in the vicinity of the coal mines. The broad parameters of coal-fired IPPs are to be:

(1) The stations are to be competitively tendered by the host power utility (BPDB or a relevant Governmental Authority) in a manner similar to the gas-fired combined cycle IPPs;

(2) There is to be a coal supply agreement entered into between the Lessee and the IPP investor. The price of coal to the power plant is to be fixed in Bangladesh Taka in this case.

(3) Coal-fired IPPs are to be given IPP status under the 1996 Private Sector Power Generation Policy and amended in 2004. But the electricity generated in these coal-fired IPPs will be sold in Bangladesh Taka.

(d) Public sector generation

BPDB has constructed a 250 MW power plant adjacent to the Barapukuria coal mine and may construct coal-fired plants in future with public sector financing. The broad parameters of public sector coal-fired stations are to be:

(1) There is to be a coal supply agreement entered into between the Lessee and BPDB or the appropriate Governmental Authority;

(2) The price of coal to the power plant is to be negotiated between the Power Division and the Lessee;

(3) The Government may choose to take all Royalties from the Lessee in kind as coal and supply it to the public sector power stations.

(e) Captive power generation

A true captive power station by coal is to use power for internal only. Excess power is to be exported to the grid, and then the price is to be mutually negotiated between the Lessee and the BPDB or power sold as per the Captive Power Policy

(10) Commercial aspects

(a) Coal prices

On a quarterly basis, the Bureau is to calculate and publish at its web site and news media, the export coal price (ECPt) that is based on the International Coal Price Index. Export coal price (ECPt) per ton will be expressed in US Dollar, which will be calculated the average of the last three months' international coal price. The price of local use coal will be ECPt x0.7 at mine mouth

(b) Royalty

Royalty is payable by the Lessee to the Government for all Local Use Coal and Export Coal produced from the Lease Area. Royalty is to be paid by the Lessee to the Government on a quarterly basis, calculated on coal production returns certified by the Bureau. The Government may choose to take the Royalty either in cash or kind.

1) Royalty of export coal

The rate of Royalty for Export Coal is to comprise of two components, a Fixed Royalty Component and a Variable Royalty Component and is to be based upon the following formula:

$$Rt = FRC + (ECP_t - ECPb)*10/ECP_b$$

Where,

Rt represents the rate of Royalty in percentage of Export Coal during the quarter at any time t

FRC represents Fixed Royalty Component that will be 6% for Opencast Mines and 5% for Underground Mines

The term $(ECP_t - ECP_b)*10/ECP_b$ represents the Variable Royalty Component in percentage, as the premium for exporting coal, and shall not be less than zero

ECP_t is the export coal price represented by the average of International Coal Price Index for the preceding 3 months, at any time t, in $/ton

ECP_b is the base year coal price, and is to be taken to be US$ 25/ton

The quarterly Royalty payment for Export Coal shall be calculated based upon the following formula:

$$QRP = R_t * EC_q * [\ 0.90*ECP_t\ ]$$

Where

- **QRP** represents the quarterly Royalty payment in US$
- EC_q is the Export Coal in tons, during the quarter

In the above formula, the QRP for Steam Coal and QRP for Coking Coal are to be calculated separately, with the appropriate numbers in ECP_t, ECP_b and EC_q. If the ECP_t values for Coking Coals are not available, then it is to be taken as 50% higher than that for Steam Coal i.e. ECP_t of Cooking Coal =1.5x ECP_t of Steam Coal

2) Royalty of local use coal

The quarterly Royalty payment for Local Use Coal shall be calculated based upon the following formula:

$$QRP = R * LUC_q * \text{Applicable coal price}$$

Where

QRP represents the quarterly Royalty payment in Taka

R represents the fixed rate of Royalty in percentage for Local Use Coal

LUC_q is the Local Use Coal in tons sold or consumed internally during the quarter

The rate of Royalty for Local Use Coal is to be the **Fixed** $=0.7*ECP_t$

(The rate of Royalty for Local Use Coal is to be the Fixed in local currency converting US$ at exchange rate fixed by Bangladesh Bank as ECP_t is in US $).

(c) Coal marketing

The Lessee is to engage distributors for the distribution of coal throughout Bangladesh. These distributors are to be responsible for the transportation of coal from the mine to the distribution centers located throughout the country. Such coal is to be sold at the retail level, at the price determined by the Mine Mouth Coal Price, plus the applicable transportation charges.

Excess Coal (if any) may be exported subject to approval of Government if the Coal Sector Development Committee recommended to export excess coal after meeting the long term demand as per Master plan and ensuring 50 years energy security of the country. The amount of this export will no way exceed the annual requirement of coal for mandatory power stations. i.e. the ratio of coal use for mandatory power station and the maximum coal export is 1:1.[1]

(d) Fees

All fees related to Exploration License and Mining Lease is to be reviewed and renewed time to time as per rules of Mines and Mineral Resource Rules and published by the Bureau.

(e) Coal fund

A Coal Fund is to be created with an immediate contribution of Taka 100 million, as a grant for carrying out the Immediate Development Works. The fund is to be maintained in a separate bank account for administering the payments from it, as per the decisions of the Coal Sector Development Committee.

(b) The fund is to be utilized by the concerned public sector organizations for the purposes such like Institutional capacity building, Manpower development, Reconnaissance survey by GSB, Higher training for concerned officials of GSB and BMD, Coal Sector Master Plan, Coal Zone Study, Peat and CBM development, Coal gasification and others.

Coal Bangla (Proposed)/BMD will be responsible for management of the above fund for overall development under supervision of Coal Committee

(f) Fiscal incentives

During the exploration phase of coal, any equipment, machinery, supplies, spares, and consumables etc. imported by the Licensee is to be exempt from customs duties and VAT;

For other matters such as corporate tax, income tax & VAT etc, the Investors will receive the benefits as applicable under the present regulations in Bangladesh at the time of contract signing, No Tax holiday facilities will be provided.

The feasibility study and development of CBM, Peat Coal, Coal to Liquid, Coal Bed Liquefaction & in-situ gasification etc are to receive similar fiscal incentives as above.

(11) Institutional development and framework

(a) Institutional development and framework

The Government is to utilize the 5-year period from July 2007 to June 2011 to consolidate the sector by undertaking Preparing a Coal Industry Master Plan(under supervision of Coal Bangla/BMD), Undertaking a Coal Zone study, Training and capacity building of government officials for planning, evaluating, negotiating and soliciting functions (Bureau) and etc.

(b) Change in law

The Licensee or Lessee is to abide by the laws, decrees, rules, regulations and ordinances on the mining industry, industry in general and environment protection, existing at the moment or to be adopted by the Government in future. Any costs related to the changes are to be borne by the Investor as a normal business risk. The Government may review this regulation time to time.

(c) Strengthening of existing organizations

1) Geological survey of Bangladesh

GSB is to bear responsibility for carrying out investigations and surveys for the discovery of coal resources. GSB is to be equipped with suitable manpower and latest technology for efficient performance of the following:

(1) To carry out geological, geophysical surveys in green fields to discover and delineate new basins

[1] There are many descriptions of the case of DDP @8% in this draft coal policy and domestic coal production is calculated by coal power generation. All produced coal is for domestic power plants so that domestic coal can not export only but also supply to domestic other industry. One idea is high price coking coal is for export and gets foreign currency, then Bangladesh import much more steaming coal.

(2) Confirm commercial coal reserve in a basin through exploratory drilling of sufficient number of boreholes
(3) Set standards to quantify coal resources in terms of measured, indicated, and inferred reserves;
(4) Set standards to define and differentiate steam coal and coking coal;
(5) Set standards for quality gradation of coal for commercial purposes;
(6) Prepare, update and maintain a data bank of mineral resources of the country;
(7) Data management and marketing to attract potential Investors in the coal sector
(8) Participate and contribute with all recent data for the creation of Coal Zone.

2) Bureau of Mineral Development

The Bureau is to assume responsibilities as follows:
(1) Selection of investors for exploration and development activities for mineral resources;
(2) Monitor development, production and marketing of coal;
(3) Regulate the macro aspects of the coal industry;
(4) Issue Coal Export Certificates;
(5) Publish export coal price (ECP_t) on a quarterly basis;
(6) Regular Inspection;
(7) Environmental protection monitoring activities etc. of the Licensees and Lessees through its Land Reclamation Wing.

3) Department of Environment

The DOE is to review the exploration, production, exploitation, storage and transportation of coal, reclamation of land etc, identify the areas that need improvement and on an urgent basis, carry out the work such that the coal sector can be developed in an environment friendly and responsible manner.

An arrangement will be taken to establish permanent office of DOE in the Mine zone to ensure the application the existing environmental laws.

4) Coal Sector Development Committee

1	Minister, Ministry of Power Energy & MR Division	Chairperson
2	Secretary, Finance Division, Ministry of Finance	Member
3	Secretary, Energy Division	Member
4	Secretary, Power Division	Member
5	Secretary, Ministry of Home	Member
6	Secretary, Ministry of Communications	Member
7	Secretary, Ministry of Land	Member
8	Secretary, Ministry of Forest & Environment	Member
9	Secretary, Ministry of Commerce	Member
10	Commissioner, Rajshahi Division	Member
11	Chairman, Petrobangla	Member
12	Chairman, BPDB	Member
13	Director General, Geological Survey of Bangladesh	Member
14	Specialists in the related field (3 Nos.)	Member
15	Director, Bureau of Mineral Development	Member

The committee may co-opt other members from private sector, civil society and experts as may be necessary from time to time. The committee is to use the Coal Fund for carrying out its activities.

5) Coal Bangla

The Government may create an institution "Coal Bangla" under the EMRD, to ensure public sector investments and participation in the coal sector. Employees will be appointed as per requirement for its efficient operation and training will be arranged for the employees on priority basis

6) Chief Inspector of Mines

An office of the Chief Inspector of Mines is to be created.

7) Mining Educational Institutions

BUET and RUET will start a degree course in mining engineering. The education and research program on geology will be strengthened in Rajshahi University, Dhaka University and Jahangirnagar University. Diploma level mining courses are to be introduced in the polytechnic institutes within the Coal Zone for creating midlevel supervisory technical personnel. Similarly, mine vocational training courses are to be introduced at the vocational training institutes within the Coal Zone, aiming to supply trained and skilled craftsmen, operators, and technicians for the industry.

8) Human Resource Development

All Lessees are to operate training in their training centers before appointment of the technical manpower and mine workers for extraction works.

The Government is to initiate action on urgent basis to train local technical personnel on short and long term basis in countries because of the need of immediate manpower requirement in the coal sector.

The Licensee and lessee will have to apply modern technology for exploration and development of coal and make the Bangladeshi manpower trained in modern technology. During construction period of mine development, the Lessee is to engage trained Bangladeshi personnel to work side by side with foreign expatriate and ensure transfer of technology.

(Note): In order to implement clause 11.3.7and11.3.8 many high level personnel are required. It is to make clear the source of personnel.

In Japan only qualified workers did important works in coal mine. In Bangladesh also this system will be required.

9) Research and Development

All different universities in Bangladesh will be encouraged to conduct mining research programs under grants of Energy & Mineral Resource Division to start coal mine development. The centre is to work in close collaboration with the mining industry, public organizations and provide technical advice to industry in matters relating to improvements in safety and health measures and prevention of occupational diseases.

The centre is to conduct researches on beneficiation, carbonization, briquetting and gasification of coal, and utilization of its bye-products. The centre is to take initiative to attract private investment in liquefaction process to convert coal into liquid fuel.

(12) Compensation, 1nsurance and settlement of disputes

(a) Compensation & insurance

The lessee will be bound to pay compensation as per Rule-18 of Mines and Mineral Resources Regulation 1968 (Amended recently) for any damages including roads, physical infrastructure, rivers, khal-beels, underground cables, telephone line, gas pipeline, drinking water sewage pipeline etc. due to insincerity or non-precautions or mechanical faults or electrical faults. The lessee will have to bear all assets & liabilities for insurance as per Rule-27M of the above Regulation if any person injured or died or any loss of properties occurred due to accident.

(b) Settlement of disputes

Any disputes found in future after signing of the contract between the Lessee and the Bureau will be settled in this country under the existing law in Bangladesh. Bangladesh Arbitration Act 2001 (Amended) will be applicable for arbitration.

Bangladesh Coal Policy Draft (1)

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Bangladesh Coal Policy Draft (2)

4.2 APPENDIX – 2 Potential coal export countries

(a) Indonesia

Oil, natural gas, and coal consumption in Indonesia for 2007 respectively accounted for 47.5%, 26.5%, and 24.3% of the country's primary energy consumption. The Government of Indonesia has retained the policy of boosting coal consumption to 33% by 2025 for alternative domestic fuel. Coal is also regarded as a resource to earn foreign currencies and production has been increasing rapidly. Indonesia is the largest steam coal exporter in the world.

Although the nation's energy policy (2004) pointed out the significance of the transportation infrastructure, it is an inadequate transportation infrastructure, including river transportation and shipping facilities that have led to supply constraints.

The nation's coal reserve is 4.33 billion tons (anthracite and bituminous coal: 1.72 billion tons; sub bituminous coal and lignite: 2.61 billion tons), which is small in terms of production volumes. According to the energy statistics (2009) and the Geological Bureau of the Indonesian government, the nation's coal reserve is 5.3 billion tons, and the probable reserve is 18.7 billion tons. Among the different coals, lignite accounts for 58.7% of the nation's coal reserves; this is the largest ratio. Hence, technology for utilizing low-grade coal has become increasingly important in terms of a stable supply of energy.

Regarding coal deposits in Indonesia, at present the Indonesian government is setting up a database of coal resources and reserves in conjunction with NEDO (Japanese organization).
APTable 4-1 has been created from Indonesia Coal Book 2008/2009, but Hypotheses have been excluded.

APTable 4-1 Coal resources and reserves in Indonesia

Quality	kcal/kg	Resources (Million tons)			%
		Indicated	Measured	Total	
Low	＜5,100	3,652	5,750	9,402	27.20
Medium	5,100 6,100	9,041	10,867	19,908	57.58
High	6,100 7,100	963	3,870	4,833	13.98
Very High	＞7,100	6	423	429	1.24
Total		13,662	20,910	34,572	100.00
Quality	kcal/kg	Reserves (Million tons)			%
		Probable	Proven	Total	
Low	＜5,100	4,292	1,105	5,397	28.84
Medium	5,100 6,100	8,214	2,971	11,185	59.78
High	6,100 7,100	671	1,276	1,947	10.41
Very High	＞7,100	73	109	182	0.97
Total		13,250	5,461	18,711	100.00

Source: IEA Coal Information 2008

The above Table shows that Total Resources are 34.5 billion tons and the Total Reserves are 18.7 billion tons. Each number shows 85% and 89% which of coal is less than 6,100kcal/kg and occupies a large proportion of coal deposits. At many remote inland areas in coal producing provinces there are many unexplored areas. When exploration works progress, these numbers will increase.

Although exploration works are at remote inland areas in Central Kalimantan and East Kalimantan, Projects for high calorie and high priced coal for steel mills are in progress. Many coal deposit areas are known in remote inland areas, but exploration works for around 5,000kcak/kg of coal are not conducted due to low prices. This area will be one of the candidates to acquire a stable coal supply for Bangladesh. APTable 4-2 shows production, consumption and trade of Indonesian coal.

APTable 4-2 Changes in coal production, consumption, and trade (unit: million tons)

Year	2003	2004	2005	2006	2007
Production	119.7	142.1	171.1	221.2	259.2
Coking coal	15.1	9.2	10.7	24.5	31.5
Steam coal	81.6	109.9	134.7	168.9	199.7
Lignite	23.0	22.9	25.7	27.8	28.0
Consumption	29.6	36.2	41.1	49.0	57.0
Export	90.1	105.5	129.2	171.6	202.2
Coking coal	15.1	9.3	10.8	24.6	31.5
Steam coal	75.0	96.2	118.4	147.0	170.7

Source: IEA Coal Information 2008

The table lists 259 million tons of coal production and 202 million tons of export for 2007. Statistics of the Ministry of Energy and Mineral Resources (MEMR) describe 193 million tons of coal production for 2006, 217 million tons for 2007, 229 million tons for 2008, and 230 million tons of production forecast for 2009.

Domestic coal consumption stood at 54 million tons for 2007, including 32.40 million tons for power generation and 6.50 million tons for cement production. In coming years, consumption of coal of low calorific value (5,100kcal/kg or below) is going to increase rapidly when the operation of the 10,000MW Coal-Fired Thermal Power Project ("Crash Program") is commenced commercial operation in 2010.

(b) Australia

Coal has accounted for 43.6% of the primary energy consumption in Australia. Domestic coal consumption for 2007 stood at 78.41 million tons, 84% of which was used for power generation. Coal production for 2008 reached a record-setting 402 million tons (fourth largest in the world) despite the abnormal climate at the beginning of the year.

The nation's coal reserve stands at 76.2 billion tons, or a decrease of 400 million tons since the end of 2005. However, Australia's exploration investment for FY 2007/2008 increased to AUD235 million from AUD 193 million for FY 2006/2007. According to some Australian statistics, the measured minable reserves are reported as 71.8 billion tons in total, including 35.5 billion tons by underground mining and 36.3 billion tons by open-cast mining.

Australia is the largest coal exporter in the world. The country exported 138.2 million tons of coking coal and 112.2 million tons of steam coal for 2007. The trade accounted for some 30% of the coal trades in the world. Japan imported 113 million tons of Australian coal (equivalent to approx. 1,087.1 billion yen), and its dependency accounted for 60.8%. The nation's coal export to

Japan has accounted for 45%, and Japan has been the largest coal importer for Australia. APTable 4-3 lists changes in coal production, consumption, and trade.

APTable 4-3 Coal production, consumption, and trade (unit: million tons)

Year	2003	2004	2005	2006	2007
Production	341.7	352.2	367.3	367.5	395.6
Coking coal	113.0	117.8	129.3	125.2	141.9
Steam coal	161.8	168.0	170.9	174.6	181.1
Lignite	66.8	66.3	67.2	67.7	72.3
Consumption	129.2	131.3	140.1	141.4	147.9
Coking coal	4.7	5.1	5.4	4.7	6.0
Export	208.7	218.4	231.3	231.3	243.6
Coking coal	107.8	111.7	124.9	120.5	132.0
Steam coal	101.0	106.7	106.4	110.8	111.6

Source: IEA Coal Information 2008)

(c) China

Coal has accounted for 70% of the primary energy consumption in China. Coal-fired power generation accounts for 80% of the power generation in the country. Coal production stood at 2.5 billion tons in 2007. In other words, China has been and is the largest coal producer and consumer in the world. According to the National Bureau of Statistics of China, the nation's coal production for 2008 was 2.62 billion tons. Although, the national development 11-5 Plan sets a production goal for 2010 as 2.6 billion tons, the production volume was achieved two years ahead of the scheduled target year.

Domestic coal prices are more expensive than those in the international market. For example, the trading prices of Shanxi steam coal and Datong coal at Qinhuangdao were respectively at 560RMB/t and 600RMB/t in March. Since the domestic demand for coal turned tight in 2004, the Government of China has implemented export constraint measures. As a result, exports peaked in 2003, reaching 93.02 million tons. Since then, exports continued to decrease to 45.43 million tons in 2008. Meanwhile, coal imports increased, especially from Vietnam, reaching 40.40 million tons. Since coal imports exceeded coal exports in the first quarter of 2009, China is expected to become a net importer of coal.

The coal reserve in China stands at 114.5 billion tons. The reserve ranks third place in the world, following the United States and Russia. In general, geological conditions in China are complicated. Besides, coal seams occur in deep underground. Hence, underground mining has accounted for 96% of the coal mines. APTable 4-4 lists changes in coal supply and demand as well as export and import.

APTable 4-4 Changes in coal supply and demand and import and export in China (unit: million tons)

	2003	2004	2005	2006	2007
Production	1,670	1,956	2,159	2,320	2,549
Consumption	1,582	1,886	2,099	2,305	2,543
Export	94.0	86.6	71.7	63.2	53.7
Import	11.1	18.6	26.2	38.1	47.6

Source: IEA Coal Information 2008

Although demand has grown, inland production areas are far distant from coastal consumption areas, bringing about many constraints in domestic distribution. Domestic transportation cost is comparatively expensive. Railway transportation is also facing some constraints. There is concern that as domestic demand for coal increases, volumes of coal import are also likely to increase in China in the future.

(d) India

Coal has accounted for 51.4% of the primary energy consumption in India. The nation's coal production for 2008 stood at 512 million tons and ranked third place in the world and the nation's coal reserve is 58.6 billion tons, also ranking third place in the world. According to a revision made by the Ministry of Coal (MOC) of India, the coal reserve includes 54.0 billion tons of bituminous coal and anthracite (92.2%) and 4.6 billion tons of lignite (7.8%). Although it is said that India can be self-sufficient in terms of coal supply, the nation has already become a coal importer. The coal industry in India has failed to catch up with rapid increases in domestic demand for coal.

Coal-fired power generation has accounted for 69.8% of the power generation in India. Although the Government of India has set up a large-scale coal-fired power station construction project ("Ultra Mega Power Project" (UMPP): 4GW x 9=36GW), the government decided on only three sites. APTable 4-5 lists changes in coal production, consumption and trade. APTable 4-6 lists the demand and supply plan announced by the Government of India. According to the plan, coking coal accounts for a major portion of the coal to be imported to India, and the nation intends to be self-sufficient in thermal coal. In reality, however, India imported 28 million tons of coal for 2007, resulting in a pessimistic view in terms of achieving self-sufficiency in meeting domestic demand with domestic resources. Although the nation exported 1.6 million tons of coal for 2007, India is unlikely to increase future exports.

APTable 4-5 Changes in coal production, consumption, and trade in India (unit: million tons)

	2003	2004	2005	2006	2007
Production	386.4	410.5	434.7	459.5	484.4
Consumption	400.1	441.3	460.9	490.6	537.3
Export	1.6	1.3	2.0	1.6	1.2
Import	21.7	28.5	38.6	43.1	54.1

Source: IEA Coal Information 2008

APTable 4-6 Demand and supply plan in India

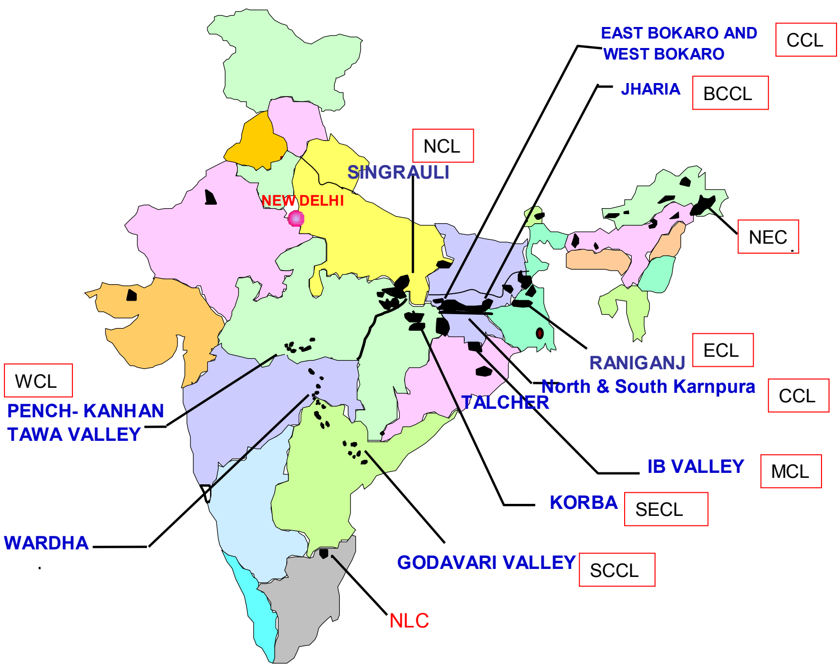
		XI Plan (2011-12)	XII Plan (2016-17)	XIII Plan (2021-22)	XIV Plan (2026-27)
Demand	Coking	69	104	125	150
	Non-Coking	662	1021	1267	1573
	Total	731	1125	1392	1723
Production		680	1060	1282	1538
Gap (Import)	Coking	41	70	85	105
	Non-Coking	10		25	80
	Total	51	70	110	185

Source: By Shri S. Chaudhuri & A. K. Wahi of CMPDIL, the 2nd Coal summit, 2007 & Coal Directory of India 2007-2008 by MOC of GOI)

Coal India Limited (CIL) has accounted for an oligopolistic 80% of the domestic coal production. CIL owns seven coal-producing companies and a design company. In addition, other companies are also being operated, including NLC, which produces lignite under the umbrella of the Ministry of Power, and SCCL, a public coal-mining corporation. India has 549 coal mines where 600,000 workers engage in mining. Annual sufferers in mine accidents are 85 on average. The number of deaths per million tons is 0.21, which is 1/6 of that of China.

Gondwana coal in the Indian Continent contains low sulfur and phosphor content but high ash content including silicic anhydride. Gondwana coal is characterized as being abrasive. Removing ash content from Gondwana coal is relatively difficult because mineral matters are closely distributed in coal composition. Coal for power generation in use has CV 3,500 kcal/kg or so, containing 38 to 40% ash content. As demand for coal increases in the future, grade of coal to be used is likely to be lowered. Moreover, thermal power stations that receive domestic coals of different calorific values, ash contents, and grain sizes are facing a low performance and working rate because such coals are different from the coals in the designed specifications. Furthermore, coal utilization has posed diverse environmental problems, including handling during transportation, low combustion efficiency, soot and dust, ash treatment, and so on.

APFig. 4-1illustrates a map of the coal fields in India. According to the map, the coal fields in Bangladesh are on the borderline extending to the Raniganji Coal field in India. Hence, it is very apparent how Bangladesh can easily import coal from the Indian coal mines surrounding Bangladesh. The NEC coal fields of the Tertiary Era in the eastern area of the country contain high sulfur content.



Source: CIL document modified by PSMP Study Team

APFig. 4-1 Map of coal fields in India

(e) South East Africa Region

1) Summary

In South East African Countries, at present The Republic of South Africa exports coal and it is also probable that, the People's Republic of Mozambique and the Republic of Botswana may also export coal in the future. A brief summary of every country has been provided below along with the detailed conditions of South Africa.

2) The Republic of South Africa (South Africa)

Recoverable coal reserves is about 31 billion tons and is the 6th largest South Africa produced 245 million tons of salable coal, marking it as the 5th largest country in the world to do so. Coal export was 73 million tons and this is 5th large country next to Australia and Indonesia, this number is close to China and Russia. Domestic coal consumption was 173 million tons, a number close to representing the amount of Japanese consumption.

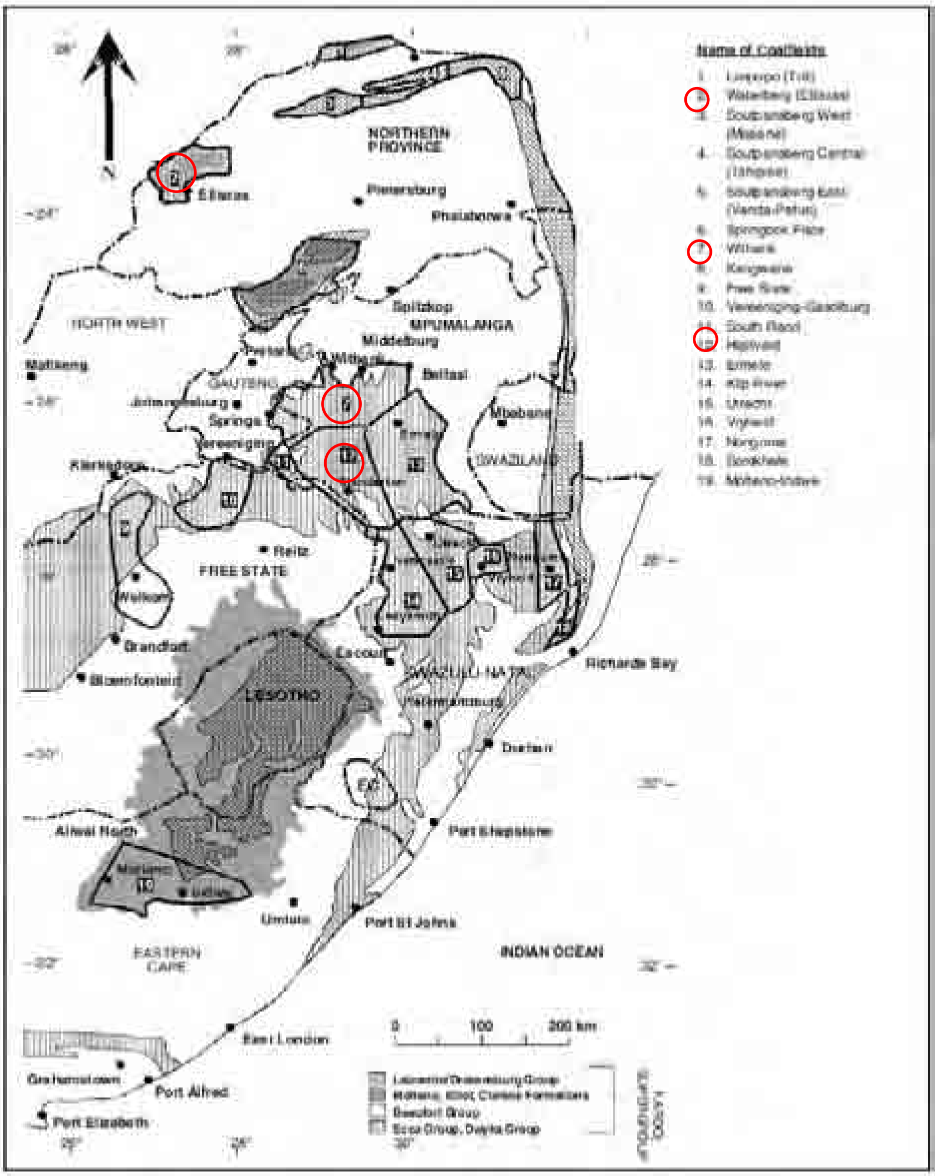
Most of the exported coal is shipped through Richards Bay Coal Terminal (RBCT). In 2006, the 5th construction work was started to increase its export capacity to up to 91 million tons per year. In the future, exported coals were mainly for Europe and are expected to increase.

3) The People's Republic of Mozambique (Mozambique)

Coal production in 2006 was about 100,000 tons and the recoverable coal reserves are estimated to be around 3 billion tons. In 2004 the government started the Moatize coal project which is expected to produce more than 9 million tons of coking coal per year and around 2 million tons of steaming coal per year. And rail roads to Beira port and the repair and expansion of port facilities would be completed by 2009.

4) The Republic of Botswana (Botswana)

The oil resources institute is an estimated 20 billion tons. Only the Morupule coal mine at the east part of the country is operated and produced 1 million tons in 2005. Most of coal was consumed for domestic purposes and a part of the coal was exported. Exploration work and development to investigate the region’s export capability are underway due to the recent high price of coal. This region has a high potential to become a coal export country/



Source： Characterization of the coal resources of South Africa by Layer

APFig. 4-2 Coal fields in South Africa

South Africa mainly produces bituminous and anthracite coal and these coals are in the Ecca Series of the Karroo System. There are some Cenozoic lignite and peat in various areas, but these coals are not counted as resources. All high quality bituminous coal in Africa is in the Ecca Series of the Karroo System. The Karroo System is a formation corresponding to the Gondowana System in India. This formation is terrestrial sediment and had been formed in the Gondowana Continent and consists of thick sediment from the Upper Carboniferous to Permian. The Karroo System is distributed throughout South Africa. Except the Southern part, this System horizontally lies over the Pre-Cambrian basement without folding movement. This System is classified as follows.

Karroo System	Stormberg Series	7,000 ft	{	Drakensberg Volcanic Rocks Moletono formation (Alternation of sandstone and shale, some coal seams)
	Beaufort Series	≧10,000 ft		Alternation of sandstone and shale
	Ecca Series	≦6,000 ft		Main coal seams, Alternation of sandstone and shale
	Dwyka Series	3,000 ft		Permian conglomerate, Shale

Coal Quality : Coal is classified to 4 kinds as followings in South Africa.

Ⅰ). High class coal ≧about 7,000 kca1/kg : Coals fields in KuaZulu-Natal

Ⅱ). Middle class coal 7,000～6,470kcal/kg : Witbank -Middleburg coal field

Ⅲ). Low class coal ≦4,850kcalkcal/kg : Coal fields in Mpumalanga, Free State

Ⅳ) Anthracite ≧ 7,000 kca1/kg : Coals fields in KuaZulu-Natal

There are coking coals at Waterberg coal field and others in Mpumalanga and the coal fields in KuaZulu-Natal. There are anthracite at Vryheid and other coal fields.

Coal in South Africa has more ash content and a lower heating value compared to Paleozoic coal in Europe.

APTable 4-7 Coal quality of main coal fields in South Africa

Coal Field	Moisture %	Ash %	Volatile %	Fixed C %	Sulfur %	Kcal/kg	Ash F/T ℃	Note
Witbank -Middleburg	2.5	13.2	27.4	56.9	1.0	6,790	1,390	―
Witbank –Middleburg (south)	3.5	19.7	26.2	50.6	1.2	5,980	1,350	―
Witbank -Middleburg	2.5	11.0	32.0	54.5	0.6	―	―	Caking
Ermelo - Breyton	3.2	15.4	31.3	50.1	1.4	6,414	1,330	Non caking
Heiderberg	7.2	20.9	25.1	46.8	1.0	5,282	+1,400	Non caking
Veyheid (Natal)	1.6	9.5	9.3	79.7	0.9	7,546	+1,400	Anthra cite
Veyheid (Natal)	1.5	16.7	19.0	62.8	0.8	6,953	+1,400	Caking
Klip River (Natal)	1.5	17.4	22.9	58.2	1.9	6,790	1,400	Caking

Source : Coal resources in Africa (volume-1) by INOUE and SOGA)

There are three famous main coal fields in South Africa, Waterberg (Limpopo Province), Witbank (Mpumalanga Province), Highveld (Mpumalanga Province)

Regarding the coal reserves there are various views, 30 – 90 billion tons.
The next table is one of them.

APTable 4-8 Estimated recoverable remaining coal reserves at the end of 2000 in South Africa

Coalfield	Reserves (million tons)		
	Recoverable (Bredell[16])	ROM production (1982-2000)	Remaining (2000)
Witbank	12460	2320.23	10139.77
Highveld	10979	972.49	10006.51
Waterberg (Elistras)	15487	384.00	15103.00
Vereeniging-Sasolburg	2233	334.91	1898.09
Ermelo	4698	101.11	4596.89
Klip River	655	85.26	569.74
Vryheid	204	81.80	122.20
Utrecht	649	64.47	584.53
South Rand	730	22.03	707.97
Somkhele & Nongoma	98	15.18	82.82
Soutpansbefg	267	6.11	260.89
Kangwane	147	0.96	146.04
Free State	4919	0.22	4918.78
Springbok Flats	1700	0.00	1700.00
Limpopo (Tuli)	107	0.00	107.00
Total	55333	4388.77	50944.23

Source： Characterization of the coal resources of South Africa by L.S. Jeffrey）

Coal production is concentrated mainly at the Witbank coal field and its surroundings. These mines are near consumer areas. Most of the coal seams are of a depth of less than 200 m from the surface, have a mild inclination and few faults. Hence, they are prime geological conditions for mining. Both O/C and U/G have been operated on. The Room & Pillar is the main method in U/G.

Two ports, Richards Bay and Durban are famous in South Africa. Most of the export coal which was mainly produced at the three coal fields as mentioned above are transported to Richards Bay Coal Terminal by trains exclusively utilized to deliver coal (1 train＝200 wagons, 16,800 tons, rail gage : 1,025 mm) and then are shipped.
In 2008, the port handled 82.7 million tons of cargo, of which 62 million tons was exported coal.
At present, ships are handled at five berths each 350m in length with a 19m water depth alongside and a permissible drought of 17.5 m.
The majority of South African coal is steaming coal for Europe. Recently, the press has reported that the coal for China and India has increased. Export coal was 67 million tons in 2004, 73 million tons in 2005, 69 million tons in 2006, 67 million tons in 2007 and 62 million tons in 2008 respectively. After the peak in 2005, export coal did not increase.
Now the coal terminal is undergoing refurbishments to increase its capacity to 92 million tons per year. After this is completed, coal exports are expected to increase.

(f) United States of America

Coal has accounted for 24.3% of the primary energy consumption in the USA and is a major source of energy, following oil and natural gas. Coal production stood at 1,052 million tons for 2007, whereas coal consumption stood at 1,029 million tons (both ranked second place in the world). Coal production for 2008 was a record-setting 1,063 million tons. Coal for power generation has accounted for 93% of the domestic consumption, and 49.8% of the power sources in the United States.

Coal exports stand at 83 million tons, while imports stand at 31 million tons. Hence, the United States is a coal exporter. The EIA (Energy Information Administration) forecasts that the nation is likely to become a coal importer in the latter half of the 2010s. APTable 4-9 lists changes in coal production and consumption of the United Sates.

APTable 4-9 Changes in Coal Production and Consumption in USA (unit: 100 million tons)

Year	2000	2004	2005	2006	2007
Production	9.72	10.19	10.39	10.68	10.52
Consumption	9.66	10.11	10.30	10.17	10.29
Thermal coal	7.796	9.219	9.412	9.313	9.493
Coking coal	0.263	0.215	0.214	0.208	0.206

Source: IEA Coal Information 2008

The nation possesses a coal reserve of 238.3 billion tons, which is the largest in the world. The minable reserve in the existing coal mines stands at 16.86 billion tons. There are 1,374 coal mines where 81,000 workers engage in mining. The number of employees including subcontractors stands at 122,900. The underground coal recovery rate is 31.0%, while the production stands at 319 million tons. For underground mining, longwall mining produces 160 million tons and chamber and pillar mining produces 1.57 million tons of coal.

4.3 APPENDIX-3 Pilot O/C coal mine

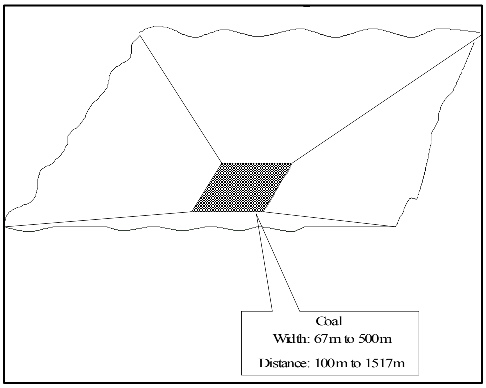
4.3.1 Proposing site and connectional layout

As a plan, Barapukuria area is taken as an example, before mining works, the slope stability of the Upper Dupi Tila and the water table around the mining area needs to be confirmed These are very important items for technical matters,

For example, a Box-Cut is made near point and the surroundings which are closest to the top of the coal seam. Then the Lower Dupi Tila is exposed to a plane of 100m×100m squares in order to observe and measure multiple phenomenon. Further, safety measures will be made to prevent slope land slides while the technology for water table stability will be confirmed.

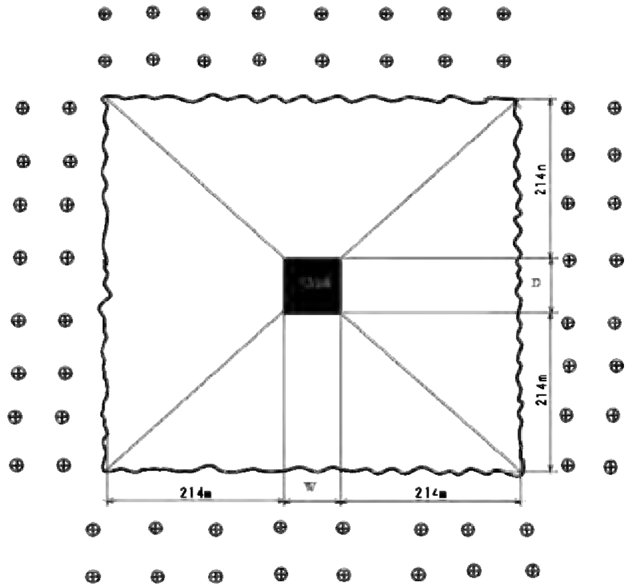
At a bird's-eye view in APFig. 4-3, the coal seam is shown in black color at the bottom.
APFig. 4-4 shows a top plan view, width and length of the coal seam is shown W& D respectively. Boring holes for dewatering and water-reinjection are arranged at the area around O/C. Each position of the hole is determined after the Hydro-Geological Study, but the two boring holes each 200m deep with a 50m span are supposed to be a cost estimation. APFig. 4-5 shows the cross-section view and here the average slope inclination is temporally 35 degrees. The normal O/C slope inclination is about 45 degrees; here the slope inclination is 35 degrees due to the weakness of the highwall. Determining the slope inclination has a big influence on the mining cost.

APFig. 4-6 shows the pilot plan at the site. This plan is suggested as a connectional one based on the production plan. Practically, a geological survey including the coal seam condition, Hydro-Geological Study, Impact area to inhabitants, pre-F/s to minimize impact to existing facilities and F/S to make a detailed plan for construction are required. Here PSMP Study Team offer partial information to assume the practical conception as material that will serve as the basis for judgments for the pilot mine.



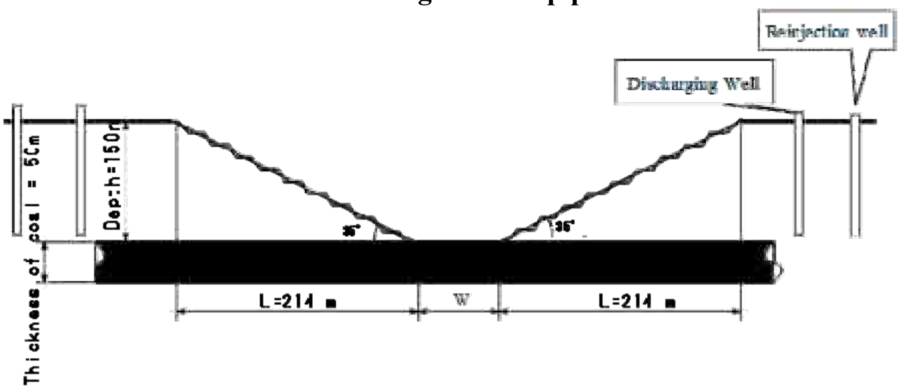
Source: PSMP Study Team

APFig. 4-3 Birds-eye view of pilot O/C coal mine



Source: PSMP Study Team

APFig. 4-4 Top plan view



Source: PSMP Study Team

APFig. 4-5 Cross-section view

4.3.2 Production Plan

(1) The calculated result of over burdens, production, mining costs are shown in APTable 4-10 shows the preliminary calculation result of the observation, production and mining costs every year. The mining cost will be budget figures and does not include the inhabitants' compensation expense or unexpected expenses after implementation of the pilot O/C coal mine.

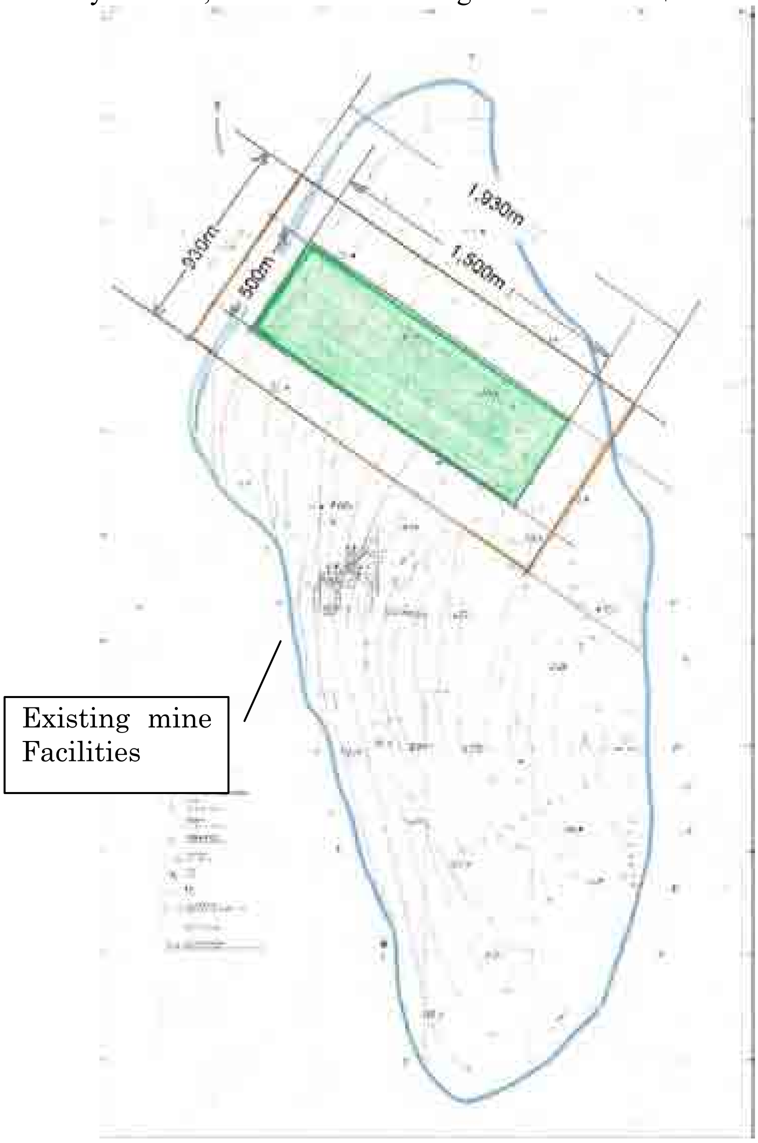
(2) The factors for preliminary calculation are used in the following Indonesian figures.

- Unit cost for stripping 2.3 US$／$m^3$
- Unit cost for coal extract 1.5 US$／t
- Truck cost for coal transport 0.14 US$／t・km

(3) The basic mining plan produces a total of 2million tons of coal for two years after the preparation works and then it will be decided whether the O/C operation continues or not after evaluating the result of the O/C mining method. It will be decided by the Bangladeshi government how much coal should be produced at the pilot O/C coal mining. However, the PSMP Study Team may suggest that the production of 2 million tons will be considered reasonable and proper because the mining cost will be US$ 75 million, a total of US$166 million including a reclamation fee and when produced coal is sold by US$ 85, the

sales income will be US$ 170million. These production figures are included in the Table 4-6.

(4) When the pilot O/C coal mining continues until 2030 and produces 53million tons, it will be economically feasible, since the total mining cost will be US$ 25.9 including reclamation.



Source: Barapukuria Coal Mine

APFig. 4-6 Working plan at the Barapukuria license area

APTable 4-10 Production plan and mining cost

No.	Item	Unit	Formula	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Av. angle (degree)			35	35	35	Evaluation of Trial O/C and preparation period of expansion of O/C area.		35	35	35	35	35	35	35	35	35	35	35	35	35
	Coal seam thickness	(m)		50	50	50			50	50	50	50	50	50	50	50	50	50	50	50	50
	Depth	(m)		150	150	150			150	150	150	150	150	150	150	150	150	150	150	150	150
	Distance	(m)		1	100	100			100	124	154	247	400	554	708	862	1,016	1,170	1,324	1,478	1,632
	Width	(m)		1	154	308			462	500	500	500	500	500	500	500	500	500	500	500	500
	Length	(m)		214	214	214			214	214	214	214	214	214	214	214	214	214	214	214	214
	S1	(m2)		1	15,400	30,800			46,200	62,000	77,000	123,500	200,000	277,000	354,000	431,000	508,000	585,000	662,000	739,000	816,000
	S2	(m2)		184,041	307,296	388,608			469,920	512,256	540,096	626,400	768,384	911,296	1,054,208	1,197,120	1,340,032	1,482,944	1,625,856	1,768,768	1,911,680
①	Total Over Barden	(1,000 m3)		9,224	19,574	26,441			33,173	37,623	41,051	51,402	68,020	84,536	100,955	117,321	133,655	149,968	166,266	182,553	198,833
②	Total Coal	(1,000 m3)		0	770	1,540			2,310	3,100	3,850	6,175	10,000	13,850	17,700	21,550	25,400	29,250	33,100	36,950	40,800
③	Total Coal[*1]	(1,000 t)		0	1,001	2,002			3,003	4,030	5,005	8,028	13,000	18,005	23,010	28,015	33,020	38,025	43,030	48,035	53,040
④	Total Stripping Ratio		①/③		19.6	13.2			11.0	9.3	8.2	6.4	5.2	4.7	4.4	4.2	4.0	3.9	3.9	3.8	3.7
	Mining Cost																				
⑤	Stripping cost	(1,000US$)	①*2.3 US$/$m^3$	21,214	45,021	60,813			76,298	86,534	94,418	118,224	156,446	194,433	232,197	269,839	307,406	344,926	382,411	419,872	457,315
⑥	Coal mining cost	(1,000US$)	③*1.5 US$/t		1,502	3,003			4,505	6,045	7,508	12,041	19,500	27,008	34,515	42,023	49,530	57,038	64,545	72,053	79,560
⑦	Coal transportation fee	(1,000US$)	③*0.14US$/t*10km		1,401	2,803			4,204	5,642	7,007	11,239	18,200	25,207	32,214	39,221	46,228	53,235	60,242	67,249	74,256
⑨	Total mining cost	(1,000US$)	⑤+⑥+⑦	21,214	47,924	66,619			85,007	98,221	108,932	141,504	194,146	246,647	298,926	351,082	403,164	455,198	507,198	559,174	611,131
⑩	Unit mining cost (a)	(US$/t)	(⑤+⑥+⑦)/③[*2]		47.9	33.3			28.3	24.4	21.8	17.6	14.9	13.7	13.0	12.5	12.2	12.0	11.8	11.6	11.5
	Water Drainage Cost																				
⑪	No. of drilling hole	Number	Span is av.50mx2holes	69	89	102			114	119	121	129	141	153	166	178	190	203	215	227	240
⑫	Drilling cost	(1,000 US$)	150US$/m x 200m	2,070	2,670	3,060			3,420	3,570	3,630	3,870	4,230	4,590	4,980	5,340	5,700	6,090	6,450	6,810	7,200
⑬	Piping & other cost	(1,000 US$)	⑫*0.2	414	534	612			684	714	726	774	846	918	996	1,068	1,140	1,218	1,290	1,362	1,440
⑭	Electricity cost	(1,000 US$)	100kw x 0.05US$/kwh	3,022	3,898	4,468			4,993	5,212	5,300	5,650	6,176	6,701	7,271	7,796	8,322	8,891	9,417	9,943	10,512
⑮	Total drilling & others cost	(1,000 US$)	⑫+⑬+⑭	5,506	7,102	8,140			9,097	9,496	9,656	10,294	11,252	12,209	13,247	14,204	15,162	16,199	17,157	18,115	19,152
⑯	Ratio of drilling cost		⑮/(⑨+⑮)	0.21	0.13	0.11			0.10	0.09	0.08	0.07	0.05	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03
	Total Mining Cost A (US$/t)		(⑨+⑮)/③		55.0	37.3			31.3	26.7	23.7	18.9	15.8	14.4	13.6	13.0	12.7	12.4	12.2	12.0	11.9
	Reclamation Cost																				

	Item	Unit	Formula	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
⑰	Transporting fee	(1,000 US$)	(①+②)x1.3t/m3x0.14US$/tx10km		27,404	37,017			46,442	52,673	57,472	71,963	95,228	118,350	141,337	164,250	187,117	209,955	232,772	255,574	278,366
⑱	Reclamation cost	(1,000 US$)	(①+②)x1.3t/m^3x1.5US$/t		39,672	54,562			69,192	79,411	87,558	112,275	152,139	191,853	231,377	270,799	310,157	349,474	388,763	428,031	467,284
⑲	Total Reclamation Cost	(1,000 US$)	⑰+⑱		67,076	91,579			115,635	132,084	145,029	184,238	247,367	310,203	372,714	435,048	497,274	559,429	621,535	683,605	745,649
⑳	Total Mining Cost B (US$/t)		(⑨+⑮+⑲)/③		122.0	83.1			69.8	59.5	52.7	41.9	34.8	31.6	29.8	28.6	27.7	27.1	26.6	26.2	25.9
	Balance of each year																				
	Over Barden of each year	(1,000m3)		184,041	10,351	6,866			6,733	4,450	3,428	10,351	16,618	16,516	16,419	16,366	16,334	16,313	16,298	16,287	16,280
	Coal production of each year	(1,000 m3)			770	770			770	790	750	2,325	3,825	3,850	3,850	3,850	3,850	3,850	3,850	3,850	3,850
	Coal production of each year	(1,000 t)			1,001	1,001			1,001	1,027	975	3,023	4,973	5,005	5,005	5,005	5,005	5,005	5,005	5,005	5,005
	Ratio of Volume (OB:Coal)				10.3	6.9			6.7	4.3	3.5	3.4	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3

calculated value

Volume of frustum of pyramid (m3)= $\frac{3}{d}\left(S1+S2+\sqrt{(S1\times Sw)}\right)$

S1: Bottom area (m3) =D x W

S2: Top area (m3) =(214 + W + 214) x (214 + D +214)

d: depth

Example of Y 2014

D=100m S1= 100*154

W=154m = 15,400 m3

d=150m S2= (214+154+214)*(214+100+214)

= 307,296 m3

$$V=\frac{150}{3}\left(15.400+307.296+\sqrt{(15.400\times 307.296)}\right)$$

= 19,574,407 m3

Source: PSMP Study Team

4.4 APPENDIX-4 Import coal price scenario

4.4.1 FOB price of import coal

(1) Pricing structure of FOB

Coal prices differ depending on where the coal was produced and other specifications. However, in general, the trend towards Indonesian Coal is cheaper than for Australian Coal when the coal specifications are the same. During price negotiations, the direct cost for coal production of each mine must be taken into consideration. For example, the direct cost of a mining contractor for the O/C coal mine in East Kalimantan Indonesia in 2008 was as follows. This cost escalated to about 2 times the cost in 2007 because of the steep rise in fort fuel and other prices.

- Stripping Cost : 2.3 US$／$m^3$
- Coal Extraction Cost : 1.5 US$／ton
- Coal Truck Costs：0.14 US$／ton・km
- Crushing and Loading to Barge：3.5 US$／ton
- Barge Transport to a Big Ship about 150km and loading to it：8 US$／ton

For example, when the stripping ratio is 8 and the road distance between the pit and loading point is 50 km、the direct cost of this mine is shown at the next calculation.

Direct cost = Extraction Cost [(2.3×8)＋1.5]＋Truck cost (0.14×50)＋Handling cost 3.5＋Barg cost 8 = (18.4+ 1.5) + ＋7＋3.5＋8＝34.9 US$/ton

The FOB is the above figure plus Management cost and profit. This price is the minimum index for FOB. But the exporter‘s desire is influenced by the international market.

The direct cost has no relation with coal specifications. From this point of view, high price mine development and high quality coal are possible in remote areas. However, in the event of low prices and low quality coal, it is desirable for mine development that the coal seam is thick, the stripping ratio is low and the pit location is nearby the river or sea port because of low transport costs.

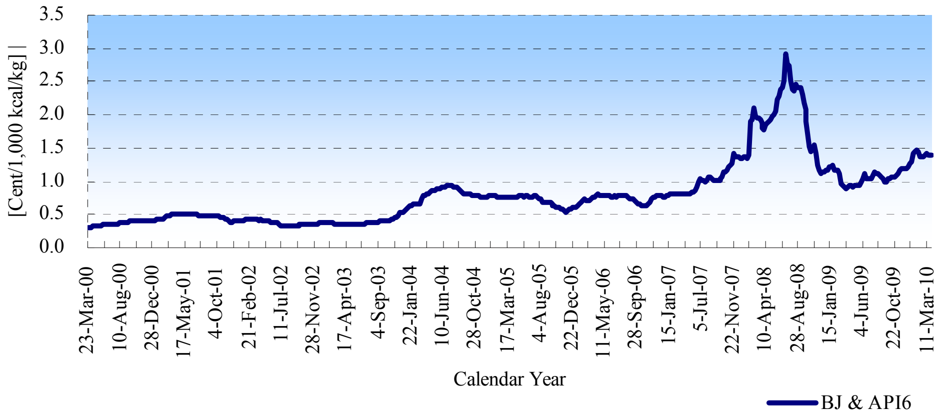
Regarding land transportation, FOB is the same structure of sea transportation. Land transport will be utilized for Indian coal. At present coals are imported from the neighboring Megalaya in India for brick factories and most of the coals are transported by truck.

For power plant handling, the volume of coal is large. It is practical to have the coal directly transported to the power plant by rail because the rail is appropriate for mass transport. Its cost is cheaper than trucks but higher than barges.

(2) Varying prices of FOB

APFig. 4-7 depicts the EIA world coal consumption trend. Based on this, coal consumption has been escalating since 2002. When coal consumption was stable, coal prices were also stable. Recently, coal prices rose because of a supply shortage due to a rapid increase of coal consumption in NON OECD countries. On the other hand, coal resources which were in the past falsely assumed to be un-minable are now being mined resulting in a coal supply increase. Therefore, the coal price will increase until the balance of supply and demand becomes stable.

As a reference, APFig. 4-7 shows a spot price fluctuation of USA Cent/1,000 Kcal/kg for FOB price of 6,700Kcal/kg steaming coal at New Castle for the 10 year period between March 2000 and March 2010. From this graph, it reveals that before September 2003, the coal price was about 0.5 cents, after that the price rapidly rose and peaked in July 2008. There is no graph in this figure, the price also stabilized at about 0.5 cents for the period between 1995 and March 2003. Though understandable, it becomes difficult to estimate future coal prices given recent price fluctuation.



Source： BJ spot price (up to 15th November 2002), Data from A/M API6 (After 15th November 2002)

APFig. 4-7 FOB fluctuation at New Castle Port

(3) Forecast of the FOB price

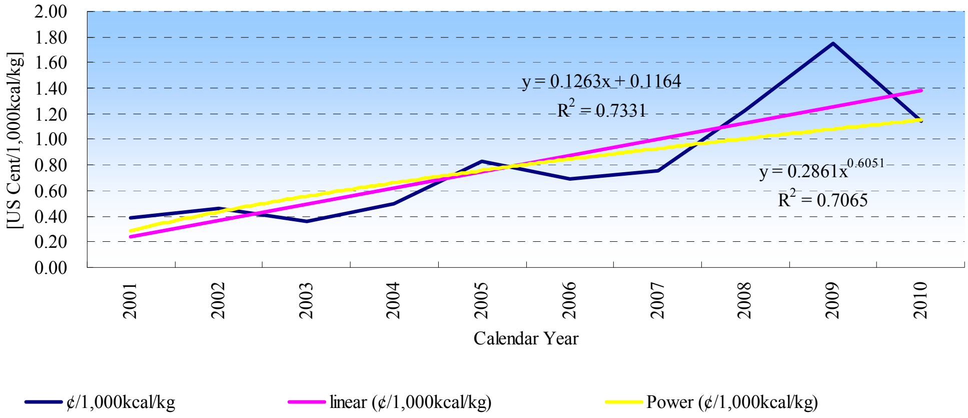
Using data from APFig. 4-7, the FOB spot price to 2030 is an estimate. Regarding the method, every year's average is shown on APTable 4-11 and the graphs are shown at APFig. 4-8. Approximations are calculated using a linear formula and a power approximation formula and the results are shown at APTable 4-12. On this Table, every average reveals a simple average calculated by a linear formula and a power approximation formula. For reference, coal prices were calculated at the case of HVV (High Heating Value) = 6,100kcal/kg.

In addition, the spot price per this 1,000kcal/kg is handled for uniformity regardless of coal quality. Generally when coal quality falls, spot price per 1,000kcal/kg and the long-term contract price tend to fall down, but treat it for uniformity to treat it to take the price risk be a safe side.

APTable 4-11 Average unit price of FOB at New Castle Port 2000－2010

Year	¢/1,000kcal/kg
2001	0.39
2002	0.462
2003	0.361
2004	0.493
2005	0.825
2006	0.694
2007	0.756
2008	1.227
2009	1.754
2010	1.146

Source： BJ spot price (up to 15th November 2002), Data from A/M API6 (After 15th November 2001)



Source: PSMP Study Team based on APTable 4-11

APFig. 4-8 Year's average FOB and approximate functions

APTable 4-12 Estimated unit price of FOB at New Castle Port by 2030

Year	US ¢ /1,000kcal/kg	US ¢ /1,000kcal/kg			US$/6,100kcal/kg		
		Reference	High	Base	Reference	High	Base
		Linear	Average	Power	Linear	Average	Power
		Y=0.1263 X+0.1164		Y=0.2861 X^0.6051	Y=0.1263 X+0.1164		Y=0.2861 X^0.6051
2001	0.390439	0.24	0.26	0.29	14.8	16.1	17.5
2002	0.461799	0.37	0.40	0.44	22.5	24.5	26.5
2003	0.360992	0.50	0.53	0.56	30.2	32.1	33.9
2004	0.493253	0.62	0.64	0.66	37.9	39.1	40.4
2005	0.824985	0.75	0.75	0.76	45.6	45.9	46.2
2006	0.694432	0.87	0.86	0.85	53.3	52.5	51.6
2007	0.755725	1.00	0.96	0.93	61.0	58.8	56.7
2008	1.226690	1.13	1.07	1.01	68.7	65.1	61.4
2009	1.754448	1.25	1.17	1.08	76.4	71.2	66.0
2010	1.146202	1.38	1.27	1.15	84.1	77.2	70.3
2011		1.51	1.36	1.22	91.8	83.2	74.5
2012		1.63	1.46	1.29	99.6	89.0	78.5
2013		1.76	1.55	1.35	107.3	94.8	82.4
2014		1.88	1.65	1.41	115.0	100.6	86.2
2015		2.01	1.74	1.47	122.7	106.3	89.8
2016		2.14	1.83	1.53	130.4	111.9	93.4
2017		2.26	1.93	1.59	138.1	117.5	96.9
2018		2.39	2.02	1.64	145.8	123.1	100.3
2019		2.52	2.11	1.70	153.5	128.6	103.7
2020		2.64	2.20	1.75	161.2	134.1	106.9
2021		2.77	2.29	1.81	168.9	139.5	110.1
2022		2.90	2.38	1.86	176.6	144.9	113.3
2023		3.02	2.46	1.91	184.3	150.3	116.4
2024		3.15	2.55	1.96	192.0	155.7	119.4
2025		3.27	2.64	2.01	199.7	161.0	122.4
2026		3.40	2.73	2.05	207.4	166.4	125.3
2027		3.53	2.81	2.10	215.1	171.7	128.2

Year	US ¢ /1,000kcal/kg	US ¢ /1,000kcal/kg			US$/6,100kcal/kg		
		Reference	High	Base	Reference	High	Base
		Linear	Average	Power	Linear	Average	Power
		Y=0.1263 X+0.1164		Y=0.2861 X^0.6051	Y=0.1263 X+0.1164		Y=0.2861 X^0.6051
2028		3.65	2.90	2.15	222.8	176.9	131.1
2029		3.78	2.99	2.19	230.5	182.2	133.9
2030		3.91	3.07	2.24	238.2	187.4	136.7

Source： PSMP Study Team

4.4.2 Price of CIF

(1) Content and variation of CIF price

In general, the CIF price includes FOB and sea transport costs (freight, insurance and others). The bulk freight market is very volatile, and it fluctuates, along with the type of cargo, the size of the ship and the route traveled all affect the final price.

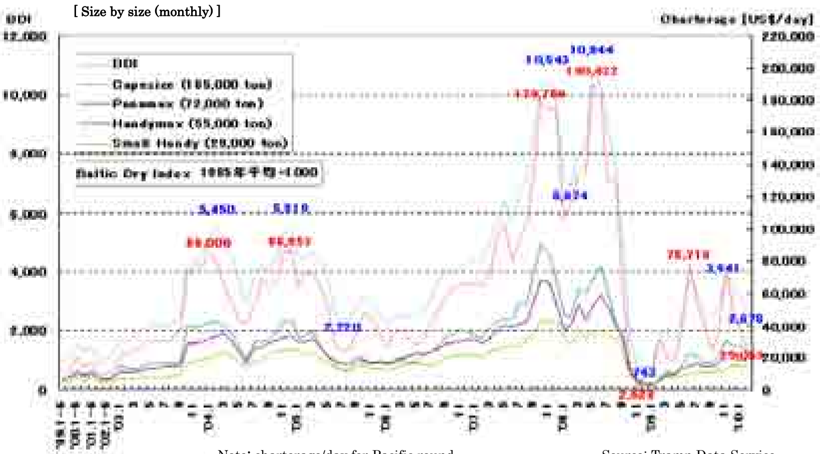
The cost to move the cape size ship of coal from South America to Europe was around US$15 to US$25 per ton in 2005. According to the Energy White Paper 2008, it has been reported that the Australian steaming coal price for FOB was US$ 55.50 per ton higher than the previous year's agreement. On the other hand, according to the Coal Yearbook, the 2009 coal price for CIF was US$70.56 per ton. From these points, the freight between Australia and Japan was estimated at US$15 per ton.
According to CoalinQ.com on April 1st 2010, the steaming coal price for FOB at New Castle was US$ 93.65 /ton and CIF in Japan was US$117.15/ton so that the freight was US$26.5/ton.

Some shippers choose to charter a ship, paying a daily rate instead of a set price per ton. In 2005, the average daily rate for a Handymax ship varied between US$18,000 – US$30,000. A Panamax ship could be chartered for $20,000 – $50,000 per day, and a Cape size for $40,000 – $70,000 per day
There is the Baltic Dry Index (BDI) which shows a bulk carrier price fluctuation. APFig. 4-9 reveals the change of charterage of every size of bulk carrier per day on the web Mitsui O.S.K. Lines, Ltd.

For example, when a Small Handy (28,000 tons) shown at Fig 5-40 is chartered at the charge of US$ 15,000/day, the annual charge is US$5,475,000. If a ship sails from the port of South East Kalimantan (South latitude 4°east longitude 115°) to the port of Bangladesh (North latitude 22°east longitude 92°), the distance is 2,100 sea miles by plane and the sailing distance will be 2,500 sea miles increasing by 20%. When cruising speed is 14 knots/hour, one way sailing becomes 176 hours =7.3 days. The estimated handling time for loading 2 days and unloading 2 days, the total sailing time is about 19 days. The number of times of sailing per year is 19 times in 365 days per year. But thinking about climate and other possible sailing times will be 80%, 15 times per year and coal tonnage per year by ship is 15×28,000＝420,000. Therefore, the charterage /ton is US$ 5,475,000/year ÷420,000 tons/year = US$ 13 /ton. Sea transport costs are charterage plus fuel, insurance and other costs which become about US$ 15 /ton. So in this case, the CIF is an estimated US$ (FOB＋15） per ton.

1. Dry Bulk Ship

① Marcket Change for Dry Bulk Ship
[Size by size (monthly)]



Note: charterage/day for Pacific round   Source: Tramp Data Service

Charterage (US$/day).   Upper Sells: average of calendar year.   Lower Sells: average of fiscal year

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Capesize	21,445	12,988	11,433	40,370	66,075	47,278	44,469	112,097	101,106	3,995
	21,437	10,676	14,834	53,524	64,506	38,095	53,428	124,617	76,841	42,182
Panamax	12,008	9,214	8,114	21,645	34,751	21,955	25,143	55,138	43,167	17,065
	12,291	7,764	9,690	28,627	32,976	17,865	29,336	59,356	32,008	22,078
Handymax	10,414	8,474	7,263	17,046	29,070	21,843	23,927	44,839	35,818	13,575
	10,566	7,425	8,451	22,575	28,336	18,592	27,235	47,975	26,605	17,306
small Handy	7,152	6,088	5,552	10,438	20,483	16,601	16,991	30,389	26,014	9,554
	7,261	5,670	6,046	13,958	20,914	14,078	19,225	33,166	19,216	11,978
BDI	1,606	1,215	1,144	2,634	4,521	3,404	3,188	7,091	6,347	2,613
	1,620	1,083	1,332	3,517	4,346	2,870	3,745	7,768	4,895	2,978

Charterage (US$/day).   Upper Sells: average of calendar year.   Lower Sells: average of fiscal year

	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Capesize	12,839	31,562	20,579	17,898	37,660	78,718	54,941	42,004	24,618	34,885	73,372	50,258
	36,876	25,053	29,899	28,140	41,796							
Panamax	2,232	7,719	11,655	10,060	15,445	22,772	21,137	17,404	16,673	21,239	31,264	27,175
	27,536	23,716	30,520	30,644	32,318							
Handymax	3,549	6,474	9,406	9,595	13,415	14,289	16,645	14,481	14,107	16,681	22,277	22,077
	20,635	17,461	26,105	22,904	25,955							
small Handy	3,840	5,460	8,310	7,083	8,569	10,089	9,914	10,956	10,892	11,259	12,742	15,539
	15,293	14,228	17,177	18,442								
BDI	905	1,816	1,958	1,659	2,540	3,823	3,362	2,685	2,351	2,746	3,941	3,572
	3,168	2,678	3,207	3,043	3,838							

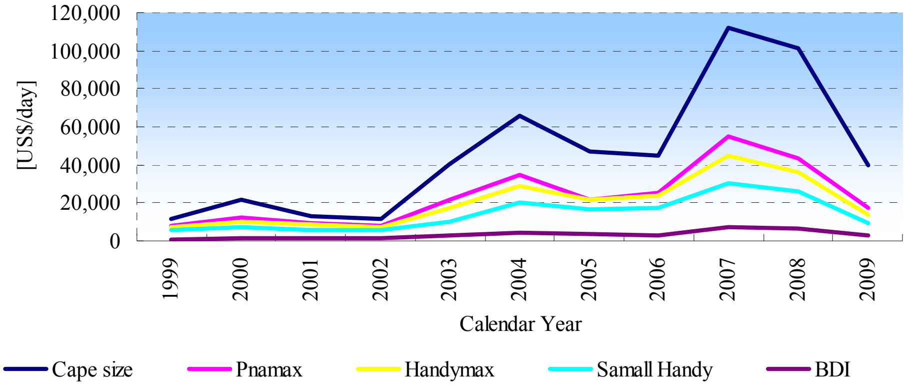
Source: Shosen Mitsui WEB site

APFig. 4-9   Change of charterage for dry bulk carrier in Marcc

(2)   Estimation of freight and insurance (F & I)

As mentioned above, the international charterage wildly fluctuates making future forecasting very difficult. It shows the fluctuation of the monthly average chartarge per day. Here for example based on APFig. 4-9, sea transport costs (Freight & Insurance) for Small Handy has been estimated until 2030 calculating the increasing ratio and is proportional to US$15 included charterage, fuel and insurance in 2010

APFig. 4-10 shows the charterage of a Small Handy in dry bulk carriers. Further, APFig. 4-11 shows the approximation formulas to estimate the chart rages of Small Handy.



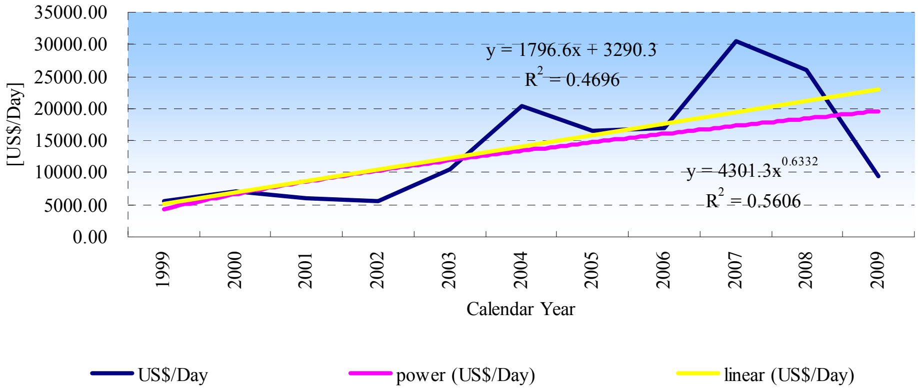
Source: PSMP Study Team based on APFig. 4-9

APFig. 4-10 Charterage of dry bulk carriers

APTable 4-13 Charterage of small handy

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
US$/Day	5,507	7,152	6,088	5,552	10,438	20,483	16,601	16,991	30,389	26,014	9,554

Source: PSMP Study Team based on Fig. APFig. 4-9



Source: PSMP Study Team based on APFig. 4-9.

APFig. 4-11 Approximation formulas to estimate charterage of small handy

APTable 4-14 shows the estimated total value (Freight and Insurance) between 2010 and 2030 in the High Case and Base Case in APFig. 4-11. The High Case shows the intermediate value from the value of Reference Case calculated via a linear approximation Formula and from values calculated via a power approximation formula while the Base case shows the value from a power approximation formula.

APTable 4-14 Freight & insurance estimation

Year	Reference Case		High Case	Base case	
	Approximation Formula of Linearization		Intermediate value	Approximation Formula of Power	
	Y=1796.6X+0.6332			Y=4301.3X^0.6332	
	Increasing Rate	US$/t of F & I	US$/t of F & I	Increasing Rate	US$/t of F & I
2010	1.00	15.0	15.0	1.00	15.0
2011	1.07	16.1	15.9	1.05	15.8
2012	1.14	17.2	16.9	1.10	16.5
2013	1.22	18.3	17.8	1.15	17.3
2014	1.29	19.3	18.7	1.20	18.0
2015	1.36	20.4	19.6	1.25	18.7
2016	1.43	21.5	20.4	1.29	19.4
2017	1.51	22.6	21.3	1.34	20.1
2018	1.58	23.7	22.2	1.38	20.7
2019	1.65	24.8	23.1	1.43	21.4
2020	1.72	25.8	23.9	1.47	22.0
2021	1.80	26.9	24.8	1.51	22.6
2022	1.87	28.0	25.6	1.55	23.3
2023	1.94	29.1	26.5	1.59	23.9
2024	2.01	30.2	27.3	1.63	24.5
2025	2.08	31.3	28.2	1.67	25.1
2026	2.16	32.4	29.0	1.71	25.7
2027	2.23	33.4	29.8	1.75	26.2
2028	2.30	34.5	30.7	1.79	26.8
2029	2.37	35.6	31.5	1.82	27.4
2030	2.45	36.7	32.3	1.86	27.9

Source: PSMP Study Team

4.4.3 Cost of handling imported coal

The handling costs of imported coal includes the cost for loading coal to barges, coal transport costs by barges to the power plants at riverside and handling costs at the coal center after arriving from overseas. In the event that a power plant is located at riverside and barge cost is the same as that with Indonesia, about US$ 0.04/ton*km, the Handling cost of import coal will estimated as follows:

When the barge distance is 200km. Expenses (import taxes and others) will be US$ 2/t, the handling costs of loading & unloading at the stock yard is US$ 2/t, a total of 200×0.04+2+2＝US$12/tons.

Utilizing the 6% inflation ratio in Bangladesh between 2003 and 2009, the handling cost of imported coal has been estimated and is shown on APTable 4-15 when the inflation ratio is 6% every year and US$12 in 2010 is the base value.

When the power plant has exclusive berth and coal yard, handling cost of imported coal becomes the cheapest. When the power plant obtains coal from the coal center, it increases.

APTable 4-15 Domestic handling cost estimation in Bangladesh (Barging and other)

Year	Inflation Rate	Handling
	(%)	Cost (US$/t)
2010	6	12.0
2011	6	12.7
2012	6	13.5
2013	6	14.3
2014	6	15.1
2015	6	16.1
2016	6	17.0
2017	6	18.0
2018	6	19.1
2019	6	20.3
2020	6	21.5
2021	6	22.8
2022	6	24.1
2023	6	25.6
2024	6	27.1
2025	6	28.8
2026	6	30.5
2027	6	32.3
2028	6	34.3
2029	6	36.3
2030	6	38.5

Source: PSMP Study Team

4.5 APPENDIX – 5 Coal center

4.5.1 Outline of coal center

Following shows an example of coal center. Following is the overview of Onahama Coal Center which is owned by TEPCO. Coal center consists of three parts, those are “Loading Facility” which receives import coal, “Coal Storage Facility” which is from receives to delivery, and “Unloading Facility” which deliver coal to domestic vessel which transport to the power plant.

TEPCO Onahama Coal Center is located in Iwaki city, Fukushima Pref., its purpose is to relay coal which is used at Hirono thermal power station #5 unit (coal-fired 600MW USC) which is located in Hirono Town, Fukushima Pref., its area is 220,000 m^2, (including 62,000 m^2 of coal stock yard), maximum storage of coal is 165,000 t, annual coal treatment amount is 1.2 million t, annual number of import vessel is 18, annual number of domestic vessel is 100. The scale is a little smaller than that this MP is proposing, however the contents is not so different. Following table shows the scale and capacity of major coal centers in Japan.

Source: Tokyo Electric Power Company Inc.

APFig. 4-12 TEPCO Onahama Coal Center

Unloading (Import vessel)

Import vessel (example):
65,500t
Length 225m, Width 32m

Unloader
1,400t/h, Height 43m

Belt conveyer (receive)
1,550t/h, Length 1.3km

Stacker
2,000t/h
Max piling height 9m

Coal stock yard
Max capacity 165,000t
461m x 37m, 2pile

Loading (domestic vessel)

Domestic coal vessel "YAMAYURI":
12,000t, Length 140m, Width 26m, Self unloading type

Reclaimer
1,000 t/h x 2

Belt conveyer (deliver)
2,400t/h, Length 900m

Ship loader
2,400t/h, Height 23.5m

Source: Tokyo Electric Power Company Inc.

APFig. 4-13 Main equipments of Onahama Coal Center

APTable 4-16 Major Coal Center in Japan

	Ube Kosan Coal Center	Tomato Coal Center	Chubu Coal Center	Shimomatsu Coal Relay Base	Idemitsu Bulk Terminal
Location	Yamaguchi Pref.	Hokkaido	Mie Pref.	Yamaguchi Pref.	Chiba Pref.
Owner/ Shareholder	Japan Trustee Service Bank, etc.	Hokkaido EPCO, Japan Coal Development Co. Oji Paper etc.	Sumitomo Corp., Japan Transcity Corporation, Etc.	JX Nippon Oil & Energy	Idemitsu Kosan
Main User	Power, Cloths etc.	Hokkaido EPCO etc.	Cement, Chemical, Cloths, Power, etc.	Chugoku EPCO	Idemitsu Kosan, Cement, neighbor factories
Coal Stock Capacity	2.5 million t	660,000 t	1 million t	300,000t	350,000t
Annual Treatment Amount	6.25 million t	4 million t	4.million t	2.7 million t	1.5 million t

Source: “Coal Note” 2008 edition

Chapter 5 Natural Gas Sector APPENDIX

APTable 5-1 Natural Gas Property of Bangladesh

		Water Content	Chemical Composition of Natural Gas (Volume Percent)								Specific Gravity	Gross Calorific Value (Btu/cft)	Hydrogen Sulphaide
SI No.	Gas Field	(lb/MMSCF)	Methane	Ethane	Propane	Iso-Butane	N-Butane	High Comp.	Nitrogen	Carbon di-oxide			
1	Sylhet	1.20	96.63	2.00	0.05	0.14	0.01	0.17	1.06	0.36	0.57	1,020.00	Nil
2	Chattack	n/a	97.90	1.80	0.20	-	-	-	-	-	-	1,005.71	Nil
3	Rashidpur	1.20	98.00	0.21	0.24	-	-	0.17	0.40	0.18	0.57	1,024.00	Nil
4	Kailastila	0.70	95.57	2.70	0.94	0.21	0.20	0.14	0.00	0.14	0.59	1,030.00	Nil
5	Titas	4.60	96.76	1.80	0.39	0.10	0.07	0.06	0.04	0.42	0.58	1,029.00	Nil
6	Habiganj	4.10	97.81	1.48	-	-	-	-	0.71	0.00	0.57	1,016.00	Nil
7	Bakhrabad	4.00	94.01	3.69	0.81	0.25	0.09	0.06	0.47	0.49	0.59	1,050.00	Nil
8	Semutang	n/a	96.94	1.70	0.14	-	0.01	-	0.86	0.35	-	-	-
9	Begumganj	n/a	95.46	3.19	0.64	0.17	0.04	-	-	0.30	0.58	1,045.61	Nil
10	Kutubdia	n/a	95.72	2.87	0.67	-	0.31	-	0.36	0.07	0.59	1,041.66	Nil
11	Beanibazar	4.40	93.68	3.43	1.10	0.29	1.23	0.17	0.99	0.12	0.60	1,061.95	Nil
12	Feni	n/a	95.71	3.29	0.65	0.15	0.05	-	-	0.15	0.58	1,049.84	Nil
13	Kamta	n/a	95.36	3.57	0.47	0.09	-	-	-	0.51	0.57	1,043.13	Nil
14	Fenchuganj	n/a	98.10	1.00	0.09	0.03	0.02	-	0.14	0.35	0.56	1,014.58	Nil
15	Jalalabad	n/a	96.02	2.45	0.56	0.30	0.07	0.30	0.26	0.05	0.59	1,054.01	Nil
16	Narsingdi	3.20	95.66	2.46	0.55	0.15	0.10	0.08	0.45	0.55	0.59	1,035.00	Nil
17	Meghna	4.40	95.16	3.06	0.65	0.17	0.10	0.04	0.39	0.43	0.59	1,043.00	Nil
18	Shahbazpur	n/a	93.68	3.94	0.71	0.20	0.07	0.04	0.46	0.90	0.58	1,046.21	Nil
19	Sangu	n/a	94.51	3.17	0.61	0.19	0.07	0.41	0.44	0.60	0.59	1,058.00	Nil
20	Saldanadi	n/a	95.12	2.20	0.91	0.29	0.18	-	0.14	0.43	0.59	1,057.48	Nil
21	Bibiyana	n/a	95.72	2.37	0.87	0.22	0.18	0.32	0.19	0.13	0.59	1,059.00	Nil
22	Bangura	2.11	95.48	2.56	0.66	0.15	0.15	0.19	0.31	0.66	0.59	1,049.20	Nil
23	Moulavibzar	n/a	97.82	1.29	0.24	0.09	0.05	0.14	0.29	0.08	0.57	1,028.74	Nil
	average		95.95	2.44	0.55	0.18	0.16	0.16	0.42	0.33	0.58	1,039.19	Nil

Source： Petrobangra Annual Report 2008）

APTable 5-2 Long Term Gas Production Forecast（Government Target Case）2009/10～2029/30

	Company	Sl. No.	Name of Gas Fields	Recoverable Reserve P1+P2+P3	P1	P2	P3	Cummulitive Production June2009	Remaining P1+P2+P3 Reserve	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
				Bcf						mmcfd																					
National	BGFCL	1	Titas Gas Field	8,299	7,441	140	718	2,996	5,303	395	408	453	578	578	578	578	678	678	650	650	600	600	600	600	600	600	600	600	550	500	485
		2	Bakhrabad Gas Field	1,587	1,106	217	264	692	895	33	36	36	56	56	56	56	56	100	100	150	150	150	150	150	100	100	90	90	10	0	0
		3	Habiganj Gas Field	3,221	2,416	372	433	1,617	1,604	236	240	260	265	270	270	275	275	275	275	250	200	100	0	0	0	0	0	0	0	0	0
		4	Narshingdi Gas Field	292	214	3	75	99	193	33	33	33	33	33	33	33	33	20	20	10	0	0	0	0	0	0	0	0	0	0	0
		5	Meghna Gas Field	101	49	0	52	36	65	0	0	15	10	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		6	Begumganj Gas Field	109	10	23	76	0	109	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	0	0	0	0	0	0
		7	Kamta Gas Field	50	19	31	0	21	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10
	SGFL	8	Sylhet Gas Field	466	301	71	94	189	277	2	7	15	15	15	15	25	25	25	25	25	25	25	40	70	70	39	0	0	0	0	0
		9	Kailashtila Gas Field	3,011	2,126	527	358	466	2,545	91	97	97	97	97	97	97	127	202	277	320	370	390	480	500	500	500	450	499	297	242	27
		10	Rashidpur Gas Field	4,010	2,465	685	860	448	3,562	50	49	49	84	84	84	84	124	220	270	330	342	470	518	600	600	600	584	550	550	550	550
		11	Beanibazar Gas Field	170	118	20	32	57	113	15	16	16	16	16	16	16	16	16	16	16	16	14	10	5	0	0	0	0	0	0	0
	BAPEX	12	Salda Gas Field	390	151	115	124	59	331	10	8	38	38	38	38	38	38	38	38	38	38	38	38	38	38	10	5	0	0	0	0
		13	Fenchuganj gas field	406	170	111	125	60	346	27	25	45	65	65	65	65	65	65	30	30	30	20	0	0	0	0	0	0	0	0	0
		14	Shahbajpur gas Field	318	224	39	55	0	318	0	8	8	8	8	8	8	8	60	80	80	80	80	80	80	80	20	0	0	0	0	0
		15	Semutang Gas Field	369	110	208	51	0	369	0	0	15	15	15	15	15	15	15	15	15	25	25	25	25	25	50	50	50	75	75	75
		16	From New Discovery							0	0	45	60	60	60	60	60	60	60	60	80	80	80	80	80	80	80	80	80	80	80
		17	Chattak(East)							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				22,799	**16,920**	**2,562**	**3,317**	**6,741**	**16,058**	**892**	**927**	**1,125**	**1,340**	**1,340**	**1,340**	**1,350**	**1,520**	**1,784**	**1,866**	**1,984**	**1,966**	**2,002**	**2,031**	**2,158**	**2,103**	**2,009**	**1,869**	**1,879**	**1,572**	**1,457**	**1,227**
IOC	Chevron	18	Jalalabad gas Field	1,727	996	249	482	509	1,218	158	130	130	230	230	280	380	380	95	0	0	0	0	0	0	0	0	0	0	0	0	0
		19	Maulavibazar gas field	1,233	625	264	344	140	1,093	74	60	90	160	160	210	310	360	360	250	10	0	0	0	0	0	0	0	0	0	0	0
		20	Bibiyana gas Field	5,971	4,426	771	774	361	5,610	527	716	716	816	916	1,016	1,116	1,166	1,166	1,156	1,132	845	799	560	400	76	50	50	10	5	0	0
	Cairn	21	Sangu gas Field	801	514	182	105	458	343	50	40	40	40	40	40	40	40	30	30	30	30	20	20	20	20	20	20	20	20	20	20
		22	Sangu gas (South) Field							0	0	30	30	30	30	30	30	30	30	30	30	0	0	0	0	0	0	0	0	0	0
	Tullow	23	Bangura gas Field	708	544	70	94	79	629	87	120	120	120	120	120	120	120	90	90	90	90	90	60	15	10	0	0	0	0	0	0
	Niko	24	Feni gas Field	202	27	103	72	62	140	3	2	2	2	2	2	2	2	2	2	2	2	2	2	10	20	20	20	20	20	20	20
		25	Chattak Gas Field (West)	727	265	209	253	26	701	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	50	50	50	50
	B: Total IOC-1			**11,369**	**7,397**	**1,848**	**2,124**	**1,635**	**9,734**	**899**	**1,068**	**1,128**	**1,398**	**1,498**	**1,698**	**1,998**	**2,098**	**1,773**	**1,558**	**1,344**	**1,047**	**961**	**692**	**495**	**176**	**140**	**140**	**100**	**95**	**90**	**90**
		26	From New Discovery(Blocks- 7)							0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100
		27	Block-16 (Magnama/Hatia/Manpura)							0	0	0	0	0	0	0	0	50	50	50	100	100	100	100	100	100	100	100	100	100	100
		28	Block-17 & 18							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		29	Offshore Bidding-2008 (IOC-3) 1							0	0	0	0	0	0	0	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
		30	From New Discovery (Netrokona, Block 11)																100	100	100	100 100	100 100	100 100	100 100	100 100	100 200	100 200	100 200	100 200	100 200
	C: Total IOC-2									**0**	**0**	**0**	**0**	**0**	**0**	**0**	**200**	**350**	**450**	**450**	**500**	**600**	**600**	**600**	**600**	**600**	**700**	**700**	**700**	**700**	**700**
	Total IOCs (B+C)									**899**	**1,068**	**1,128**	**1,398**	**1,498**	**1,698**	**1,998**	**2,298**	**2,123**	**2,008**	**1,794**	**1,547**	**1,561**	**1,292**	**1,095**	**776**	**740**	**840**	**800**	**795**	**790**	**790**
			Petrobangla + IOC							**1,791**	**1,995**	**2,253**	**2,738**	**2,838**	**3,038**	**3,348**	**3,818**	**3,907**	**3,874**	**3,778**	**3,513**	**3,563**	**3,323**	**3,253**	**2,879**	**2,749**	**2,709**	**2,679**	**2,367**	**2,247**	**2,017**
			LNG (Import)							0	0	0	0	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
	D: Total LNG									**0**	**0**	**0**	**0**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**	**500**
	E: Total IOCs (B+C+D) + LNG									**899**	**1,068**	**1,128**	**1,398**	**1,998**	**2,198**	**2,498**	**2,798**	**2,623**	**2,508**	**2,294**	**2,047**	**2,061**	**1,792**	**1,595**	**1,276**	**1,240**	**1,340**	**1,300**	**1,295**	**1,290**	**1,290**
Total	**F: Petrobangla+IOC-1+IOC-2 (A+B+E)**			**34,168**	**24,317**	**4,410**	**5,441**	**8,376**	**25,792**	**1,791**	**1,995**	**2,253**	**2,738**	**3,338**	**3,538**	**3,848**	**4,318**	**4,407**	**4,374**	**4,278**	**4,013**	**4,063**	**3,823**	**3,753**	**3,379**	**3,249**	**3,209**	**3,179**	**2,867**	**2,747**	**2,517**

Source: PSMP Study Team

APTable 5-3 Long Term Gas Production Forecast（PSMP Study Case 1）2009/10～2029/30

	Company	Sl. No.	Name of Gas Fields	Recoverable Reserve P1+P2	P1	P2	P3	Cummulitive Production June2009	Remaining P1+P2 Reserve	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
				Bcf						mmcfd																					
National	BGFCL	1	Titas Gas Field	7,581	7,441	140	718	2,996	4,585	395	408	453	560	565	578	578	678	678	650	650	600	600	600	600	600	600	600	600	550	500	485
		2	Bakhrabad Gas Field	1,323	1,106	217	264	692	631	33	36	36	46	46	51	51	56	56	56	56	56	56	56	56	56	56	56	56	10	10	0
		3	Habiganj Gas Field	2,788	2,416	372	433	1,617	1,171	236	240	260	260	260	260	260	260	260	260	250	200	100	50	31	17						
		4	Narshingdi Gas Field	217	214	3	75	99	118	33	35	35	30	30	30	25	25	20	20	10	0	0	0	0	0	0	0	0	0	0	0
		5	Meghna Gas Field	49	49	0	52	36	13	0	0	10	10	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		6	Begumganj Gas Field	33	10	23	76	0	33	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	0	0	0	0	0	0
		7	Kamta Gas Field	50	19	31	0	21	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10
	SGFL	8	Sylhet Gas Field	372	301	71	94	189	183	2	7	25	25	25	25	25	25	25	25	25	25	25	40	40	35	35	0	0	0	0	0
		9	Kailashtila Gas Field	2,653	2,126	527	358	466	2,187	91	97	97	97	97	97	97	127	140	156	274	274	274	274	274	274	274	252	250	200	200	200
		10	Rashidpur Gas Field	3,150	2,465	685	860	448	2,702	50	49	49	84	84	84	84	124	174	270	350	350	430	430	530	530	587	584	556	490	520	455
		11	Beanibazar Gas Field	138	118	20	32	57	81	15	15	15	15	15	15	15	15	15	16	16	16	16	16	0	0	0	0	0	0	0	0
	BAPEX	12	Salda Gas Field	266	151	115	124	59	207	10	8	23	35	8	8	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		13	Fenchuganj gas field	281	170	111	125	60	221	27	24	44	64	64	65	65	65	65	30	30	30	30	0	0	0	0	0	0	0	0	0
		14	Shahbajpur gas Field	263	224	39	55	0	263	0	8	10	10	10	10	10	60	60	80	80	80	80	80	80	30	30	0	0	0	0	0
		15	Semutang Gas Field	318	110	208	51	0	318	0	0	15	15	15	15	15	15	15	15	15	15	15	15	15	15	25	25	25	25	25	25
		16	From New Discovery	0				0	0	0	0	45	60	60	60	60	60	60	60	60	60	60	60	60	60	80	80	80	80	80	80
		17	Chattak(East)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A: Total Petrobangla			**19,482**	**16,92**	**2,562**	**3,317**	**6,741**	**12,741**	**892**	**927**	**1,117**	**1,311**	**1,284**	**1,303**	**1,298**	**1,515**	**1,578**	**1,648**	**1,826**	**1,716**	**1,696**	**1,631**	**1,696**	**1,627**	**1,697**	**1,607**	**1,577**	**1,365**	**1,345**	**1,255**
IOC	Chevron	18	Jalalabad gas Field	1,245	996	249	482	509	736	158	130	130	230	230	250	250	265	230	138	0	0	0	0	0	0	0	0	0	0	0	0
		19	Maulavibazar gas field	889	625	264	344	140	749	74	60	90	160	160	160	130	130	150	150	150	150	150	130	130	50	20	0	0	0	0	0
		20	Bibiyana gas Field	5,197	4,426	771	774	361	4,836	527	716	716	800	800	900	900	900	900	800	800	600	600	500	500	500	430	400	400	300	200	60
	Cairn	21	Sangu gas Field	696	514	182	105	458	238	50	40	20	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		22	Sangu gas Field (South)	0					0		0	30	30	30	30	30	30	30	30	30	30	0	0	0	0	0	0	0	0	0	0
	Tullow	23	Bangura gas Field	614	544	70	94	79	535	87	120	120	120	120	120	120	120	90	90	90	90	90	60	25	0	0	0	0	0	0	0
	Niko	24	Feni gas Field	130	27	103	72	62	68	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		25	Chattak Gas Field (West)	474	265	209	253	26	448	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B: Sub Total IOC-1			**9,245**	**7,397**	**1,848**	**2,124**	**1,635**	**7,610**	**899**	**1,068**	**1,108**	**1,362**	**1,352**	**1,462**	**1,432**	**1,447**	**1,402**	**1,210**	**1,072**	**872**	**842**	**692**	**657**	**552**	**452**	**402**	**402**	**302**	**202**	**62**
		26	From New							0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100
		27	Block-16							0	0	0	0	0	0	0	0	50	50	50	100	100	100	100	100	100	100	100	100	100	100
		28	Block-17 & 18							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C: Sub Total IOC-2									**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**150**	**150**	**150**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
		29	**Offshore Bidding-2008**							0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	D: Sub Total IOC-3									**0**	**0**	**0**	**0**	**0**	**0**	**0**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
	D: Total IOCs (B+C+D)									**899**	**1,068**	**1,108**	**1,362**	**1,352**	**1,462**	**1,432**	**1,547**	**1,652**	**1,460**	**1,322**	**1,172**	**1,142**	**992**	**957**	**852**	**752**	**702**	**702**	**602**	**502**	**362**
			Petrobangla + IOC							**1,791**	**1,995**	**2,225**	**2,673**	**2,636**	**2,765**	**2,730**	**3,062**	**3,230**	**3,108**	**3,148**	**2,888**	**2,838**	**2,623**	**2,653**	**2,479**	**2,449**	**2,309**	**2,279**	**1,967**	**1,847**	**1,617**
			LNG Import											200	400	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Total	**E: Petrobangla+IOCs(D)**			**28,727**	**24,31**	**4,410**	**5,441**	**8,376**	**20,351**	**1,791**	**1,995**	**2,225**	**2,673**	**2,836**	**3,165**	**3,230**	**3,562**	**3,730**	**3,608**	**3,648**	**3,388**	**3,338**	**3,123**	**3,153**	**2,979**	**2,949**	**2,809**	**2,779**	**2,467**	**2,347**	**2,117**

Source: PSMP Study Team

APTable 5-4 Long Term Gas Production forecast（PSMP Study Case 2）2009/10～2029/30

Company	Sl. No.	Name of Gas Fields	Recoverable Reserve P1+P2	P1	P2	P3	Cummulitive Production June2009	Remaining P1+P2 Reserve	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			Bcf						mmcfd																					
BGFCL	1	Titas Gas Field	7,581	7,441	140	718	2,996	4,585	395	408	453	560	560	560	450	450	400	400	350	350	300	300	300	200	200	200	200	200	200	200
	2	Bakhrabad Gas Field	1,323	1,106	217	264	692	631	33	36	36	36	46	51	51	56	56	56	56	56	56	56	56	56	56	56	56	10	10	0
	3	Habiganj Gas Field	2,788	2,416	372	433	1,617	1,171	236	240	260	260	260	260	260	260	260	260	250	200	100	50	50	17	0	0	0	0	0	0
	4	Narshingdi Gas Field	217	214	3	75	99	118	33	35	35	30	30	30	25	25	20	20	10	0	0	0	0	0	0	0	0	0	0	0
	5	Meghna Gas Field	49	49	0	52	36	13	0	0	10	10	10	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	Begumganj Gas Field	33	10	23	76	0	33	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	0	0	0	0	0	0
	7	Kamta Gas Field	50	19	31	0	21	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10
SGFL	8	Sylhet Gas Field	372	301	71	94	189	183	2	7	25	25	25	25	25	25	25	25	25	25	25	40	40	35	35	0	0	0	0	0
	9	Kailashtila Gas Field	2,653	2,126	527	358	466	2,187	91	97	97	97	97	97	97	127	140	156	174	224	254	254	274	274	274	250	250	250	200	200
	10	Rashidpur Gas Field	3,150	2,465	685	860	448	2,702	50	49	67	85	85	85	85	124	134	238	250	300	350	350	430	530	547	560	556	490	520	400
	11	Beanibazar Gas Field	138	118	20	32	57	81	15	15	15	15	15	15	15	15	15	16	16	16	16	16	16	0	0	0	0	0	0	0
BAPEX	12	Salda Gas Field	266	151	115	124	59	207	10	8	23	35	8	8	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	Fenchuganj gas field	281	170	111	125	60	221	27	24	44	64	64	60	60	60	60	30	30	30	30	0	0	0	0	0	0	0	0	0
	14	Shahbajpur gas Field	263	224	39	55	0	263	0	8	10	10	10	10	10	10	60	80	80	80	80	80	80	80	80	0	0	0	0	0
	15	Semutang Gas Field	318	110	208	51	0	318	0	0	0	0	0	15	15	15	15	15	15	15	15	15	15	15	15	25	25	25	25	25
	16	From New Discovery	0				0	0	0	0	45	60	60	60	60	60	60	60	60	60	60	60	60	60	80	80	80	80	80	80
	17	Chattak(East)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A: Total Petrobangla			**19,482**	**16,92**	**2,562**	**3,317**	**6,741**	**12,741**	**892**	**927**	**1,120**	**1,287**	**1,270**	**1,281**	**1,166**	**1,232**	**1,255**	**1,366**	**1,326**	**1,366**	**1,296**	**1,231**	**1,331**	**1,277**	**1,297**	**1,181**	**1,177**	**1,065**	**1,045**	**915**
Chevron	18	Jalalabad gas Field	1,245	996	249	482	509	736	158	130	130	200	200	200	200	180	180	150	150	100	100	80	0	0	0	0	0	0	0	0
	19	Maulavibazar gas field	889	625	264	344	140	749	74	60	70	70	80	80	80	90	100	120	120	100	90	80	65	50	0	0	0	0	0	0
	20	Bibiyana gas Field	5,197	4,426	771	774	361	4,836	527	716	716	750	800	850	900	900	840	790	750	650	600	600	600	500	500	476	450	300	200	100
Cairn	21	Sangu gas Field	696	514	182	105	458	238	50	40	20	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	22	Sangu gas Field (South)						0		0	30	30	30	30	30	30	30	30	30	30	0	0	0	0	0	0	0	0	0	0
Tullow	23	Bangura gas Field	614	544	70	94	79	535	87	120	120	120	120	120	120	120	90	90	90	90	90	60	25	0	0	0	0	0	0	0
Niko	24	Feni gas Field	130	27	103	72	62	68	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	25	Chattak Gas Field (West)	474	265	209	253	26	448	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B: Total IOC-1			**9,245**	**7,397**	**1,848**	**2,124**	**1,635**	**7,610**	**899**	**1,068**	**1,088**	**1,192**	**1,242**	**1,282**	**1,332**	**1,322**	**1,242**	**1,182**	**1,142**	**972**	**882**	**822**	**692**	**552**	**502**	**478**	**452**	**302**	**202**	**102**
	26	From New Discovery(Kajula,							0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	27	Block-16							0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	28	Block-17 & 18							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C: Total IOC-2									**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**	**150**
		Offshore Bidding-2008							0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D: Total IOC-3									**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
E: Total IOCs (B+C+D)									**899**	**1,068**	**1,088**	**1,192**	**1,242**	**1,282**	**1,332**	**1,322**	**1,392**	**1,332**	**1,292**	**1,122**	**1,032**	**972**	**842**	**702**	**652**	**628**	**602**	**452**	**352**	**252**
		Petrobangla + IOC							**1,791**	**1,995**	**2,208**	**2,479**	**2,512**	**2,563**	**2,498**	**2,554**	**2,647**	**2,698**	**2,618**	**2,488**	**2,328**	**2,203**	**2,173**	**1,979**	**1,949**	**1,809**	**1,779**	**1,517**	**1,397**	**1,167**
		LNG import												200	300	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
F: Petrobangla+IOCs(E)			**28,727**	**24,31**	**4,410**	**5,441**	**8,376**	**20,351**	**1,791**	**1,995**	**2,208**	**2,479**	**2,512**	**2,763**	**2,798**	**3,054**	**3,147**	**3,198**	**3,118**	**2,988**	**2,828**	**2,703**	**2,673**	**2,479**	**2,449**	**2,309**	**2,279**	**2,017**	**1,897**	**1,667**

Source: PSMP Study Team

APTable 5-5 Power Station Mid Long Term Tlan

Unit:mmcfd

	node		Power Station Site	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
TGTD CL	18	Ex.	Ashuganj 150 MW Steam Turbine #3	25	22	23	22	23	21	20	19	18	19	19	19	19	19	19	0	0	0	0	0	0	0
	18	Ex.	Ashuganj 150 MW Steam Turbine #4	25	22	23	22	23	21	20	19	18	19	19	19	19	19	19	0	0	0	0	0	0	0
	18	Ex.	Ashuganj 150 MW Steam Turbine #5	25	22	23	22	23	21	20	19	18	19	19	19	19	19	19	0	0	0	0	0	0	0
	18	Ex.	Ashuganj 2x64 MW Steam Turbine	26	23	23	22	23	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	Ex.	Ashuganj Combined Cycle	8	8	7	7	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	Ex.	Ashuganj GT 1	8	8	7	7	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18	Ex.	Ashuganj GT 2	8	8	7	7	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	18		Ashuganji CCPP #1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	50	51	51
	18		Ashuganji CCPP #2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	50	51	51
	18		Ashuganji CCPP #3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51
	56	Ex.	Ghorasal 210 MW S/T #5	36	35	36	34	35	31	30	29	27	28	28	29	27	28	29	30	31	31	33	32	25	0
	56	Ex.	Ghorasal 210 MW S/T #6	36	35	36	34	35	31	30	29	27	28	28	29	27	28	29	30	31	31	33	32	25	0
	56	Ex.	Ghorasal 210 MW Steam Turbine #3	36	35	36	34	35	31	30	29	27	28	28	29	27	28	29	30	31	31	33	32	25	0
	56	Ex.	Ghorasal 210 MW Steam Turbine #4	36	35	36	34	35	31	30	29	27	28	28	29	27	28	29	30	31	31	33	32	25	0
	56	Ex.	Ghorasal 55 MW Steam Turbine #1	10	9	9	8	9	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	56	Ex.	Ghorasal 55 MW Steam Turbine #2	10	9	9	8	9	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	47	Ex.	Haripur 3x33 MW Gas Turbine	27	28	24	25	25	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	48	Ex.	Siddhirganj 210 MW Steam Turbine	36	35	36	34	35	31	30	29	27	28	28	29	27	28	29	30	31	31	33	32	25	35
	59	Ex.	Tongi 100 MW Gas Turbine	19	16	22	20	23	17	14	13	10	11	13	14	13	14	16	21	21	21	22	22	23	24

	node		Power Station Site	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	45	Ex.	CDC, Haripur	53	53	53	53	53	53	53	52	51	51	51	51	50	50	50	50	50	50	0	0	0	0
	43	Ex.	CDC, Meghnaghat	64	64	64	64	64	64	64	64	63	63	63	63	62	62	62	62	62	62	0	0	0	0
	43		Meghnaghat 360MW CCPP #1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	51	50	51	51
	43		Meghnaghat 360MW CCPP #2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	50	51	51
	47	Ex.	NEPC (Haripur, BMPP)	17	17	17	17	17	17	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	58	Ex.	RPCL (Mymensingh)	25	25	25	25	25	25	25	25	25	24	24	24	24	24	24	24	24	0	0	0	0	0
	60	Ex.	Tangail SIPP (22 MW)	4	4	5	5	5	5	5	5	3	4	4	5	4	4	4	5	0	0	0	0	0	0
	51	New	Kaliakair, Gazipur	0	0	0	20	21	20	19	19	18	18	18	18	18	17	19	13	19	18	12	0	0	0
	59	New	Savar, Dhaka	0	0	0	20	21	20	19	19	18	18	18	18	18	17	19	13	19	18	12	19	19	20
	56	New	Ghorasal	0	0	0	38	38	35	33	32	30	30	30	31	30	31	31	33	33	34	35	35	36	36
	18	New	Ashuganj – 3 yrs	0	13	13	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	57	New	Mouna, Gazipur SIPP(REB)	6	4	5	5	5	5	5	5	3	4	4	5	4	4	4	5	0	0	0	0	0	0
	50	New	Narsindi SIPP(REB)	4	4	5	5	5	5	5	5	3	4	4	5	4	4	4	5	0	0	0	0	0	0
	50		Mahdabdi, Narsindi Summit SIPP, REB	7	4	5	5	5	5	5	5	3	4	4	5	4	4	4	5	0	0	0	0	0	0
	54	New	Rupganj , Narayanganj	6	4	5	5	5	5	5	5	3	4	4	5	4	4	4	5	0	0	0	0	0	0
BGSL	41	Ex.	Chittagong (Shkalbaha) 1x60 MW Steam Turbine	9	8	8	8	8	8	7	7	6	7	7	0	0	0	0	0	0	0	0	0	0	0
	41	Ex.	Chittagong (Shkalbaha) 2x28 MW Barge Mounted GT	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	41	Ex.	Rauzan (Chittagong) 210 MW S¥T (1st)	41	36	37	36	37	34	33	32	29	30	31	31	29	30	31	31	32	31	0	0	0	0
	41	Ex.	Rauzan (Chittagong) 210	41	36	37	36	37	34	33	32	29	30	31	31	29	30	31	31	32	31	2	30	0	0

	node		Power Station Site	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
			MW S¥T (2nd)																						
	40	Ex.	Barabkundu	4	4	5	5	5	5	5	5	3	4	4	5	4	4	4	5	0	0	0	0	0	0
	37	Ex.	Feni SIPP (22 MW)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	0	0
	33	Ex.	Jangalia , Comilla	6	7	8	8	8	7	7	7	5	5	6	7	6	7	6	7	0	0	0	0	0	0
	33	Ex.	Summit Power (REB)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
	33		Ashulia, Dhaka Summit SIPP, REB	9	4	5	5	5	5	5	5	3	4	4	5	4	4	4	5	0	0	0	0	0	0
	33		Chandina, Comillaj Summit SIPP, REB	5	4	5	5	5	5	5	5	3	4	4	5	4	4	4	5	0	0	0	0	0	0
	34	New	Chandpur 150 MW CC (BPDB)	0	0	0	24	24	30	24	23	20	20	22	22	21	22	22	22	22	21	21	22	22	17
	41	New	Sikalbaha 150 MW Peaking Plant (BPDB)	0	31	35	34	35	32	26	24	17	18	20	24	20	24	25	30	29	30	31	31	33	33
	72	New	Haripur 360 MW CCPP (EGCB)	0	0	0	0	0	53	53	52	51	51	51	51	50	50	50	50	50	50	51	50	51	51
	73	New	Siddhirganj 2X120 MW Peaking Plant (EGCB)	0	49	55	54	56	51	41	39	28	29	31	38	32	38	40	48	47	49	50	50	53	52
	71	New	Meghnaghat Combined Cycle Power Plant (2nd unit) Duel Fuel	0	0	0	0	0	0	0	0	52	54	55	56	54	55	54	55	54	54	55	53	55	55
	73	New	Siddirganj 2x150 GT (EGCB)	0	0	0	0	69	64	51	49	35	36	39	48	40	47	49	60	59	61	62	62	66	65
	37	New	Feni SIPP(REB)	2	2	3	3	3	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0
JGTDSL	6	Ex.	Fenchuganj C.C. (Unit #1)	15	15	15	15	15	15	15	15	14	14	14	14	13	14	0	0	0	0	0	0	0	0
	15	Ex.	Shahjibazar 60 MW Gas Turbine	18	18	16	15	16	11	15	10	14	14	15	15	9	9	10	0	0	0	0	0	0	0
	15	Ex.	Shahjibazar Gas Turbine(7 units)	14	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	Ex.	Sylhet 1x20 MW Gas Turbine	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	Ex.	Kumargao 10 MW (15 Years)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0

	node		Power Station Site	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	2	Ex.	Kumargoan (3 Years)	9	10	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	Ex.	Sahzibazar RPP (3 Years)	10	10	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	Ex.	Sahzibazar RPP (15 Years)	17	17	20	21	21	19	19	19	14	14	15	18	15	17	17	19	0	0	0	0	0	0
	6	New	Fenchuganj 90 MW CCPP (BPDB)	0	14	14	14	14	18	14	14	12	12	13	13	13	13	13	13	13	13	13	13	13	10
	6		Mahdabdi, Narsindi Summit SIPP, REB	0	10	4	4	4	4	4	4	3	3	3	4	3	4	3	4	0	0	0	0	0	0
	2	New	Sylhet 150 MW CCPP (BPDB)	0	0	0	24	24	30	24	23	20	20	22	22	21	22	22	22	22	21	21	22	22	17
	13	New	Bibiyana Combined Cycle Power Plant (2nd Unit)	0	0	0	0	0	0	64	63	58	61	62	63	61	62	61	62	61	61	61	60	61	61
	13	New	Bibiana 450 MW CCPP (Power Cell)	0	0	0	0	0	65	64	63	58	61	62	63	61	62	61	62	61	61	61	60	61	61
	13		Bibiana 360MW CCPP #3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	51	50	51	51
	13		Bibiana 360MW CCPP #4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	51	50	51	51
	6	New	Fenchuganj – 3 Yrs rental	0	10	12	12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	New	Hobiganj SIPP(REB)	2	2	3	3	3	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0
PGCL	67	Ex.	Baghabari 100 MW Gas Turbine	18	16	22	20	22	17	14	13	10	12	12	13	12	14	0	0	0	0	0	0	0	0
	67	Ex.	Baghabari 71 MW Gas Turbine	17	17	17	17	17	17	16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	67	Ex.	WEST MONT (Baghabari)	14	15	14	15	14	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	69	Ex.	Bogra Rental (15 Years)	4	4	4	4	4	4	4	4	3	3	3	4	3	4	0	0	0	0	0	0	0	0
	1*	New	Bhola Combined Cycle Power Plant (2nd unit)	0	0	0	0	0	0	24	23	20	20	22	22	21	22	22	22	22	21	21	22	22	17
	63	New	Sirajganj 150 MW GT (NWPGC)	0	0	0	0	0	32	26	24	17	18	20	24	20	24	25	30	29	30	31	31	33	33
	63	New	Serajganj 450 MW CCPP/ 500 MW Coal (Power Cell)	0	0	0	0	0	0	64	63	58	61	62	63	61	62	61	62	61	61	61	60	61	61

	node		Power Station Site	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	63		Sirajganj 360MW CCPP #2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51
	69	New	Bogra –3 yrs rental	0	4	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	67	New	Ullapara SIPP (REB)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
S/SW	1*	New	Bhola 150 MW CCPP (BPDB)	0	0	0	0	0	30	24	23	20	20	22	22	21	22	22	22	22	21	21	22	22	17
	1*		Bhola (3 Years)	0	7	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	77	New	Bheramara 360 MW CCPP (NWPGC)	0	0	0	0	0	0	53	52	51	51	51	51	50	50	50	50	50	50	51	50	51	51
	83	New	Khulna 150 MW GT (NWPGC)	0	0	0	0	0	32	26	24	17	18	20	24	20	24	25	30	29	30	31	31	33	33
Total				826	919	941	1027	1112	1223	1276	1218	1107	1135	1170	1219	1135	1186	1169	1151	1225	1209	1193	1207	1168	1154

Source: PSMP Study Team

APTable 5-6 TGTDCL Gas Demand Forecast (Base Case)

Unit : mmcfd

F. year	Power	Captive P.	Fertilizer	Industry	Commercial	Domestic	CNG	Tea Estate	Total
2009	537	219	97	234	13	142	58	0	1,301
2010	541	214	155	235	13	169	63	0	1,389
2011	553	231	155	262	13	191	74	0	1,479
2012	620	250	155	291	14	215	85	0	1,630
2013	631	290	155	323	15	243	96	0	1,754
2014	568	291	155	360	16	274	107	0	1,772
2015	490	314	155	400	17	310	118	0	1,804
2016	466	340	155	444	18	350	129	0	1,903
2017	422	110	155	494	20	395	140	0	1,736
2018	428	110	155	549	21	446	152	0	1,860
2019	434	110	155	611	22	504	163	0	1,998
2020	446	110	155	679	24	569	174	0	2,155
2021	425	99	155	744	25	631	185	0	2,264
2022	435	88	155	815	26	701	196	0	2,416
2023	445	77	155	892	28	778	207	0	2,582
2024	391	66	155	978	29	864	218	0	2,701
2025	431	55	155	1,071	31	960	229	0	2,932
2026	410	44	155	1,164	33	1,056	240	0	3,103
2027	447	33	155	1,266	34	1,163	251	0	3,350
2028	438	22	155	1,377	36	1,280	263	0	3,571
2029	408	11	155	1,497	38	1,409	274	0	3,792
2030	368	0	155	1,628	40	1,552	285	0	4,028

Source: PSMP Study Team

APTable 5-7 BGSL Gas Demand Forecast (Base Case)

Unit : mmcfd

F. year	Power	Captive P.	Fertilizer	Industry	Commercial	Domestic	CNG	Tea Estate	Total
2009	42	32	92	37	6	48	21	0	278
2010	191	32	120	37	5	57	23	0	465
2011	205	35	120	41	6	64	27	0	498
2012	224	37	120	45	6	73	31	0	537
2013	301	40	120	50	7	82	35	0	635
2014	336	44	120	56	7	93	39	0	695
2015	298	47	120	62	7	105	43	0	683
2016	290	51	120	69	8	118	47	0	703
2017	291	16	120	77	8	134	51	0	698
2018	300	16	120	86	9	151	56	0	737
2019	312	16	120	95	10	170	60	0	784
2020	332	16	120	106	10	192	64	0	840
2021	301	15	120	116	11	214	68	0	844
2022	324	13	120	127	11	237	72	0	904
2023	328	12	120	139	12	263	76	0	950
2024	356	10	120	152	13	292	80	0	1,023
2025	324	8	120	167	13	325	84	0	1,042
2026	328	7	120	182	14	357	88	0	1,096
2027	271	5	120	197	15	393	92	0	1,094
2028	298	3	120	215	16	433	96	0	1,181
2029	279	2	120	233	16	477	100	0	1,227
2030	273	0	120	254	17	525	104	0	1,293

Source: PSMP Study Team

APTable 5-8 JGTDSL Gas Demand Forecast (Base Case)

Unit : mmcfd

F. year	Power	Captive P.	Fertilizer	Industry	Commercial	Domestic	CNG	Tea Estate	Total
2009	62	7	15	14	1	12	1	2	115
2010	124	6	15	14	1	14	2	2	178
2011	113	7	15	16	1	16	2	2	172
2012	114	7	15	17	1	18	2	2	177
2013	117	7	15	19	2	21	2	2	184
2014	171	7	45	22	2	23	3	2	275
2015	224	7	45	24	2	26	3	2	333
2016	216	8	45	27	2	30	3	2	332
2017	196	8	45	30	2	34	4	2	319
2018	203	8	45	33	2	38	4	2	335
2019	211	8	45	37	2	43	4	2	352
2020	217	9	45	41	2	49	4	2	368
2021	199	8	45	45	3	54	5	2	359
2022	206	7	45	49	3	60	5	2	376
2023	191	6	45	53	3	67	5	2	372
2024	186	5	45	59	3	74	6	2	379
2025	257	4	45	64	3	82	6	2	463
2026	256	3	45	70	3	90	6	2	476
2027	258	3	45	76	3	99	6	2	492
2028	255	2	45	83	4	109	7	2	506
2029	259	1	45	90	4	121	7	2	528
2030	251	0	45	98	4	133	7	2	539

Source: PSMP Study Team

APTable 5-9 PGCL Gas Demand Forecast (Base Case)

Unit : mmcfd

F. year	Power	Captive P.	Fertilizer	Industry	Commercial	Domestic	CNG	Tea Estate	Total
2009	62	2	0	2	0	5	5	0	76
2010	56	5	0	2	0	6	5	0	74
2011	63	6	0	2	1	6	6	0	84
2012	62	7	0	2	1	7	7	0	85
2013	64	8	0	2	1	8	8	0	91
2014	85	10	0	3	1	9	9	0	116
2015	163	12	0	3	1	10	10	0	198
2016	146	14	50	3	1	12	11	0	236
2017	110	17	50	4	1	13	11	0	206
2018	115	21	50	4	1	15	12	0	218
2019	120	25	50	4	1	17	13	0	230
2020	127	30	50	5	1	19	14	0	246
2021	118	27	50	5	1	21	15	0	238
2022	126	24	50	6	1	23	16	0	246
2023	108	21	50	6	1	26	17	0	230
2024	115	18	50	7	1	29	18	0	238
2025	112	15	50	8	1	32	19	0	236
2026	112	12	50	8	1	35	20	0	239
2027	114	9	50	9	1	39	20	0	242
2028	113	6	50	10	1	43	21	0	244
2029	116	3	50	11	1	47	22	0	251
2030	162	0	50	12	1	52	23	0	300

Source: PSMP Study Team

APTable 5-10 SGCL Gas Demand Forecast (Base Case)

Unit : mmcfd

F. year	Power	Captive P.	Fertilizer	Industry	Commercial	Domestic	CNG	Tea Estate	Total
2009	0	0	0	0	0	0	0	0	0
2010	7	0	0	0	0	0	0	0	7
2011	7	0	0	0	0	11	0	0	18
2012	7	0	0	0	0	12	0	0	19
2013	0	0	0	0	0	13	0	0	13
2014	62	0	0	0	0	14	0	0	76
2015	102	0	0	0	0	15	0	0	117
2016	100	0	0	0	0	17	0	0	117
2017	89	0	0	0	0	18	0	0	106
2018	89	0	0	0	0	19	0	0	108
2019	93	0	0	0	0	21	0	0	114
2020	98	0	0	0	0	22	0	0	120
2021	91	0	0	0	0	23	0	0	115
2022	96	0	0	0	0	24	0	0	120
2023	96	0	0	0	0	26	0	0	122
2024	103	0	0	0	0	27	0	0	130
2025	101	0	0	0	0	28	0	0	129
2026	102	0	0	0	0	29	0	0	131
2027	103	0	0	0	0	31	0	0	133
2028	103	0	0	0	0	32	0	0	135
2029	106	0	0	0	0	33	0	0	139
2030	100	0	0	0	0	34	0	0	135

Source: PSMP Study Team

5.1.1 Assessment of current status for existing gas fields

The production status of existing gas fields was investigated through the site survey for the purpose of forecasting scenarios of the future gas development program in the Bangladesh. The summary of investigating results for each gas fields are shown as following paragraphs.

(1) Titas gas field (Block 12) (BGFCL)

Titas gas field lies at the foundation of village in Brahmanbaria area approximately 100km away from northeast of the capital Dhaka in Bangladesh. Pakistan Shell Oil Company carried out the rudimentary seismic survey and found this gas field in 1962. The structure of the gas field is asymmetry anticline structure extending north and south long of approximately 19km x 10km2, which is the large gas field with the vertical closure of 500m. The production was started in 1968 and the accumulated production volume by June 30, 2009 reached 2,996Bcf (billion cubic feet). It is equivalent to 58 % of recoverable reserves (P1+P2) 5,128 Bcf officially announced by Petrobangla, so the residual recoverable reserves are 2,131 Bcf, however, the reserves are reviewed at the current moment and the wide upward revision is expected. Until now, sixteen production wells have been excavated and 395mmcfd (million cubic feet per day) gas is produced from fifteen wells. Seven vertical wells and nine inclined wells are excavated at six locations approximately 8 km away each other. The excavation of seventeenth and eighteenth wells are planned in future. Currently, it keeps the second highest production volume in Bangladesh after Cheveron gas field of IOC. The gas field has five Glycol dehumidifying facilities with processing capacity of 60 mmcfd per facility and six low-temperature separation type gas processing facilities and the gas is supplied to the pipeline of Titas Gas Transmission & Distribution Co. Ltd (TGTDCL) and Gas Transmission Co. Ltd. (GTCL). For Titas 14th well, the production was discontinued in November 2006 because of flooding, however, the renovation was terminated in September 2009 and the production was restarted. For the third well of Titas, which has kept leaking of gas because of the blast since 2003, the leakage was stopped by an American expert in January 2008 and it was reclaimed with cement. Consequently, the gas does not leak from the windz, however, the leakage from the crack in the windz seems to be continued.

(2) Bakhrabad gas field (block 9)

Bakhrabad gas field lies at Muradnagar upazila in Comilla area approximately 40km away from east of the capital Dhaka. It was discovered by Pakistan Shell Oil Co.Ltd (PSCO) in 1969 in a same way as Titas and Habiganj gas fields. Concerning the structure, the first well was excavated up to 2,838m based on the magnetic measurement carried out by Pakistan Petroleum Ltd. (PPL) in 1953 and the result of 1-polymerization seismic experiment carried out by Shell in 1968 and a lot of gas layers were confirmed. The anticline structure has long and thin symmetric shape facing NNW-SSE direction and the scale is approximately 69 km (L) and 10 km (W). The production was started in 1984 and the accumulated gas production by the end of June 2009 is 692 Bcf. It is equivalent to 66% of recoverable reserves (1,049 Bcf) officially announced by HCU. Consequently, it is reported that the residual recoverable reserves is 357 Bcf. Total eight production wells were excavated at two locations, however, the production of four wells are discontinued because of flooding. It is planned to stop the flooding by the renovation. The gas production that reached 120 mmcfd once decreased to 33 mmcfd from four wells at the current moment. One well is a vertical well, however, other wells are inclined wells. It has four silica gel type gas processing plants and after the processing, the gas is supplied to Transmission pipeline of BGSL.

(3) Habiganj gas field (block 12) (BGFCL)

Habiganj gas field lies in Habiganj area approximately 100 km away from northeast of the capital Dhaka. The structure of this gas field exists at the north end of Tripuran Baramura anticline structure in India and there are a main gas layer and upper gas sandstone bed in south of Sadr. In 1962, PSOC carried out 1-polymerization seismic survey here and in 1963, carried out the exploratory excavation to find the gas-containing sandstone bed configured with two layers. Concerning the scale of the structure, the height of 12km x 5km square km closure is 300m. The production was started in 1968 and the accumulated gas production volume by the end of June 2009 is 1,617 Bcf and 42 % of recoverable reserves (3,852 Bcf) are produced. It is reported that the residual reserves are 2,235 Bcf. Currently, 238mmcfd gas is produced from nine production wells in eleven wells. The produced gas is processed by six Glycol type dehumidifying plants and supplied to Transmission line of Titas Gas Transmission Co. Ltd. (TGTDCL), Jalalabad Transmission Co.Ltd. (JDTDSL), and Gas Transmission Co. Ltd (GTCL). Nine wells are vertical wells and two remaining wells are inclined wells. Nine wells are dispersed at places approximately 14km away from each other. The eighth well and the ninth well have problems of flooding and sand generation at the current moment and the production is discontinued.

(4) Narsingdi gas field (block 9)

Narsingdi gas field lies in Narsingdi area in Shibpur upazila approximately 45 km away from the capital Dhaka. This area exists at the north peak of large Bakhrabad anticline area and it was named A 2 peak by Shell in the beginning of 1960s. Shell decided that it was a prospect with high risk. In 1984-86, Petrobangla carried out 12-polymerization seismic experiment for this area and reevaluated the prospect, and decided that it had the potential of 2,474 Bcf 50% of the time. In 1990, the exploratory excavation was carried out with a name of Bakhrabad ninth well and the gas-containing sandstone bed configured with two layers (upper and lower) was confirmed and the test was carried out for the lower layer. The production was started in 1996 and the accumulated production volume by the end of June 2009 is 99Bcf. It is equivalent to approximately 46% of recoverable reserves (215 Bcf). The residual reserves are 116Bcf. The production of 34mmcfd is kept in two production wells as of middle of November 2009. The produced gas is dehumidified by the gas processing plant and supplied to TGTDCL.

(5) Meghna gas field (block 9)

Meghna gas field lies in Brahmanbaria area. This area is typified by a lot of side streams of Meghna river. Concerning the gas field structure, the gravity anomaly was confirmed in 1953 and it was certified as a prospect by 1-polymerization seismic survey carried out by Shell. After that, Petrobangla carried out 24-polymerization seismic survey in 1984-86. In 1990, a test well was excavated and the gas-containing sandstone bed configured with six layers was confirmed in the depth between 2,850m and 3,020m. The production was started in 1997 and 36Bcf gas, which equivalent to 30% of recoverable reserves (120 Bcf) was produced until the production was stopped in 2007. The current residual recoverable reserves are 84Bcf. The production is not carried out currently.

(6) Sylhet (Haripur) gas field (block 13)

Sylhet gas field lies in the neighborhood of Sylhet city in Sylhet area 225km away from northeast of the capital Dhaka. The rock of Dupi Tila period is exposed on the land surface. The first well was excavated based on the geological and physical exploration data in 1955 and three gas layers were confirmed in the depth of 2,377m. However, the cement filled in 10-7/8" casing pipe was not sufficient, so the gas blew out from the abnormal overpressured zone and a fire was generated, and it disappeared under the ground with drilling rig and its auxiliary equipment. Then, the fire was extinguished naturally, however, a crack was generated on the geological layer and the gas reached the peripheral hill and it keeps bursting. In the next year, the second well was excavated, however, the blast of the gas due to the abnormal overpressured zone was generated in the depth of 2,818m. In order to control the blast, the windz was reclaimed and abolished. In 1957, the third well was excavated and the excavation was stopped in the depth of 1,800m and the gas-containing sandstone bed at upper part and lower part was finished as two layers. In 1969, the production was stopped at the lower layer because the formation water increased. The production at the upper layer was continued by 1988, however, the gas production was discontinued in the same year because of the increase of the formation water. In this period, accumulated total of 89 Bcf gas was produced. In

1962, the fourth well was excavated, however, the abnormal overpressured zone was found when the excavation reached 338m, so this well was abolished from the viewpoint of safety. In 1969, the fifth well was excavated next to the fourth well, however, it was abolished because of a technical reason. In 1964, the sixth well was excavated up to 1,515m and the upper and lower Bokabil sandstone beds were finished in two layers. In 1993, the production at the lower layer was discontinued because of the ingress of formation water. However, the production at the upper layer was continued currently, however, the production volume as of June 2009 is very small; 2mmcfd. The production from this well will be discontinued in the immediate future. The accumulated production volume by June 2009 is approximately 189 Bcf.

The seventh well was excavated by BAPEX, however, the petroleum was discovered between the depth of 2009-2033m and it was finished as a production well of petroleum. It is the first discovery of petroleum in Bangladesh. For this well, the petroleum was produced 350 barrels per day at first, however, the production volume of formation water increased gradually and the production was stopped in July 1994. The accumulated production volume of crude was 560,869 bbls. Then, this well was renovated in March 2005 and changed to the gas production well. At first, 15 mmcfd gas was produced, however, the production is currently discontinued and the re-renovation is planned. The product is processed by the silica gel type gas processing plant with the processing capacity of 30 mmcfd in Haripur.

(7) Kailastilla gas field (block 13)

Kailastilla gas field lies at Gurapganj in Sylhet area approximately 300km away from northeast of the capital Dhaka. Shell estimated Kailastilla structure based on the analog seismic experiment data of one polymerization carried out in 1960. Shell says that the anticline structure is 4-way inclination closure. In 1961, the first well was excavated and it was excavated up to 4,138m to confirm the gas-containing sandstone bed configured with four layers. Then, the second well and the third well were excavated in 1988 and the production was started in 1992. In 1955, the fourth well was excavated and the production volume reached 65mmcfd. From 2006 to 2007, the fifth well and the sixth well were added. The windz group is laid off at two points 6km away each other. The accumulated production volume by the end of June 2009 is 466 Bcf and it is equivalent to 24% of recoverable reserves. The residual recoverable reserves are 1,439Bcf. For the fifth well, the production volume decreases because of the ingress of water currently and the production was discontinued more recently. Currently, the gas production of whole gas field is 91mmcfd as of June 2009. For the fifth well, a new layer that did not exist in other well was found at the lowest layer at the time of completion work, so the main layer at the upper part was saved and the new layer was finished in order to avoid the residual resource of the new layer. It is planned to carry out the production from the upper sandstone bed by carrying out the renovation at some future date. Since 1983, the silica gel type gas processing plant with the capability of 30mmcfd has been operated. Additionally, the Molecular Sieve Turbo Expander plant with the capability of 90mmcfd has been operated since 1995. Currently, the preparation for the excavation of the seventh and eighth wells is promoted in order to increase the production from this gas field.

Kailashtila gas field
(2009/10/31)

Kailashtila gas field
(2009/10/31)

(8) Rashidpur gas field (block 12)

Rashidpur gas field lies at the place approximately 100 km away from northeast of the capital Dhaka. Rashidpur structure was drawn based on the seismic experiment record of one polymerization carried out by Shell from 1959 to 1960, which is the anticline structure extending long in north and south. The first well was excavated in 1960 and the gas-containing sandstone bed configured with two layers (upper and lower) was confirmed. In 1961, the second well was excavated up to 4,593m. After the research result of gas under the lower layer, it was water. Then, up to the seventh well was excavated and the production was started in 1993. The accumulated production volume by the end of June 2009 is 448 Bcf and it is equivalent to approximately 32 % of recoverable reserves(1,402 Bcf). It is reported that the residual recoverable reserves are 954 Bcf . Currently, the production of the second and fifth wells is discontinued because of the ingress of formation water. The gas production volume from five wells as of June 2009 is approximately 50mmcfd. For the fifth and second wells for which the production is discontinued, the renovation is planned. The excavation of the eighth well is newly planned. Four gas processing plants are operated and one plant is the Glycol type with processing capacity of 60 mmcfd, one plant is the silica gel type with the processing capacity of 70 mmcfd, and two plants are the silica gel type with the processing capacity of 45mmcfd.

(9) Beanbazar gas field (block 14)

Beanbazar gas field lies at a place 15km away from east of Kailashtilla gas field. The structure of the gas field was identified by PSOC in the beginning of the 1960s for the first time, however, Oil And Gas Development Corporation (OGDC) carried out the geological research later. In 1971, Plakla Seosmos carried out 12-polymerization seismic survey in this area. After the data was analyzed, the first well was excavated from 1980 to 1981 and the gas-containing sand stone configured with two layers (upper and lower) was confirmed. The scale of the structure is 12 km (north and south) and 7 km (east and west) and the height of the closure is 425m. The second well was excavated from 1988 to 1989 and the production was started in 1999, and the accumulated production volume by June 2009 is 57 Bcf and it is equivalent to 34% of recoverable reserves(170 Bcf). It is reported that the residual reserves are 113 Bcf. The production volume as of June 2009 is 15mmcfd from two wells. The silica gel type gas processing plant was transferred from Feni gas field and laid at the location 1 of this gas field. The test operation was carried out in May 1999 and the operation was started in July officially.

(10) Saldanadi gas field (block 9)

Saldanadi gas field lies in Brahmanbarai near the border of India 75km away from east of the capital Dhaka. Saldah anticline is a part of the large Rukhia structure, which extends north and south. BAPEX identified this structure based on the data of past seismic survey and excavated the first well in 1996. The gas-containing sandstone bed with two layers was confirmed and this gas field was discovered. The production was started in 1998 and the second well was excavated in 1999, however, the continuousness of the sandstone bed was not confirmed. Then, the production of the gas from two production well has been continued and 59Bcf gas has been produced by the end of June 2009. It is equivalent to approximately 51% of recoverable reserves (116 Bcf). The residual recoverable reserves are 57 Bcf. The gas production volume in June 2009 is 10 mmcfd.

(11) Fenchuganj gas field (block 14)

Fenchuganj gas field lies approximately 200km from northeast of the capital Dhaka and it is surrounded by Beanni Bazaar gas field in northeast, Bibiyana gas field in west, Molvi Bazar gas field in southeast, and Kailastila gas field in north. The existence of Fenchuganj anticline structure can be clearly confirmed in air photo and satellite photo etc. For the subsurface structure, the contour was identified by PPL as a result of analog seismic experiment in 1957. The test well was excavated in 1960, however, the gas was not discovered. Petrobangla got Prakla Seismos to take multi-polymerization digital seismic experiment record under the technical support of Germany and rewire the anticline structure drawing based on this record. As a result, it came out that the first well existed in southwest from the central part of the structure. Petrobangla excavated the second well from 1985 to 1986 and the depth reached 4,975m. As a result, the carbon hydride-containing sandstone bed with five layers was confirmed by the well logging analysis. The open hole test was conducted in five times and the production of the gas was confirmed. An existence of petroleum was also confirmed slightly in the lower layer. Then, the third well was excavated and the production was started in 2004. It is reported that the accumulated production volume by the end of June 2009 was 60Bcf. It is equivalent to approximately 21% of recoverable reserves (283 Bcf). The residual recoverable reserves are 223 Bcf. The production volume as of June 2009 is 27mmcfd.

(12) Shahbazpur gas field (block 10)

Shahbazpur gas field lies in Bhola area approximately 140km away from south of the capital Dhaka and the nearest gas field is Begumganj in a place 80km northwest of it. The unproduced gas field over the ocean and Kutubdia gas field lie approximately 100km away from south of this gas field. In this area, the seismic survey was carried out for the first time in the 1950s. To Atlantic Rich Field Co. (ARCO), the marine mine site of one zone including Bhola island was given and this company carried out the shallow-water seismic survey around the island and exploratory excavation, and then returned the mine site. Petrobangla carried out the seismic survey in this area from 1986 to 1987 and selected the excavation position. This company excavated the first well from 1993 to 1994, however, this company found an abnormal overpressured zone in the depth of 3,631m, so the excavation organization was held. The excavation organization was released using the coil tubing unit (CTU). The depth between 3,201m and 3,210m was tested using the CTU and the flow of the dry gas was confirmed. Continuously, the side track well in horizontal displacement of 250m from the same position of the first well was excavated the well up to 3,342m in 1995 and the existence of the gas sand was confirmed by well logging. The additional seismological measurement was carried out from 1995 to 1996. As a result, it came out that a raise of a structure existed in north. BAPEX reanalyzed the data of these seismic surveys with Unocal Corporation to evaluate the structure again. In 2001, the evaluation and the development project of this gas field were accepted by ECNEC. The main consumer of this gas field is Bhola, which is PDB that promotes the power station of 150MW. As the construction of the power station by PDB is not promoted, the production of the gas from this gas field was held up. However, the rental power station of 30MW that was laid in Bhola changed this situation. With the operation of this power station, the consumption of 10mmcfd is expected and it sees the light of the production, so the LTX gas processing plant of Meghna gas field was transferred to this gas field. Additionally, the excavation, the test and the completion of the second well were completed and the production was started. The gas production volume in November 2009 is 7mmcfd. The accumulated production volume by June 2009 is 0.1Bcf and the residual recoverable reserves are forecasted to be approximately 466 Bcf. Considering reserve amount, 70 mmcfd could be produced in near future.

(13) Jalalabad gas field (block 13) (IOC: Chevron)

Jalalabad gas field lies at the place approximately 200 km away from northeast of the capital Dhaka. Jalalabad structure was identified by Petrobangla under the technical support of Germany. This structure was selected as an excavation candidate for the multiple windz excavation project under the support of Germany, however, it was not realized. It was left without excavation for a long time. In 1987, PSC of this area including Jalalabad was given to Scimitar Oil and this company excavated the first well in 1989 to discover the gas. As a test result, the gas-containing sandstone bed of three layers was confirmed. The structure shows the anticline structure in SW-NE direction. The PSC of block 13 in Scimitar that fell due in 1995 was given to Occidental. Occidental excavated four additional wells by 1998, however, 3 wells in 4 wells were gas wells. Occidental started the production in February 1999. In this year, Unocal obtained the right of Occidental to become an operator. This company also laid 15km pipeline to gas processing plant and existing north and south Transmission lines. The accumulated production volume by June 2009 is 509 Bcf and it is equivalent to 61 % of recoverable reserves (837 Bcf). It is forecasted that the residual recoverable reserves are 328 Bcf. The production volume of this gas field as of June 2009 is 158 mmcfd. If current production continues, the reserve would be depleted within 3 to 4 years, however, Chevron is optimistic regarding future production based on their 3D seismic survey.

(14) Moulavi Bazar gas field (block 14) (IOC: Chevron)

MoulaviBazar gas field lies Kalapur, Srimangal, Moulavi Bazar area approximately 170km away from northeast of Dhaka. For this area, a lot of geological engineers have drawn geological survey maps according to each era. The southern part of the structure lay on India side, so the closure was not drawn within the territory of Bangladesh. As a result, it seemed that this area was not so attractive as a target of exploration. The digital multi-polymerization seismic survey was carried out under the technical support of Germany and a new structural drawing was shown. After the result of detailed inspection, it was decided that this structure had a value of exploration and it was selected as an exploration target of multiple windz excavation project funded by German government. However, this project was not realized. From 1990 to 1991, BAPEX carried out the additional seismic survey for covering this structure. In 1995, the mine sites of blocks 12, 13, and 14 were given to Occidental. In 1997, Occidental started excavating the first well, however, the gas sand of think layer was found in the depth of 840m and it blew out, so the work was discontinued. Unocal that took over the project from Occidental excavated the second well up to 3,510m in 1999 and confirmed the gas-containing sandstone bed of a few layers. The third well was also excavated in order to research the scale of the gas field. Then, Chevron that took over Unocal concluded the Purchase and Sales Agreement (GPSA) with Petrobangla in 2003 and added three production wells to start the production in 2005. This company also constructed the gas processing plant with the processing capacity of 150 mmcfd and laid 24km pipeline newly. The accumulated gas production volume by the end of June 2009 is 140 Bcf. It is equivalent to approximately 39% of recoverable reserves(360 Bcf). It is reported that the residual reserves are 220 Bcf. The gas production volume in June 2009 is 74mmcfd.

Cheveron Bibiyana gas plant
(2009/10/31)

Bibiyana gas plant south area
(2009/10/31)

(15) Bibiyana gas field (block 12) (IOC: Chereron)

Biniyana gas field lies in Habiganj area approximately 220km away from northeast of the capital Dhaka. The gas field shows the long anticline structure in north and south and the scale of the closure is 14km (L) and 4km (W). From 1997 to 1998, Occidental in US identified Bibiyana as a gas structure for the first time and excavated the first well in the next year, 1999. This company excavated the well up to 4,014m, however, the fallen object remained in the depth of 3,618m, so total six tests were conducted for the remaining of the upper part. The second well was also excavated by Occidental up to 4,276m and the test for the gas-containing sandstone bed at the lowest part was conducted. In the excavation of first two wells, the gas-containing sandstone bed of nine layers was confirmed. From 1998 to 1999, 3D seismic survey for Bibiyana structure was carried out. In 1999, Unocal obtained the right of mine sites of blocks 12, 13 and 14 from Occidental to become an operator.

Then, Chevron that took over the project from Unocal constructed five wells in south area, seven wells in north area, total twelve production wells and 600 mmcfd gas processing plant and laid 42km pipeline from gas processing plant to Muchai, and started the production in March 2007. The accumulated gas production volume by the end of June 2009 is 361 equivalent to approximately 15 % of recoverable reserves (2,401 Bcf). It is reported that the residual reserves are 2040 Bcf. The gas production volume as of June 2009 is 527 mmcfd, so it is the largest gas field in Bangladesh. However, the reserves are currently evaluated again and it may be upwardly revised widely.

(16) Sangu gas field (block 16) (IOC: Cairn)

UK-based Cairn Energy Plc. has been involved in petroleum / gas exploration development project in Bangladesh since 1994. After 2D seismic survey was carried out in the mine site of block 16 obtained by PSC, the first marine gas field was discovered in Bangladesh in 1996. The gas field lies on ocean approximately 45km away from southwest of the second city of Bangladesh, Chittagon. The platform for excavation was constructed on ocean with water depth of approximately 10m and total nine production wells were excavated. The production was started in 1998 by constructing the gas processing facility with the gas processing capacity of 520mmcfd at Chillimpur terminal in Chittagon and linking the platform and the gas processing facility with 20" pipeline. The mine mouth pressure that was 4,600 psi at first decreased to around 1,000psi currently. As of June 2009, six production wells produce approximately 50 mmcfd gas. The accumulated production volume by the end of June 2009 was 458 Bcf and it is equivalent to 92% of recoverable reserves (500 Bcf). It is forecasted that the residual recoverable reserves are 42 Bcf. The structure of the gas field is the anticline structure facing NW-SE direction, however, the top of the structure is filled with clastics. The reservoir is configured with the gas-containing sandstone bed of ten layers, however, the main component is the sandstone bed called SG.3155, which makes up 50% of structure. It is forecasted that the production from this gas field will be terminated in a few years.

(17) Bangola gas field (block 9) (IOC: Niko)

Bangola gas field lies 100km away from southeast of the capital Dhaka. Tullow Oil Plc has been involved in the petroleum / gas exploration activities in Bangladesh since 1997. In 2001, this company obtained PSC for the mine site of block 9. This company is the operator, however, it is the collaborative development by Tullow (30%), Niko (60%), and BAPEX (10%). The detailed information on the background and the structure of exploration is not obtained. It seems that Lalmi-Bangora large anticline structure has been identified by Tullow. The third well of Lalmi was excavated in May 2004 and a gas layer was discovered as a result of a test. The first well of Bongora was excavated in 40km away from north of the third well of Lalmi and it was excavated the well up to 3,636m and a gas-containing sandstone bed was discovered in the depth between 2,580m and 3,285m. The test result recorded the production capability of 25mmcfd. Then, the excavation of the fifth well was finished by May 2009 and the production was started (a part of production was started in April 2006). As Ashuganj-Bakhrabad pipeline is laid in the neighborhood, the gas is supplied through the gas processing plant with the processing capacity of 120 mmcfd. Currently, the result of production data and 3D seismic survey is generally studied including the relationship with Lalmi structure. The accumulated gas production volume by the end of June 2009 is 79 Bcf and it is equivalent to approximately 26 % of recoverable reserves (309 Bcf). It is reported that the residual recoverable reserves are 230 Bcf. The gas production volume in June 2009 was 87mmcfd.

(18) Feni gas field (block 15) (IOC: Niko)

Feni gas field lies approximately 125km away from the capital Dhaka. After obtaining 1-polymerization seismic experiment data carried out from 1975 to 1976, Taila Sandhani Company named this structure Feni. From 1979 to 1980, 2-polymerization analog seismic experiment was carried out and a new structural drawing was obtained. As a result, it was a long and thin anticline structure. In June 1960, the first well was excavated. The overpressured zone was found in the depth of 3,200m and the digging was stopped at this depth and the upper layer was evaluated. The gas-containing sandstone bed with two layers of upper and lower was confirmed in well logging and test. In 1991, Feni gas field started the production. The second well was excavated in 1994 and the production was started in 1995. However, the production was discontinued in 1998 because of ingress of formation water.

In 2003, Niko Resouces Ltd. signed the joint venture with BAPEX in order to promote the development and the production of Feni gas field and Chhatak gas field. Feni gas field and Chhatak gas field discontinued the production activities in 1996 and 1982, respectively. Niko Resouces Ltd. restarted the production in November 2004 and the production volume was recovered to 20mmcfd. Additionally, in January 2005, the production processing plant was reinforced. However, the activities are stopped after that. As of June 2009, the production volume is 3mmcfd. The accumulated production volume by the end of June 2009 is 62 Bcf equivalent to approximately 47% of recoverable reserves. It is reported that the residual reserves are 67 Bcf.

(19) Kamta gas field (block 9) (suspended)

Kamta gas field lies at Kaliganj in Gazipur area approximately 17km away from north of the capital Dhaka. This gas field was discovered by Petrobangla in 1982. The gas production was started in November 1984, however, the gas production volume that reached 20 mmcfd in the beginning of the production decreased gradually because of the ingress of water and decreased to 3 mmcfd in 1988. Then, the production volume kept decreasing, so the production was discontinued in 1991 until now. The accumulated production volume in this period is 21 Bcf and it is equivalent to approximately 42% of recoverable reserves (50Bcf). However, the residual recoverable reserves are 29 Bcf and the possibility of re-development in future is left.

(20) Chattak gas field (block 12) (suspended)

Chatak gas field lies at the place approximately 2.5 km away from northwest of Sylhet city. The structure of the gas field exists at the north end of Surma basin, which is the anticline structure in ESE-WNW direction. In 1959, PPL carried out the seismic survey of 75km. In 1959, the first well of Chatak was excavated up to 2135m and the gas-containing sandstone bed of nine layers was found in the depth between 1090m-1975m. In 1960, the gas production was started in Bangladesh for the first time. However, the gas production was discontinued since 1986 because of the ingress of formation water. It is reported that the accumulated production volume is 26 Bcf. The reserves have been reviewed by various organizations very frequently and the latest information reports that the residual recoverable reserves are 447 Bcf, so it seems that the considerable amount of gas is not recovered and the unrecovered gas may be recovered in future.

In 2000, Niko Resouces of Canada (Nico) focused on Chatak gas field and carried out the collective research for reserves with BAPEX. The legal issues outstanding between BAPEX and Nico regarding the Joint Venture Agreement (JVA) is going to be settled soon as the Govoerment has taken all out initiatives effort over the matter. Hence it is expected that the development program for Chhatak East can be initiated. The 3D seismic survey has already carried out in this field which has positive indications.

(21) Block 17 and 18

Exploration and development under PSC in Block # 17 and 18 is being uncertain because Total E & P left Bangladesh without any discovery. Recently Okland of USA has showed interest to carry out some study in these blocks. A new offshore bidding round needed to be invited by Petrobangla. If so, there might be some gas discovery which may lead to production form Block # 17 and 18.

5.1.2 Risk assessment and recommendation for stable supply to gas power plants

(1) Risk for Generation of Formation Water

Spring of formation water is a serious problem to collect natural gas under the ground. Collecting gas is suspended in many gas fields in Bangladesh due to increased formation water. High flowing bottom hole pressure is required to push excessive formation water flown into a well out to the ground by gas. It is often the case that, even a producing well currently in natural flow of gas should be closed due to a certain reason. It is, however, often that such producing well can no longer produce natural flow of gas due to deteriorated gas layers. In a gas layer, formation water slipped into it can block a path of gas to the well. Action of formation water imposes a great impact on gas production. Due to this, production control of gas wells in gas fields is very important. In order to systematically produce gas, gas wells must be controlled appropriately. For this sake, condition of gas production from a well must be understood correctly. In addition to daily monitoring and measurement (i.e. choke size, wellhead pressure, temperature, volume of gas, volume of liquid including water and condensates, etc.), bottom hole pressure should be measured regularly (normally once in 6 months) and fluid analysis should be made as well as production capacity tests should be implemented as required. By understanding gas production conditions, it is necessary to maintain gas production volume at an appropriate level and to control generation of formation water as much as possible. Unfortunately, in Bangladesh, the demand to gas is high and measuring bottom hole pressure by temporary suspending gas production is not made at many gas fields. Generally speaking, bottom hole pressure is monitored by drilling an observation well around a gas fields. Any gas field in the world isn't exempt from inflow of formation water after certain volume of gas has been produced. To delay the inflow as much as possible, it is essential to take measures from the onset of developing a gas well to finish a gas layer horizontally, rather than vertically. "Insertion"

Inflow of formation water could generate a plug of sand in sandstone beds to block a path of gas and thus, it is necessary to take a measure by using a special pipe filled with sand to prevent sands from flowing into a well. In addition, there is a way to minimize movement of formation water by injecting chemicals into a well. It is essential to examine how inflow of formation water should be blocked from various ways to keep a risk of suspension of gas production to a minimum.

(2) Risk for generation of sand

Generation of sand and clogging of gas production path arising from it as well as erosion of facilities used for collecting gas can progress in a rapid speed and can be a serious problem leading to suspension of gas production. Generation of sand is depending on the degree of density of sand layers, gas production paths and gas layer pressure. It is often triggered by generation of formation water. Erosion can occur frequently to safety valves in wells, wellhead facilities, chokes, bending part of flow lines where smooth flow is significantly hindered. Erosion caused by generation of sands decreases strength of facilities in a well and can be a cause of gas leakage.

For a gas layer consisting of sandstone layers, once sand starts flowing, it is difficult to stop it. In order to prevent it, sand flow prevention measures should be implemented in an assured manner when the layer is finished. In order to do so, it is extremely essential to learn the property of sand beforehand. Grain size analysis is one of them. Layer completion must be made in the most appropriate way judging from the sand data obtained beforehand.

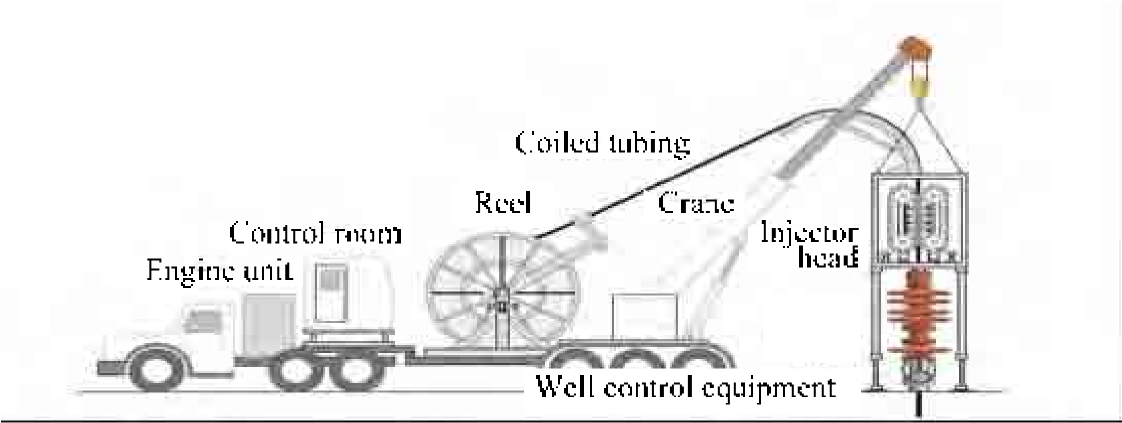
There are several ways in general to stop sand flow including mechanical method, chemical method and combination of the two. Mechanical method refers to make a bridge over loose sand stones to stop flowing out of sand. Use of gravel packs is the representative method of it. Chemical method refers to injecting epoxy or furane resins in a layer to artificially consolidate loose sandstones, which are otherwise referred to as plastic consolidation.

(3) Risk for generation of scales

Formation water generated along with collection of natural gas contains salts of calcium carbonate, calcium sulfate and barium sulfate. These salts can become scales in gas pipes and/or flow lines due to decrease in pressure and in temperature. The scales become deposits on inner surface of pipes narrow and block up the pipes completely, which impede gas production. These deposits have low solubility and removal of them is almost impossible.

In order to prevent this, periodical measurement of inner diameter of gas pipes and removal of scales are required. For this purpose, a hot acid is generally used. A magnesium bar is suspended in a well to pour hydrochloride acid with addictives. Part of the hydrochloride acid reacts with magnesium to generate heat. Remaining hydrochloride acid is warmed up and reacts with hydrate rapidly to dissolve it. However, barium sulfate that doesn’t react against hydrochloride acid should be removed mechanically. In this case, there is no way but removing hydrates using a coil tubing unit. When inhibitors that prevent generation of scales appropriately can be identified by such methods as water quality analysis, the inhibitors must be injected in the well periodically. Anyway, it is important to prevent deposit of scales by periodically measuring inner diameter of gas pipes.

APFig. 5-1 is an example of a trailer-mount type coil tubing device. Its performance is highly remarkable, because it is not only capable of removing scales but also used for other applications as well. To this sense, early introduction of it is wanted.



Source: Sekiyu Kaihatsu Jiho No.157 (08/05)

APFig. 5-1 Trailer-Mount Type Coil Tubing Device

(4) Risk of clogging due to clay minerals

Flowing of filtrated water of mud water and cement slurry into oil and gas layers containing clay minerals makes the clay minerals inflated and dispersed and cavities in the layers are clogged. If this happens, the rate of penetration of the layers downs. The inflation and dispersion are caused by attachment of water onto the surface and edges of clay minerals and between layers. Freshwater has a strong tendency to this, but seawater and oil barely cause the phenomenon. Once the rate of penetration is decreased, it is hard to recover it. Hence, it is necessary to carefully make a plan for drilling and completion. There are several ways to prevent this: (1) to curtail time for drilling and completion to reduce generation of filtrated water, (2) to reduce the specific gravity of mud water to narrow the gap between oil and gas layer pressure to reduce generation of filtrated water, (3) to form thin but strong mud walls to reduce generation of filtrated water, (4) to use mud water containing either salt or oil for layers that are easy to inflate or to disperse .

(5) Risk of clogging by solid substances

Solid substances contained in mud water (such as bentonite, baryte and slime) form a mud wall onto the well wall as mud water penetrates through oil and gas layers. If this happens, the solid substances clog cavities in oil and gas layers to reduce the rate of penetration of the layers. The depth of the affected areas will depend on difference between mud water column pressure and oil/gas layer pressure, etc. Typically it is said to be 2 to 30 cm. As the affected area will be perforated through and making deep holes in the layers, such impediment should normally be accepted. Measures to prevent this include decreasing the specific gravity of mud water t reduce pressure difference with oil/gas layer pressures and to mechanically separate solid substances from mud water at the same time.

(6) Risk for cementing failure

Cementing is an important process that could significantly impact on productivity of a well. Failure to do this could trigger various impediments. Failure to shield production layers from upper and lower layers can cause unnecessary generation of formation water, which leads to a decrease in productivity and in the ratio of collecting gas. To prevent occurrence of this, it is necessary to make and implement a well-established cementing plan.

(7) Risk of clogging of perforated holes

Perforated holes may sometimes be clogged causing a well unable to demonstrate its due production capacity. The cause of this include (i) clogging by iron scrap, cement, fine particles contained in mud water and rocks caused by drilling operation, (2) scales generated due to decreased temperature and pressure, (3) clogging by paraffin and asphalt contents. Measures against this include perforation using a perforator of large bore size and having strong drilling performance leaving no residual matters or to inject perforation fluid in the well in lieu of conventional one and to use through tubing perforator to drill a hole using pressure lower than that of oil/gas layers.

(8) Risk of freezing

Natural gas generated from gas layers are saturated with water. The temperature of gas at the well mouth is, generally, lower than that in gas layers. Thus, water in natural flow of fluids is condensed near the well mouth. The water in this state enters into a flow line. When there is a large decrease of pressure at the well mouth, gas will inflate causing its temperature further down. This generates water and/or gas hydrates in the flow line. This hinders flow of gas in the flow line. In the worst case of scenario, the line is totally clogged by it. Naturally, small bore pipes cause the pipe freezing phenomenon more serious than large bore pipes. When a pipe is partially narrowed by deposits of sands and gravels, the narrowing phenomenon increases and the pipe is finally totally clogged. In order to prevent clogging by freezing, there are no alternatives but removing water content in gas. Separation of water contents in gas starts when fluids pass through layers into the well and is accelerated as it goes through gas collection pipes, flow lines and above-ground facilities. On the above-ground, a 3-phase separator is used to separate oil/condensate, gas and water. The gas so separated will be subject to total removal of water contents using a dehumidification system before it is delivered to the market through flow lines. As gas in the pipeline from the well mouth to the separator hasn't been dehumidified, it is necessary to take anti-freezing measures. Typical measures include heating and injection of agents that prevents generation of hydrates (methanol and glycol, etc.) as well as decreasing gas pressure in pipes.

Chapter 6 Other Primary Energy APPENDIX

6.1 Renewable Energy Sector

6.1.1 Potentiality of Renewable Energy

Past investigations revealed that potential renewable energies available for use in the country include solar power, wind power, biomass and small-scale hydraulic power. Among them, solar power and biomass (incl. rice husk, baggasse and jute) are potentially and comparatively high as future power generation sources.

(1) Solar Power Generation

Located at 20.30° to 26.38° north, Bangladesh receives 4.0 to 6.5 kWh/m^2/day of average solar radiation. The solar radiation volume reaches its peak in March and April and its bottom in December and January. Bangladesh is a region suitable for solar power generation. However, the present cost for solar power generation is extremely expensive at 30 cents/kWh or higher and is uncompetitive with other power sources in terms of grid connection. The country is blessed with a solar power source, but the cost of power generation is basically high and has little chance to compete with other power sources in the case of connecting to power distribution systems. Due to this, it is necessary to receive subsidies to introduce solar power generation in the country. Actually, GEF, UNDP, WB, GTZ and KfW provide financial support for rural areas minus a grid connection.

(2) Wind Power Generation

Nationwide surveys are conducted to explore wind conditions. According to existing surveys, the average wind velocity at an altitude of around 25m above ground is low i.e. approx. 3.0 m/s to 4.5 m/s even during the monsoon period. Bangladesh has little places where wind condition is good for power generation. A separate survey, however, found several places along the coastal side that has a wind velocity of 6 m/s or above, which is suitable for wind power generation. Thus, although the past surveys are inaccurate, there seem to be potential sites with an average wind speed of 6 m/s or more which is a generally accepted as an economically viable point for wind-power generation. BPDB installed an experimental test plant to Muhuri Dam (Feni), one of such sites in September 2005. The plant consists of four 225 kW power generators, the total output power of 900 kW. GoB plans to invite a bid of 400 MW wind power generation plant but due to the low purchasing price (approx. 6 cents/kWh) it is estimated that only a small number of organizations would submit their bidding documents.

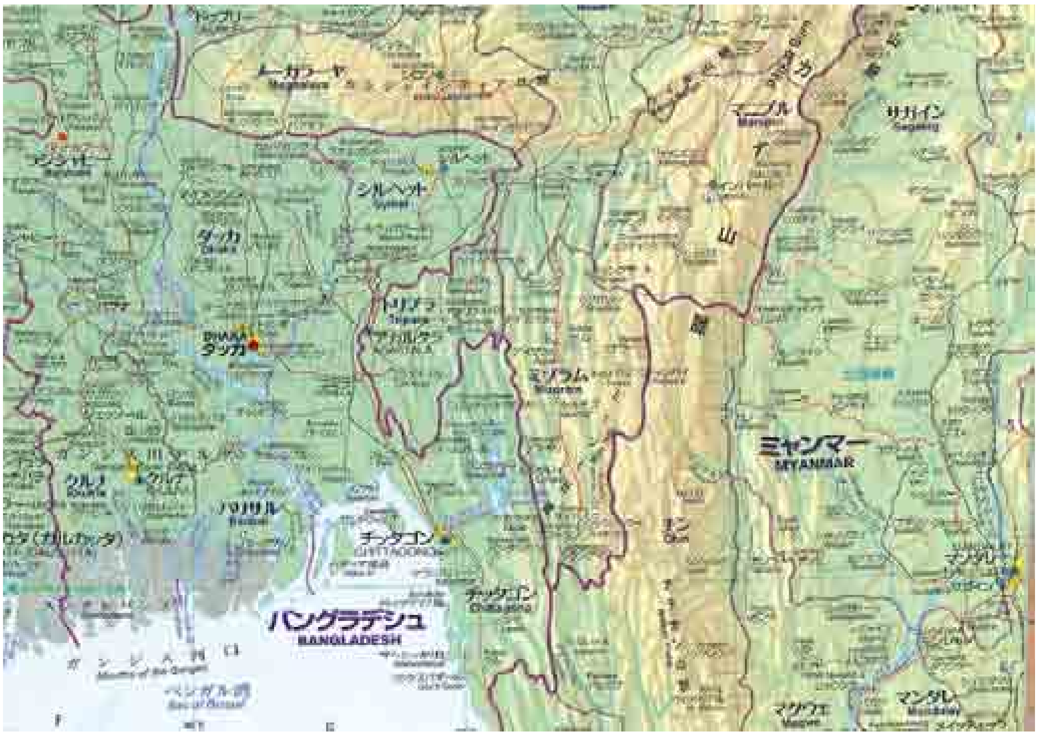
(3) Biomass Power Generation

Bangladesh is a producer of agricultural products namely rice, sugar cane and jute. Their residues are evaluated to be used as promising biomass resources for power generation. Even now, residues of agricultural products are effectively applied to multiple purposes including fuel, fertilizers and animal feeds. The residues are barely disposed as wastes.

(4) Hydropower Generation

Candidate places for small-scale hydropower generation plant having an output power of several hundred kilowatt that can be connected to electricity distribution systems have just been found and are located in the country's south-east areas (especially the hillside of Chittagong). An existing preliminary survey, however, indicates that hydropower generation requires a hefty amount of cost and hence it is not feasible to develop it as a project for profit.

Thus, there are a few places suitable for hydraulic power generation in Bangladesh. However, there exist suitable places for hydraulic power generation with mountain ranges of 1000 - 2000 m in height located in the East and North of Bangladesh as shown below.



Source: GRAND NEW WORLD ATLAS

APFig. 6-1 Map of Bangladesh (Northern, Eastern)

According to the Central Electricity Authority (CEA) of India, the hydraulic power potential in northeast India is considerably large (more than 60000 MW). The hydraulic power potential in regions surrounding Bangladesh has been reported as follows.

APTable 6-1 Hydraulic Power Potentials in Regions Surrounding Bangladesh (March 2008)

(Unit: MW)

State	Potential	Developed/ Under construction	Not developed	Under 50000MW initiative
Meghalaya	2,394	309	2,085	931
Manipur	1,784	105	1,679	362
Mizoram	2,196	0	2,196	1,500
Total	6,374	414	5,960	2,793

Source: Central Electricity Authority (CEA) of India

Undeveloped hydraulic power potentials of about 6000 MW exist in the regions surrounding Bangladesh. CEA has already prepared a Preliminary Feasibility Report for 2800 MW of the above undeveloped hydraulic power potential as part of the 50,000 MW initiative.

If hydropower generation is developed on a relatively large scale (100 MW or more) in such regions, the generated electric power will not be completely consumed in the northeastern provinces in the rainy season. Thus, the electric power will need to be transmitted to major power-consuming areas such as Kolkata. In considering this point, it is likely to be more economical to connect to the grid on the Bangladesh system to transmit electricity to Bangladesh in the rainy season.

Another issue is that most of those potentials exist in the basin of the River Barak (Bangladeshi name: River Kushiyara/Meghna) on the Bangladeshi side of the mountain ranges. Given that the rainwater that falls on the Bangladeshi side of the mountain areas is flowing into the sea via

Bangladesh, hydropower development on a relatively large scale will cause no little impact to Bangladesh.

In light of these points, it is recommended that the Bangladesh side requests the India side to set up a forum for discussion on hydropower development on a relatively large scale and encourage India to participate in the joint development by having both countries fully take advantage of such an opportunity.

The most effective means of joint development is to connect a part of the developed units directly to the Bangladeshi system by changing the number of connected units according to the supply-demand situation of the two countries. The hydraulic generator responds more promptly to load changes than the thermal generator. The hydraulic generator is therefore more responsive than the thermal generator to frequency changes associated with load changes under normal conditions and is more resistant to the system disturbance that occurred in facility failures. Accordingly, connecting the hydraulic generator directly to the system will strengthen the system and contribute to the improvement of electric power quality.

(5) Waste Power Generation

In Bangladesh, the per capita generation of waste is around 0.4 kg/day to 0.5 kg/day in city areas, and around 0.15 kg/day in rural areas. As there is an abundant amount of waste generated in city areas, this waste can be a very good energy source in city areas. If the per capita waste generation is 0.24 kg/day (0.01 kg/hour), the total population is 140 million, and the waste calorie is 1500 kcal/kg, the electric power generated by inputting all waste into power generation is estimated to be approximately 700 MW per hour by simple arithmetic. Thus, much cannot be expected from waste power generation. In addition, the generation of waste usable for power generation is predicted to further decrease with the progress in waste segregation and recycling.

Proposals to establish power plants (output power: 100 MW each) using wastes in such large cities as Dhaka, Chittagong, Khulna and Rajshahi are submitted to GoB, but there has been no progress seen since then.

6.1.2 Assistance from International and ODA Agencies

Donors extend loans and/or provide technical assistance mainly to the off-grid solar power development for the rural electrification in Bangladesh. Projects of each donor are as follows:

(1) UNDP

UNDP provided financial assistance for the “Sustainable Rural Energy Project” executed between 1998 and 2006. The objective of the project, implemented by the Local Government Engineering Department, was the development of a community-based rural electrification model by renewable energy. To achieve that, there were three components of activities under the project:

- Demonstration of renewable energy technologies (RETs)
- Capacity building through training on RETs
- Development of a renewable energy information network

As a result, 40.5kW solar energy, 10kW wind-solar hybrid energy, 15.5kW biomass energy and 10kW microhydro energy were developed and the web site for wide dissemination of renewable energy technologies, named Renewable Energy Information Network (REIN), opened[1].

(2) World Bank, GEF

The World Bank has supported “Rural Electrification and Renewable Energy Development Project” and the “Grameen Shakti Solar Home Systems Project”.

The Rural Electrification Board (REB) and the state-owned Infrastructure Development. Co. Ltd. (IDCOL) are the implementing agencies of “Rural Electrification and Renewable Energy Development Project” and aims to achieve rural electrification via the grid extension and

[1] http://www.lged-rein.org/

dissemination of the Solar Home System (SHS). There are two program schemes for installation of SHS, one is the public program by REB and the other is IDCOL's program with its microfinance, implemented through 23 registered private partner organizations. "Grameen Shakti Solar Home Systems Project" supports the activities by Grameen Shakti, one of the partner organizations.

World Bank approved to provide financial assistance with $190.98 million in 2002 and, given the successful implementation of the IDCOL program, additional assistance with $130 million with grant aid by GEF in 2009. Following the same project design, KfW and GTZ also started to support the project by providing grant funds for technical assistance. The latest IDCOL target is to finance 1 million SHSs by the end of year 2012 and a total of 645,033 SHSs have already been installed under the program by August 2010. Under this assistance, World Bank signed an Emissions Reduction Purchase Agreement with IDCOL and Grameen Shakti.

(3) KfW, GTZ

KfW and GTZ supports SHS program on the basis of successful support by IDCOL.

(4) ADB

In 2008, ADB and GoB signed a loan agreement of $165 million for the Public-Private Infrastructure Development Facility and $33 million of that was for the promotion of renewable energy through IDCOL's renewable energy program.

(5) USAID

In 2000, USAID gave Grameen Shakti a grant equivalent to $4.0 million and 38,500 SHSs were installed in various parts of Bangladesh successfully by the time the project ended in August 2005. USAID continues the support for Grameen Shakti program with $2.0 million in funding to focus on rural women economical empowerment by training to install and maintain a Solar Home System.

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APTable 9-1 Result of each substation demand forecast (MW)

East or West	Region	Name of Grid Substation	2015	2020	2025	2030
East	Southern	Chandraghona	33.7	70.9	112.8	160.9
East	Southern	Hathazari	55.3	93.8	132.3	174.5
East	Southern	Baroirhat, Ctg	63.3	112.1	162.3	218.2
East	Southern	Madunaghat	89.2	147.9	205.3	267.8
East	Southern	Sikalbaha	64.7	113.9	164.4	220.6
East	Southern	Dohazari	51.7	87.6	123.5	162.9
East	Southern	Cox's bazar	63.9	101.0	135.4	172.1
East	Southern	Halishahar	54.4	81.8	105.5	129.9
East	Southern	Agrabad	60.1	94.5	126.3	160.1
East	Southern	Kulsi	65.4	106.1	145.1	187.3
East	Southern	Abul Khair Steel Mills	38.3	69.2	101.4	137.4
East	Southern	Baraulia	60.6	104.6	149.2	198.4
East	Southern	Bakulia	74.9	129.0	183.6	243.8
East	Southern	Julda	29.3	46.9	63.5	81.3
East	Southern	Shahmirpur	19.4	52.6	92.5	139.3
East	Southern	Rangamati	34.4	72.9	116.4	166.3
East	Southern	Feni	58.0	98.6	139.1	183.6
East	Southern	Chowmuhani	48.6	68.5	83.6	98.0
East	Southern	Khagrachari	60.7	108.5	158.1	213.4
East	Southern	Ramganj	66.0	115.7	166.6	223.0
East	Southern	Chouddagram	50.3	81.3	110.8	142.6
East	Southern	Comilla (N)	75.6	151.6	235.7	331.4
East	Southern	Comilla (S)	56.9	99.1	142.1	189.7
East	Southern	Chandpur	59.6	105.5	152.9	205.6
East	Southern	Daudkandi	58.7	105.8	154.9	209.8
East	Southern	Kaptai	12.3	24.4	37.6	52.6
East	Southern	Bakulia	74.9	129.0	183.6	243.8
East	Southern	Chandpur	59.6	105.5	152.9	205.6
East	Southern	Chouddagram	50.3	81.3	110.8	142.6
East	Southern	Feni	58.0	98.6	139.1	183.6
East	Southern	Kulsi	65.4	106.1	145.1	187.3
East	Southern	Agrabad	60.1	94.5	126.3	160.1
East	Southern	Halishahar	54.4	81.8	105.5	129.9
East	Southern	Dohazari	51.7	87.6	123.5	162.9
East	Southern	Comilla (S)-2	56.9	99.1	142.1	189.7
East	Dhaka	Haripur	66.6	129.9	198.9	277.3
East	Dhaka	Siddhirganj	69.8	97.1	117.0	135.6
East	Dhaka	Moghbazar	56.8	90.0	121.0	154.1
East	Dhaka	Maniknagar	63.5	102.2	139.0	178.5
East	Dhaka	Ullon	80.7	135.5	189.8	249.3
East	Dhaka	Dhanmondi	82.9	138.5	193.4	253.3
East	Dhaka	Narinda	69.6	107.4	141.5	177.2

East or West	Region	Name of Grid Substation	2015	2020	2025	2030
East	Dhaka	Matuail	54.9	112.7	177.2	251.0
East	Dhaka	BangaBhaban	95.3	155.4	213.1	275.6
East	Dhaka	Shyampur	84.9	128.2	165.8	204.7
East	Dhaka	Madanganj	70.9	122.3	174.3	231.7
East	Dhaka	Hasnabad	92.9	151.5	207.9	269.0
East	Dhaka	Sitalakhya	98.1	181.6	270.2	369.8
East	Dhaka	Meghnaghat	56.7	103.1	151.7	206.2
East	Dhaka	Gulshan	79.6	144.0	211.5	286.9
East	Dhaka	Munshiganj	76.2	129.5	182.8	241.3
East	Dhaka	Kamrangirchar	96.6	195.4	304.8	429.8
East	Dhaka	Hasnabad	92.9	151.5	207.9	269.0
East	Dhaka	Mirpur	81.1	137.2	193.0	254.2
East	Dhaka	NewTongi	90.6	140.7	186.2	234.3
East	Dhaka	Kalyanpur	56.6	106.4	159.8	219.9
East	Dhaka	Uttara	97.2	175.8	258.0	349.9
East	Dhaka	Basundhara	71.5	123.9	177.1	235.9
East	Dhaka	Tongi	56.6	99.2	142.8	191.3
East	Dhaka	Kabirpur	64.3	129.9	202.6	285.7
East	Dhaka	Manikganj	61.3	107.3	154.5	206.8
East	Dhaka	Tangail	82.6	146.1	211.6	284.5
East	Dhaka	Ghorasal	87.2	142.5	195.8	253.4
East	Dhaka	Narsingdi	77.5	131.3	184.9	243.7
East	Dhaka	Joydebpur	50.9	91.1	132.8	179.3
East	Dhaka	Bhulta	55.0	85.4	112.9	141.8
East	Dhaka	Savar	57.9	91.5	122.8	156.1
East	Dhaka	Purbachal	19.4	52.6	92.5	139.3
East	Dhaka	Madartek	75.8	128.9	182.1	240.5
East	Dhaka	Nabinagar(Md.pur)	64.5	100.5	133.4	168.1
East	Dhaka	DhakaUniversity	82.9	138.5	193.4	253.3
East	Dhaka	Cantonment	80.3	135.1	189.3	248.7
East	Dhaka	OldAirport	67.8	105.0	138.7	174.0
East	Dhaka	Sreepur	86.6	143.6	199.4	260.0
East	Dhaka	Savar	57.9	91.5	122.8	156.1
East	Dhaka	Matuail	54.9	112.7	177.2	251.0
East	Dhaka	Kamrangirchar	96.6	195.4	304.8	429.8
East	Dhaka	OldAirport	67.8	105.0	138.7	174.0
East	Dhaka	Nabinagar(Md.pur)	64.5	100.5	133.4	168.1
East	Dhaka	Joydebpur	50.9	91.1	132.8	179.3
East	Dhaka	Tangail	82.6	146.1	211.6	284.5
East	Dhaka	Manikganj	61.3	107.3	154.5	206.8
East	Dhaka	Kabirpur	64.3	129.9	202.6	285.7
East	Dhaka	Tongi	56.6	99.2	142.8	191.3
East	Dhaka	Kalyanpur	56.6	106.4	159.8	219.9
East	Dhaka	Shyampur	84.9	128.2	165.8	204.7
East	Dhaka	Moghbazar	56.8	90.0	121.0	154.1

East or West	Region	Name of Grid Substation	2015	2020	2025	2030
East	Dhaka	Siddhirganj	69.8	97.1	117.0	135.6
East	Dhaka	Uttara-2	97.2	175.8	258.0	349.9
East	Dhaka	Gulshan-2	79.6	144.0	211.5	286.9
East	Dhaka	Basundhara-2	71.5	123.9	177.1	235.9
East	Dhaka	Basundhara-3	71.5	123.9	177.1	235.9
East	Dhaka	Narinda-2	69.6	107.4	141.5	177.2
East	Central	Ashuganj	48.0	82.1	116.5	154.3
East	Central	Kishoreganj	79.4	130.4	179.7	233.3
East	Central	Mymensingh	65.2	103.5	139.2	177.4
East	Central	Jamalpur	98.8	197.4	306.1	430.0
East	Central	Netrokona	55.9	92.0	127.1	165.1
East	Central	Bhaluka	73.3	125.6	178.2	236.1
East	Central	Sherpur	71.3	122.9	175.0	232.5
East	Central	Brahmanbaria	54.7	100.4	148.6	202.7
East	Central	Shahjibazar	76.9	125.2	171.7	222.0
East	Central	Sreemangal	55.4	85.0	111.6	139.3
East	Central	Fenchuganj	55.7	89.7	121.8	156.4
East	Central	Sylhet	66.8	123.8	184.2	252.1
East	Central	Chhatak	55.7	91.5	126.1	163.6
East	Central	Sylhet-2	52.0	83.5	113.4	145.6
East	Central	Sylhet-2	52.0	83.5	113.4	145.6
East	Central	Sylhet	66.8	123.8	184.2	252.1
West	Western	Goalpara	21.4	49.1	81.1	118.1
West	Western	Khulna(C)	67.3	101.2	130.5	160.7
West	Western	Chuadanga	62.7	105.0	146.7	192.2
West	Western	Noapara	61.9	104.6	147.0	193.5
West	Western	Jessore	71.3	101.3	124.3	146.5
West	Western	Jhenaidah	55.0	84.0	109.7	136.6
West	Western	Kustia(Bottail)	59.7	96.9	132.4	170.8
West	Western	Magura	62.7	105.0	146.7	192.2
West	Western	Bheramara&GKProject	49.0	77.7	104.3	132.7
West	Western	Faridpur	95.2	152.2	205.8	263.3
West	Western	Gopalganj	45.9	85.5	127.6	175.0
West	Western	Madaripur	50.8	85.3	119.5	156.8
West	Western	Barisal	56.5	93.2	128.9	167.6
West	Western	Bhandaria	58.0	101.3	145.4	194.3
West	Western	Bagerhat	63.3	104.1	143.5	186.4
West	Western	Barisal (N)	59.1	100.0	140.8	185.6
West	Western	Mongla	35.6	63.5	92.5	124.8
West	Western	Gallamari	62.7	105.0	146.7	192.2
West	Western	Patuakhali	84.9	153.3	224.9	304.8
West	Western	Satkhira	65.5	111.5	157.6	208.2
West	Western	Madaripur	50.8	85.3	119.5	156.8
West	Western	Jessore	71.3	101.3	124.3	146.5
West	Western	Khulna(C)	67.3	101.2	130.5	160.7

East or West	Region	Name of Grid Substation	2015	2020	2025	2030
West	Northern	Ishurdi	49.5	86.6	124.4	166.4
West	Northern	Natore	51.9	88.4	124.9	165.0
West	Northern	Niamatpur	73.0	125.1	177.6	235.5
West	Northern	Rajshahi	73.0	144.5	223.2	312.7
West	Northern	Ch. Nowabganj	87.2	148.2	209.3	276.4
West	Northern	Rajshahi New	71.7	123.4	175.5	233.1
West	Northern	Pabna	72.1	112.4	149.0	187.8
West	Northern	Shahjadpur	75.8	131.4	187.8	250.2
West	Northern	Sirajganj	65.1	113.7	163.3	218.3
West	Northern	Bogra	68.5	117.5	166.9	221.4
West	Northern	Joypurhat	76.2	129.5	182.8	241.3
West	Northern	Noagaon	99.2	192.1	293.1	407.6
West	Northern	Palashbari	61.8	115.8	173.5	238.5
West	Northern	Rangpur	56.8	97.6	138.8	184.2
West	Northern	Lalmonirhat	82.9	143.5	205.0	272.9
West	Northern	Saidpur	81.6	112.9	135.1	155.7
West	Northern	Purbasadipur	95.2	162.3	229.5	303.5
West	Northern	Panchaghar	60.7	108.5	158.1	213.4
West	Northern	Thakurgaon	82.1	166.5	260.1	367.1
West	Northern	Barapukuria	74.0	126.5	179.3	237.3
West	Northern	Rangpur	56.8	97.6	138.8	184.2
West	Northern	Bogra	68.5	117.5	166.9	221.4
West	Northern	Bogra	68.5	117.5	166.9	221.4
West	Northern	Sirajganj	65.1	113.7	163.3	218.3
West	Northern	Natore	51.9	88.4	124.9	165.0
Total			10282.95	17599.58	24955.58	33056.969

Source: PSMP Study Team

APTable 9-2 The list of generators for system analys

Station Name	2015 Heavy Load	2015 Light Load	2020 Heavy Load	2025 Heavy Load	2030 Heavy Load	2030 Light Load	Bus Number
Barapukuria 2x125 MW ST	200	200	200	200	200	200	2042
Barapukuria 250MW (3rd unit)	250	0	250	250	250	0	2042
B-K-D-P 1 600MW #1	0	0	600	600	600	0	4507
B-K-D-P 1 600MW #2	0	0	600	600	600	0	4507
B-K-D-P 1 600MW #3	0	0	600	600	600	0	4507
B-K-D-P 2 600MW #1	0	0	0	600	600	0	4507
B-K-D-P 2 600MW #2	0	0	0	600	600	0	4507
B-K-D-P 2 600MW #3	0	0	0	0	600	0	4507
B-K-D-P 3 1000 MW #1	0	0	0	0	1000	0	4507
B-K-D-P 3 1000 MW #2	0	0	0	0	1000	0	4507
B-K-D-P 4 1000 MW #1	0	0	0	0	1000	0	4507
B-K-D-P 4 1000 MW #2	0	0	0	0	1000	0	4507
B-K-D-P 5 1000 MW #1	0	0	0	0	1000	0	4507
B-K-D-P 5 1000 MW #2	0	0	0	0	1000	1000	4507
Khulna South 600 MW ST #1	0	0	600	600	600	0	4051
Khulna South 600 MW ST #2	0	0	600	600	600	0	4051
Chittagong 600 MW ST #1	0	0	600	600	600	0	4026
Chittagong 600 MW ST #2	0	0	600	600	600	0	4026
Chittagong South 600MW #1	0	0	600	600	600	0	4026
Matarbari 600MW #1	0	0	0	600	600	0	4509
Matarbari 600MW #2	0	0	0	600	600	0	4509
Matarbari 600MW #3	0	0	0	0	600	0	4509
Matarbari 600MW #4	0	0	0	0	600	600	4509
Megnagatt 600MW #1	0	0	0	0	600	0	2014
Mawa 600MW #1	0	0	0	0	600	0	4505
Zajira 600MW #1	0	0	0	0	600	0	4506
Siddhirgonj 210 MW ST #1	177	0	177	177	177	0	2004
Ghorasal 4x210 ST #6	178	0	178	178	0	0	2010
Ghorasal 4x210 ST #5	178	0	178	178	0	0	2010
Ghorasal 4x210 ST #4	178	0	178	0	0	0	2010
Ghorasal 4x210 ST #3	178	0	178	0	0	0	2010
Ashuganj 3x150 MW ST #5	120	0	120	0	0	0	2008
Ashuganj 3x150 MW ST #4	120	0	120	0	0	0	2008
Ashuganj 3x150 MW ST #3	120	0	120	0	0	0	2008
Raozan 2X210 ST#2	175	0	175	175	0	0	2001
Raozan 2X210 ST#1	175	0	175	175	0	0	2001
Ghorasal 2x55 ST #1	50	0	0	0	0	0	1130
Ghorasal 2x55 ST #2	30	0	0	0	0	0	1130
Ashuganj 2x64 MW ST #2	0	0	0	0	0	0	1201
Ashuganj 2x64 MW ST #1	0	0	0	0	0	0	1201
Chittagon (Sikalbaha) 60 MW ST	0	0	0	0	0	0	1006
NEPC, Haripur BMPP	110	0	0	0	0	0	1101
Jangalia, comilla SIPP	0	0	0	0	0	0	1031
Tangail SIPP (22 MW)	0	0	0	0	0	0	1128
Feni SIPP	0	0	0	0	0	0	1020

Station Name	2015		2020	2025	2030		Bus
	Heavy Load	Light Load	Heavy Load	Heavy Load	Heavy Load	Light Load	Number
Barobkundo SIPP	0	0	0	0	0	0	1006
Kumargao 10 MW (15 Years)	0	0	0	0	0	0	1215
Hobiganj,Feni, Rupganj, Mouna, Narsindi, Ullapara, SIPP, REB	0	0	0	0	0	0	
Chandina,Mahdabdi,AshuliaSummit , REB	0	0	0	0	0	0	
Kumargoan 48MW (3 Years)	0	0	0	0	0	0	1215
West Mount Baghabari BMPP	70	0	0	0	0	0	1412
Sahzibazar RPP (3 Years)	0	0	0	0	0	0	1211
Sahzibazar RPP (15 Years)	86	0	86	0	0	0	1211
Tongi 100 MW GT	100	0	100	100	0	0	1125
Baghabari 100 MW CT	99	0	99	0	0	0	1412
Baghabari 100 MW CT (Repowering)	0	0	0	165	0	0	1412
Baghabari 71 MW CT	70	0	0	0	0	0	1412
Shahjibazar GT 7 units	0	0	0	0	0	0	1211
Shahjibazar2x35 MW CT #2	0	0	0	0	0	0	1211
Shahjibazar2x35 MW CT #1	0	0	0	0	0	0	1211
Chittagon (Sikalbaha) BMGT	0	0	0	0	0	0	1006
Haripur 3x33 CT #3	0	0	0	0	0	0	1101
Haripur 3x33 CT #2	0	0	0	0	0	0	1101
Haripur 3x33 CT #1	0	0	0	0	0	0	1101
Sylhet 20 MW CT	0	0	0	0	0	0	1215
Ashuganj CT 56 MW	0	0	0	0	0	0	1201
CDC, Haripur	360	360	360	360	0	0	2015
CDC, Meghnaghat	450	0	450	450	0	0	2014
Mymenshing (RPC) 210 MW CC	175	175	175	175	175	175	1208
Fenchuganj CC	88	0	88	0	0	0	1214
Ashuganj 90 MW CC	0	0	0	0	0	0	1201
Ghorasal, Dual Fuel, Peaking Plant	290	0	290	290	290	290	2010
Kaliakair, Dual Fuel, Peaking Plant	100	0	100	100	0	0	1147
Savar, Dual Fuel, Peaking Plant	100	0	100	100	0	0	1135
Ashuganj – 3 yrs Rental, commissioned	0	0	0	0	0	0	1201
Fenchuganj (15 Years), commissioned	51	0	51	51	0	0	1214
Ashuganj 50	52	0	52	52	52	52	1201
Comilla Peaking, Dual Fuel, Peaking Plant	50	0	50	50	0	0	1030
Fenchuganj – 3 Yrs rental, U/C	0	0	0	0	0	0	1214
Bhola (3 Years), Commissioned	0	0	0	0	0	0	1328
Bogra –3 yrs rental, U/C	0	0	0	0	0	0	1415
Siddhirgonj 2X150 MW CT	450	0	450	450	450	0	2004
Ashuganj 150 MW	150	0	150	150	150	0	1201
Khulna 150MW , Dual Fuel, Peaking Plant	150	0	150	150	150	0	1303
Sikalbaha 150MW Peaking Plant, U/C	149	0	149	149	149	0	1006
Sirajganj 150MW , Dual Fuel, Peaking Plant	150	0	150	150	150	0	2036
Siddhirgonj 2X120 MW Peaking Plant (U/C)	208	0	208	208	208	0	1102
Keraniganj, 750 MW, CC	0	0	750	750	750	750	2504
Meghnaghat Large #1, 750 MW, CC	0	0	750	750	750	750	2014
Meghnaghat Large #2, 750 MW, CC	0	0	750	750	750	750	2014
Ashuganj 450 MW CCPP	0	0	450	450	450	450	2008
Bibiana 450 MW CCPP(Ist Unit)	450	450	450	450	450	450	4054
Bibiana 450 MW CCPP(2nd Unit)	450	450	450	450	450	450	4054

Station Name	2015		2020	2025	2030		Bus
	Heavy Load	Light Load	Heavy Load	Heavy Load	Heavy Load	Light Load	Number
Meghnaghat CCPP (2nd unit) Dual Fuel	450	450	450	450	450	450	2014
North Dhaka 450MW CCPP	0	0	450	450	450	450	4047
Serajganj 450 MW CCPP	450	450	450	450	450	450	2036
Bheramara 360 MW CCPP (NWPGC)	360	360	360	360	360	360	2044
Haripur 360 MW CCPP (EGCB)	360	360	360	360	360	360	1101
Bhola 150MW CCPP(Ist unit), BPDB	150	0	150	150	150	150	2055
Chandpur 150 MW CCPP (BPDB), U/C	150	150	150	150	150	150	1032
Sylhet 150 MW CCPP (BPDB), U/C	150	150	150	150	150	150	1215
Fenchuganj CC(2nd Phase), U/C	108	108	108	108	108	108	1214
Bhola CCPP(2nd unit)	225	225	225	225	225	225	2055
Madanganj,Keraniganj CCPP Dual Fuel	225	225	225	225	225	225	1112
Sikalbaha 225 MW Dual Fuel, CC	225	225	225	225	225	225	2009
Khulna 60 MW ST	33	0	0	0	0	0	1301
khulna 110 MW ST	54	54	0	0	0	0	1301
Syedpur Peaking Plant	100	0	100	100	0	0	1425
Jamalpur Peaking Plant	100	0	100	100	0	0	1204
Chapai Nababgonj Peaking Plant	100	0	100	100	0	0	1406
Khulna Peaking Plant	100	0	100	100	0	0	1332
Dohazari Peaking Plant	100	0	100	100	100	0	1008
Hathazari Peaking Plant	100	0	100	100	100	0	1003
FaridpurPeaking Plant	50	0	50	50	50	0	1313
Baghabari Peaking Plant	50	0	50	50	50	0	1412
Katakhali Peaking Plant	50	0	50	50	50	0	1405
Santahar Peaking Plant	50	0	50	50	50	0	1417
BPDB & RPCL, 150MW	150	0	150	150	150	0	1208
Khulna(quick rental)	115	0	0	0	0	0	1301
Modanganj(quick rental)	102	0	0	0	0	0	1112
Gopalgonj Peaking Plant	100	0	100	100	100	0	1314
Julda(quick rental)	100	0	0	0	0	0	1017
Kadda, Meghna(quick rental)	100	0	0	0	0	0	1115
Kadda, Sidhirganj(quick rental)	100	100	0	0	0	0	1102
Keranigong(quick rental)	100	0	0	0	0	0	1119
Meghnagat(quick rental)	100	0	0	0	0	0	1115
Noapara, Jessore, Rental, U/C	100	0	0	0	0	0	1306
Bera, Pabna, Peaking Plant	70	0	70	70	70	0	1410
Shikalbaha – 3 yrs rental, commissioned	0	0	0	0	0	0	1006
Barisal, Rental,U/C	50	0	0	0	0	0	1320
Chapai Nawabgonj(quick rental)	50	0	0	0	0	0	1406
Doudkandi	50	0	50	50	50	0	1033
Gazipur 50 MW	50	0	50	50	50	0	1132
Katakhali(quick rental)	50	0	0	0	0	0	1405
Katakhali, Rajshahi, Peaking Plant	50	0	50	50	0	0	1405
Noapara(quick rental)	0	0	0	0	0	0	1305
Raujan 20 MW	0	0	0	0	0	0	
Tangail 20 MW	0	0	0	0	0	0	1128
Chandpur 15 MW	0	0	0	0	0	0	1032
Narayanganj 30MW	0	0	0	0	0	0	1032
Keraniganj Peaking	0	0	0	0	200	0	1119

Station Name	2015		2020	2025	2030		Bus
	Heavy Load	Light Load	Heavy Load	Heavy Load	Heavy Load	Light Load	Number
Bogra Peaking	0	0	0	100	100	0	1415
Comilla Peaking	0	0	100	100	100	0	1031
Daudkandi Peaking	0	0	0	0	100	0	1106
Jessore Peaking	0	0	100	100	100	0	1306
Jhenaidah Peaking	0	0	0	100	100	0	1307
Halishahar Peaking	0	0	0	100	100	0	1011
Khulna Center Peaking	0	0	0	100	100	0	1302
Ashuganj Peaking	0	0	200	200	200	0	2008
Mymensingh Peaking	0	0	0	0	100	0	1203
Rajshahi Peaking	0	0	0	0	100	0	1405
Rangpur Peaking	0	0	0	0	100	0	1420
Khulna Rental (3 Years)	0	0	0	0	0	0	1301
KPCL, Khulna BMPP	106	0	0	0	0	0	1301
Rangpur 20MW CT	19	0	0	0	0	0	1420
Saidpur 20MW CT	19	0	0	0	0	0	1425
Barisal 2x20MW CT #1	0	0	0	0	0	0	1320
Barisal 2x20MW CT #2	0	0	0	0	0	0	1320
Bheramara 3x20 MW CT #1	0	0	0	0	0	0	1310
Bheramara 3x20 MW CT #2	0	0	0	0	0	0	1310
Bheramara 3x20 MW CT #3	0	0	0	0	0	0	1310
Barisal Diesel (9 units)	0	0	0	0	0	0	1320
Bhola Diesel	0	0	0	0	0	0	1328
Bhola Diesel (New)	0	0	0	0	0	0	1328
Ghorashal (quick rental)	0	0	0	0	0	0	2010
Bheramara, Rental , U/C	0	0	0	0	0	0	1310
Siddirganj(quick rental)	0	0	0	0	0	0	1102
Khulna(quick rental)	0	0	0	0	0	0	1301
Pagla, Narayaganj(quick rental)	0	0	0	0	0	0	
Thakurgao, Rental, U/C	0	0	0	0	0	0	1432
Karnafuli hydro power plant #1	40	40	40	40	40	40	1001
Karnafuli hydro power plant #2	40	40	40	40	40	40	1001
Karnafuli hydro power plant #3	50	50	50	50	50	50	1001
Karnafuli hydro power plant #4	50	50	50	50	50	50	1001
Karnafuli hydro power plant #5	50	50	50	50	50	50	1001
Karnafuli Hydro (#6&7, 2x50 MW)	0	0	0	100	100	100	1001
Sarishabari, Jamalpur	0	0	0	0	0	0	1204
Rajabarihat Goat Development Firm	0	0	0	0	0	0	1405
Kaptai Power Plant	0	0	0	0	0	0	1001
Patenga Offshore, Chittagong	100	100	100	100	100	100	1011
Rooppur Nuclear # 1, 1000 MW	0	0	1000	1000	1000	1000	4508
Rooppur Nuclear # 2, 1000 MW	0	0	1000	1000	1000	1000	4508
Rooppur Nuclear # 3, 1000 MW	0	0	0	1000	1000	1000	4508
Rooppur Nuclear # 4, 1000 MW	0	0	0	0	1000	0	4508
PALLATANA to COMILLA	0	0	0	250	250	0	2005
SILCHAR to FENCHUGANJ 1	0	0	0	750	750	750	2065
BAHARAMPUR to BHERAMARA Phase-1	500	0	500	500	500	500	2044
BAHARAMPUR to BHERAMARA Phase-2	0	0	0	500	500	0	2044
Hydro from Nepal (Kishanganj (PURNIA) to Bogra)	0	0	0	500	500	500	2040

Station Name	2015		2020	2025	2030		Bus
	Heavy Load	Light Load	Heavy Load	Heavy Load	Heavy Load	Light Load	Number
Hydro from Bhutan (Alipurduar to Bogra)	0	0	0	500	500	500	2040
Meghalaya to Mymengsing	0	0	0	0	0	0	
Myanmmer to Bangladesh (should refer from PGCB PP)	0	0	500	500	500	500	2603
Total	12688	4822	22010	27586	36254	15400	

Source :PSMP Study Team

APTable 9-3 Standard parameters of the newly installed transmission line 100MVA Base

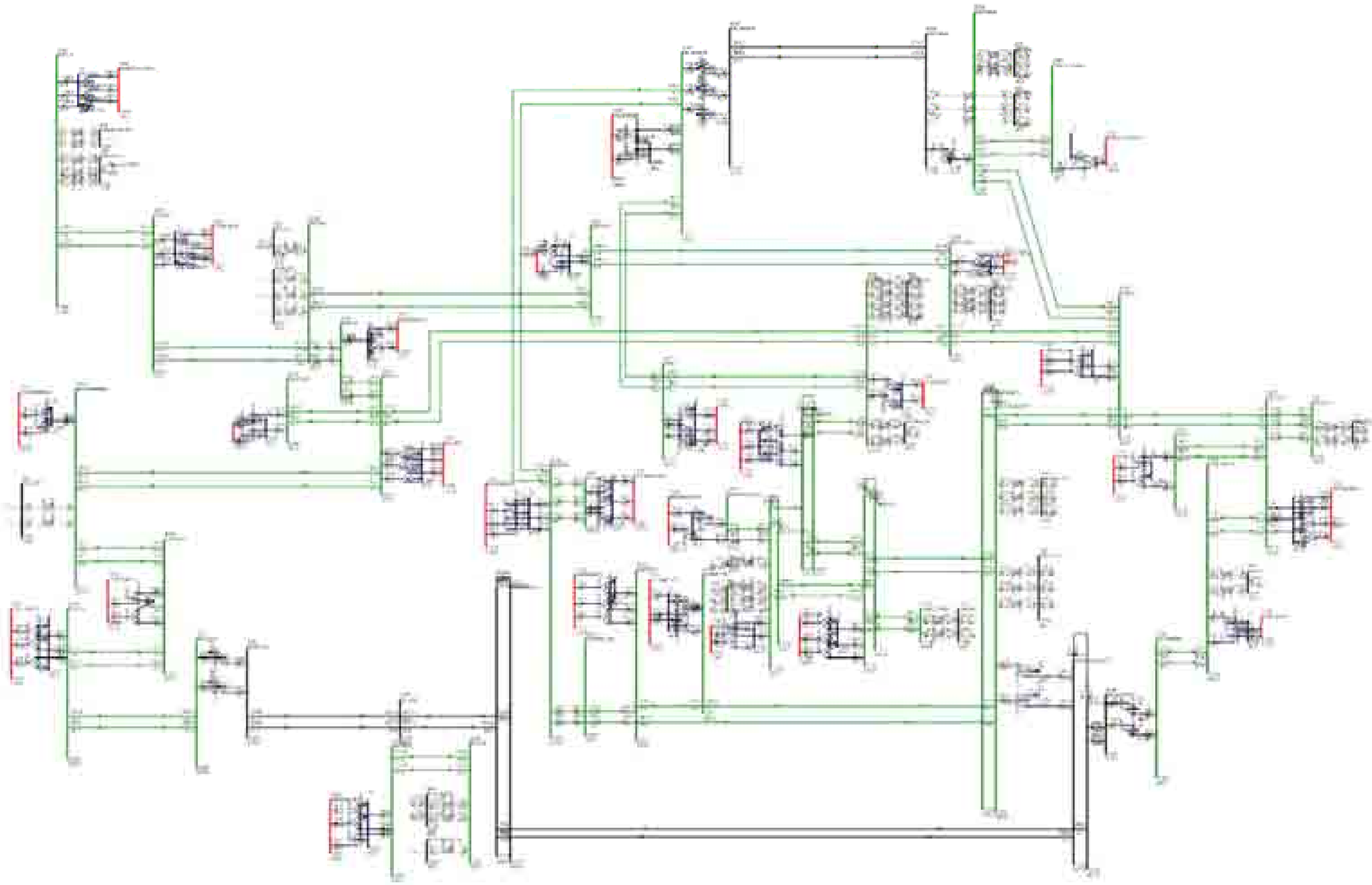
	R_1 [pu/km]	X_1 [pu/km]	B_1 [pu/km]	R_0 [pu/km]	X_0 [pu/km]	Allowable Current [MVA]
400kV	1.9×10^{-5}	1.71×10^{-4}	7.0×10^{-3}	9.7×10^{-5}	4.98×10^{-4}	2347.2
230kV	8.0×10^{-5}	5.5×10^{-4}	2.1×10^{-3}	6.0×10^{-4}	2.0×10^{-3}	597.6
132kV	5.8×10^{-4}	2.2×10^{-3}	5.2×10^{-4}	1.8×10^{-3}	7.7×10^{-3}	150.9

Source :PSMP Study Team

APTable 9-4 Standard parameters of 400kV/230kV transformer

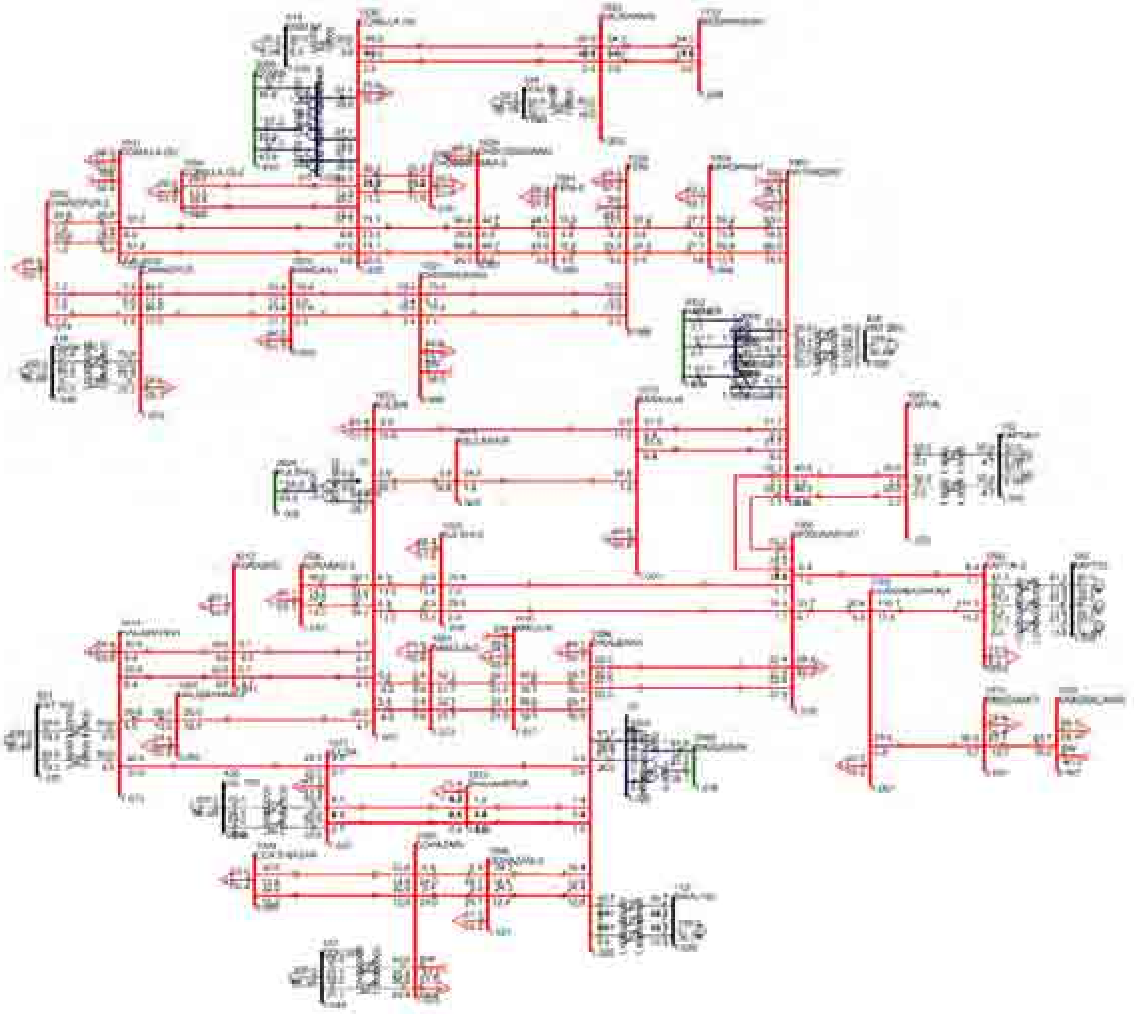
400kV/230kV			Allowable Current [MVA]		500
Positive Sequence Impedance [pu]					
P-S		S-T		P-T	
R_1	X_1	R_1	X_1	R_1	X_1
3.1×10^{-3}	1.3×10^{-1}	2.8×10^{-3}	1.1×10^{-1}	4.5×10^{-4}	1.9×10^{-2}
Zero Sequence Impedance [pu]					
P		S		T	
R_0	X_0	R_0	X_0	R_0	X_0
3.1×10^{-3}	1.3×10^{-1}	2.8×10^{-3}	1.1×10^{-1}	4.5×10^{-4}	1.9×10^{-2}

Source :PSMP Study Team



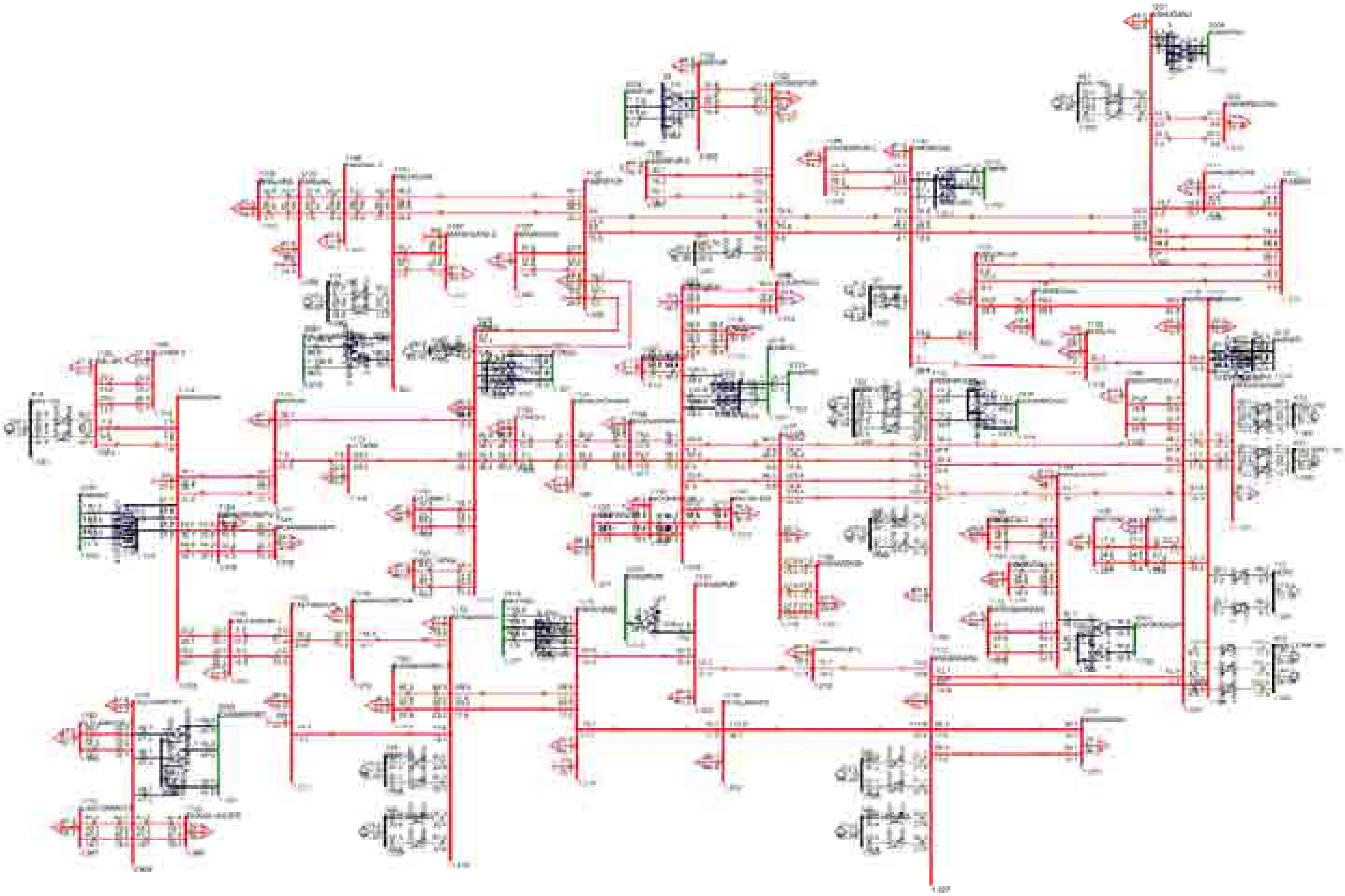
Source: PSMP Study Team

APFig. 9-1 230kV・400kV power flow (2015, pattern east)



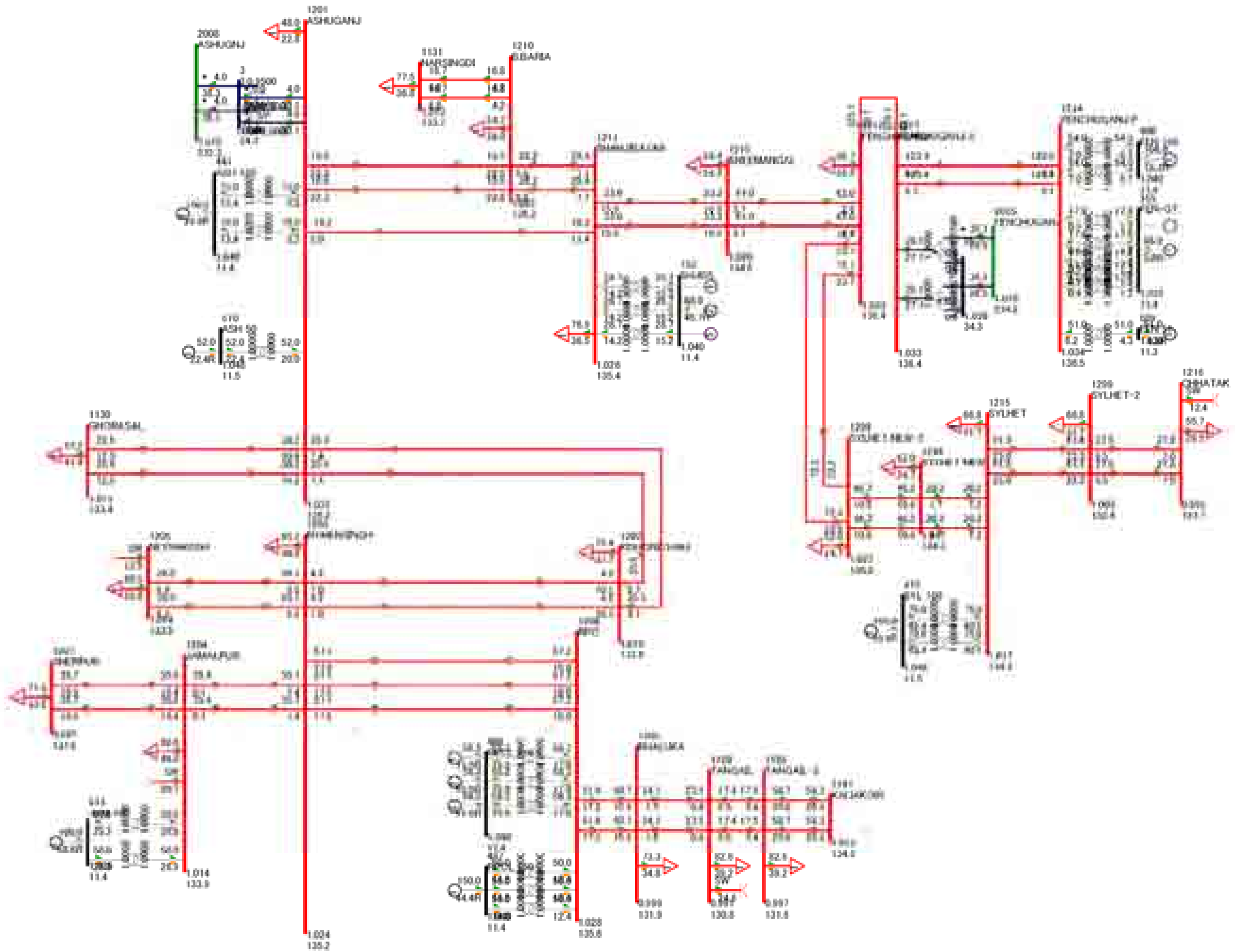
Source: PSMP Study Team

APFig. 9-2 132kVSouthern power flow (2015, pattern east)



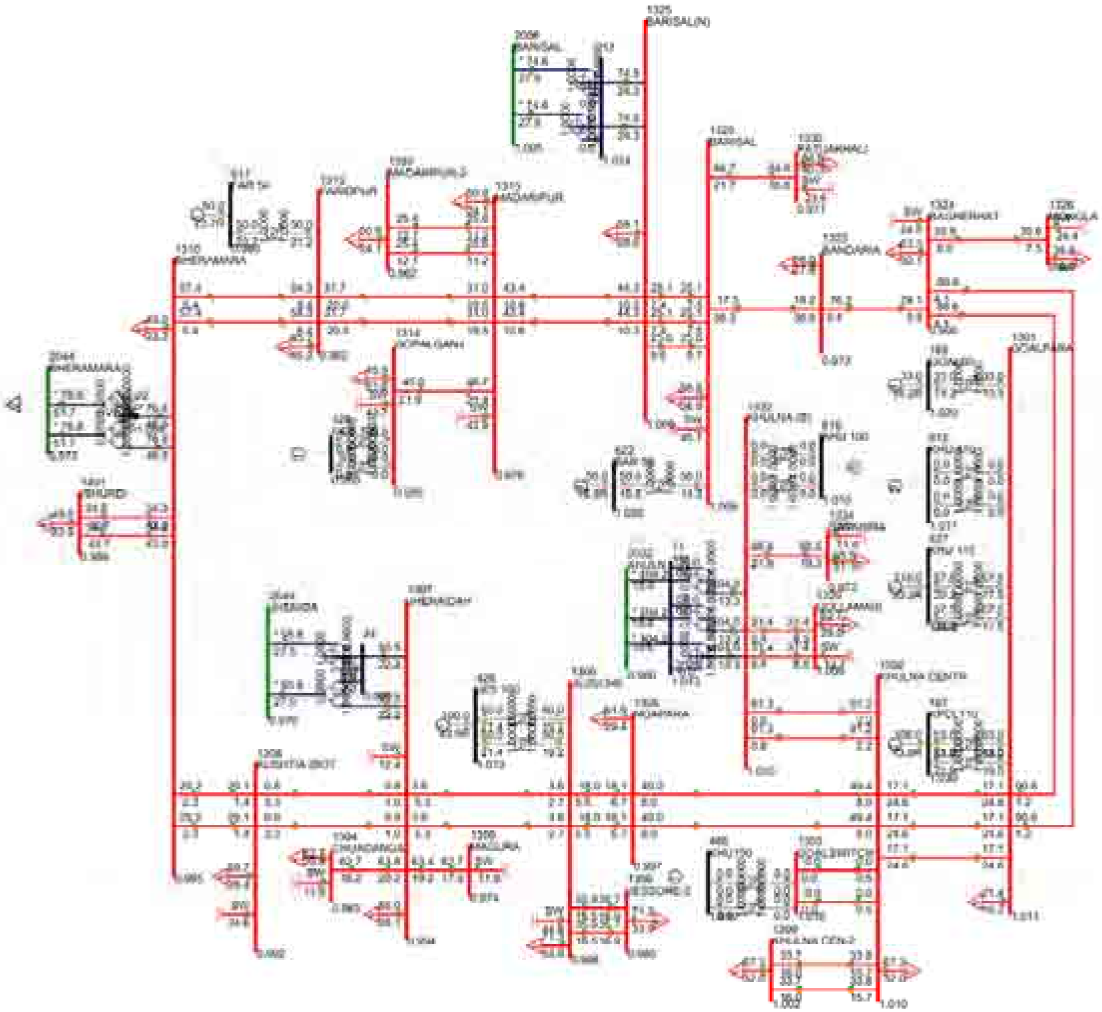
Source: PSMP Study Team

APFig. 9-3 132kVDhaka power flow (2015, pattern east)



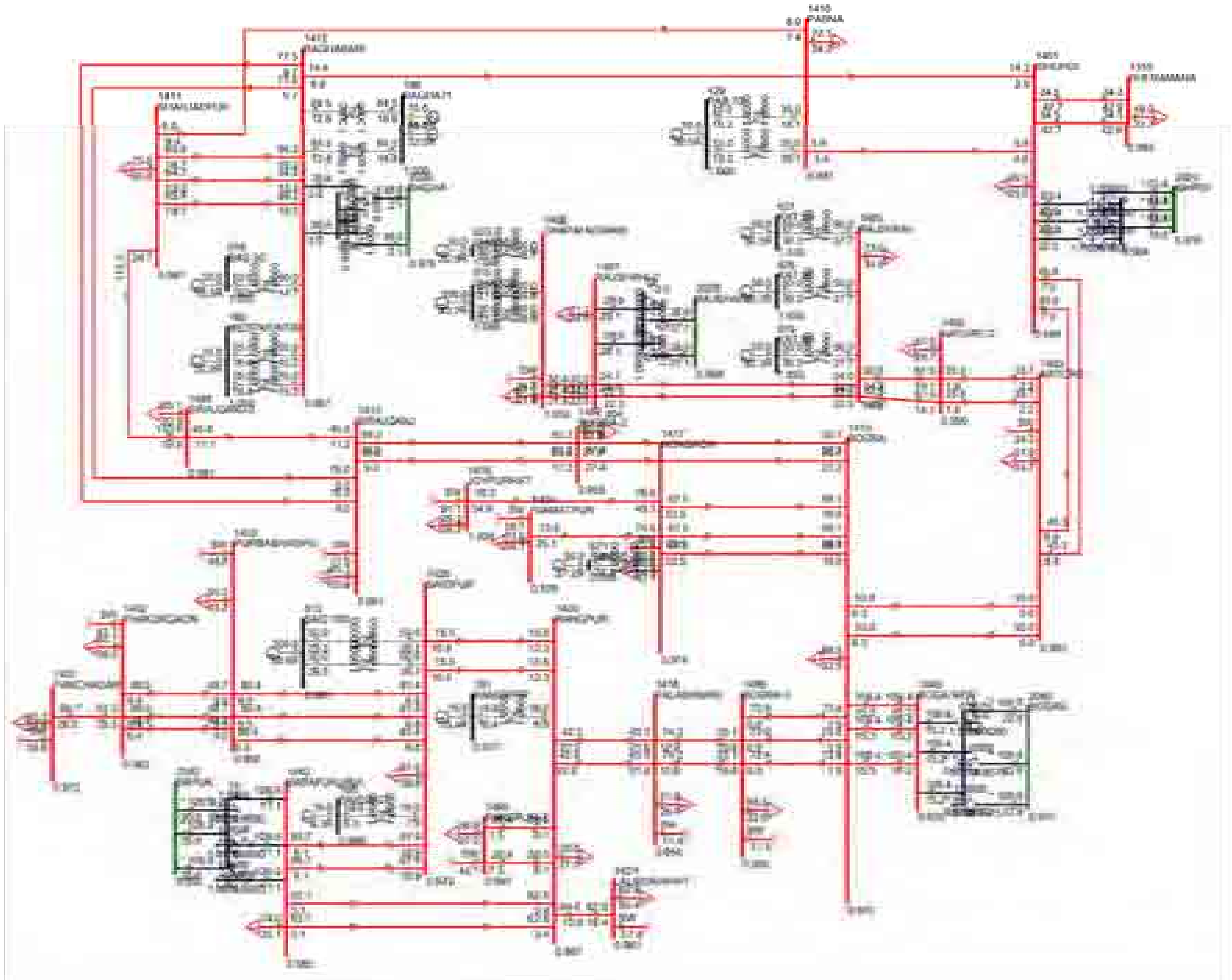
Source: PSMP Study Team

APFig. 9-4 132kVCentral power flow (2015, pattern east)



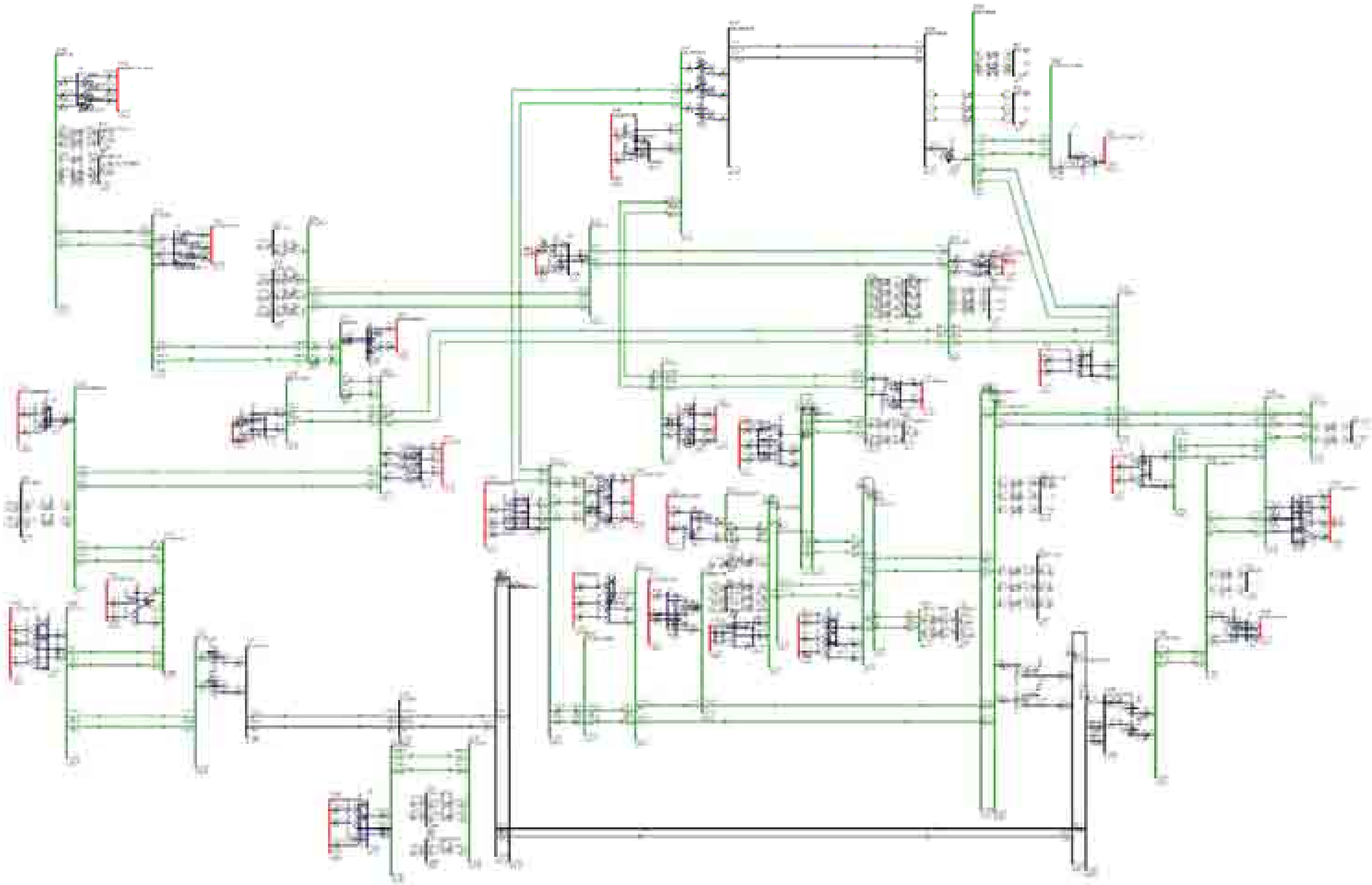
Source: PSMP Study Team

APFig. 9-5 132kVWestern power flow (2015, pattern east)



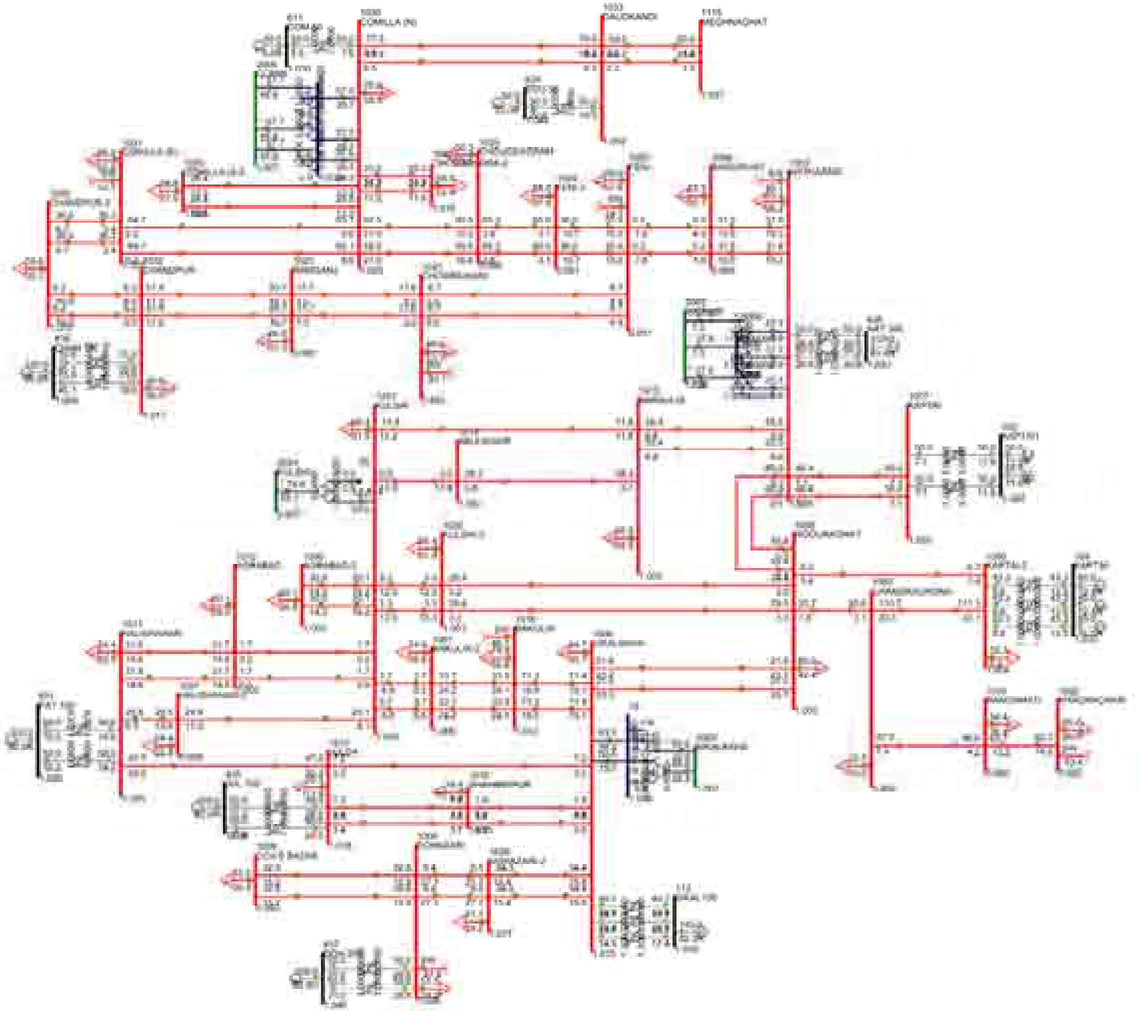
Source: PSMP Study Team

APFig. 9-6 132kVNorthern power flow (2015, pattern east)



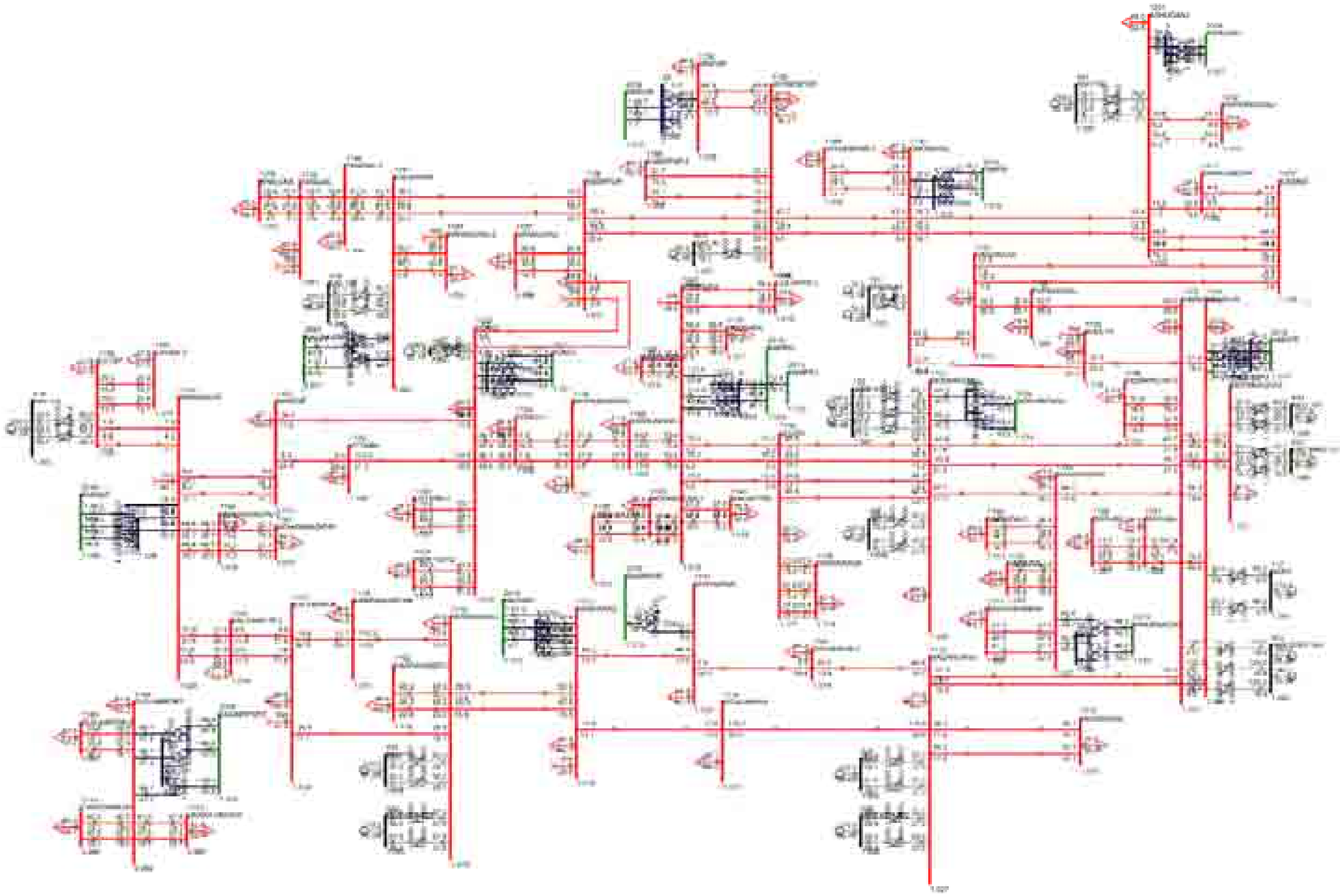
Source: PSMP Study Team

APFig. 9-7 400kV, 230kV power flow (2015, pattern west)



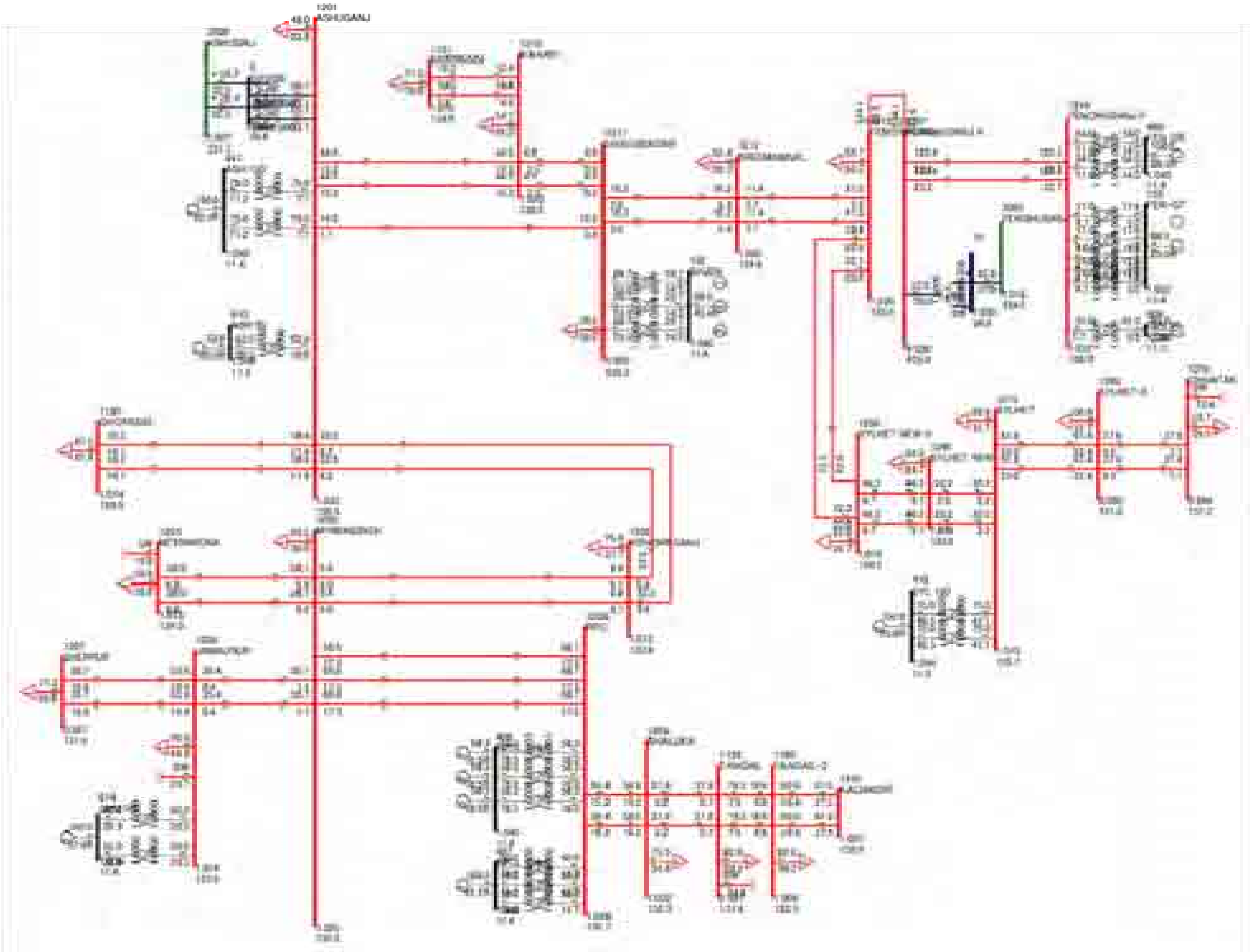
Source: PSMP Study Team

APFig. 9-8 132kV Southern power flow (2015, pattern west)



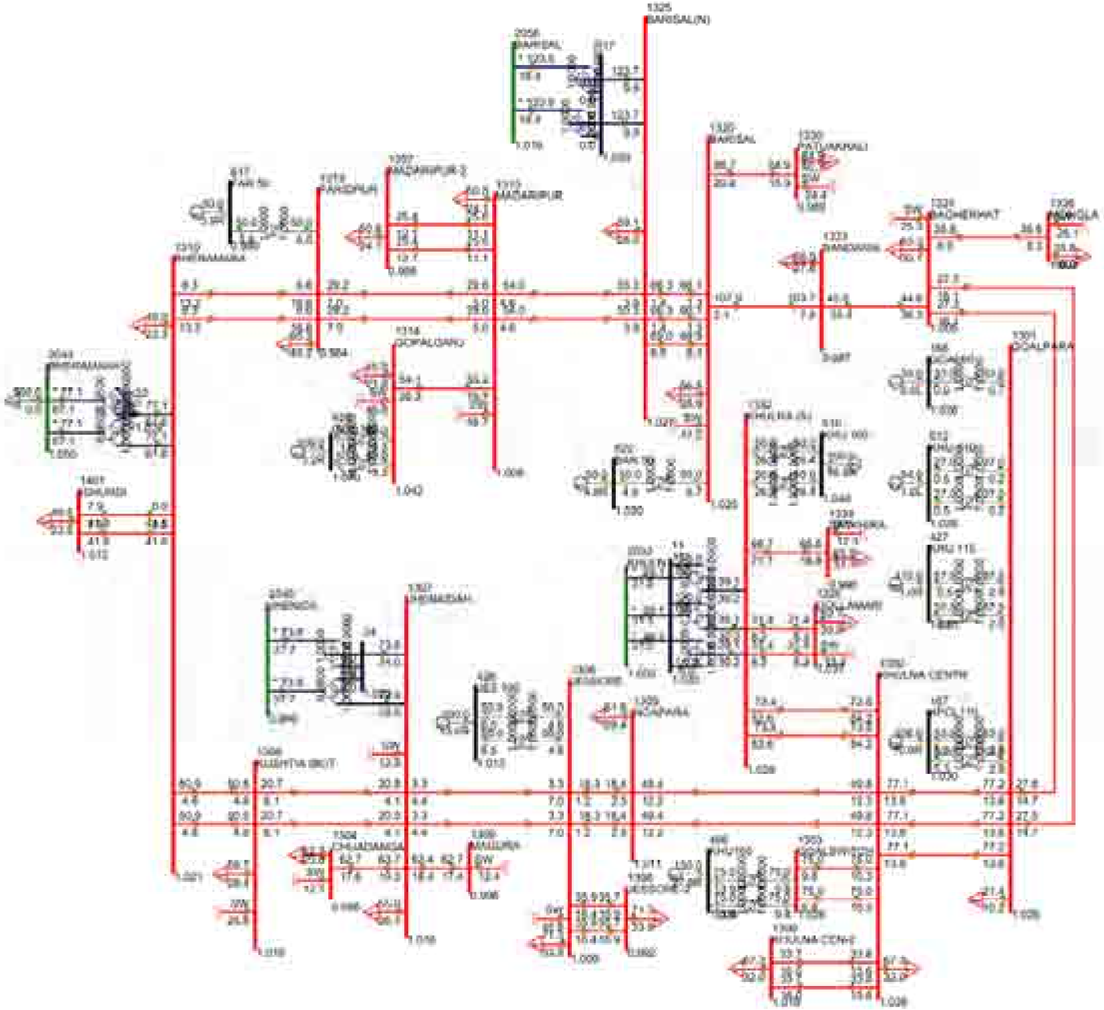
Source: PSMP Study Team

APFig. 9-9 132kV Dhaka power flow (2015, pattern west)



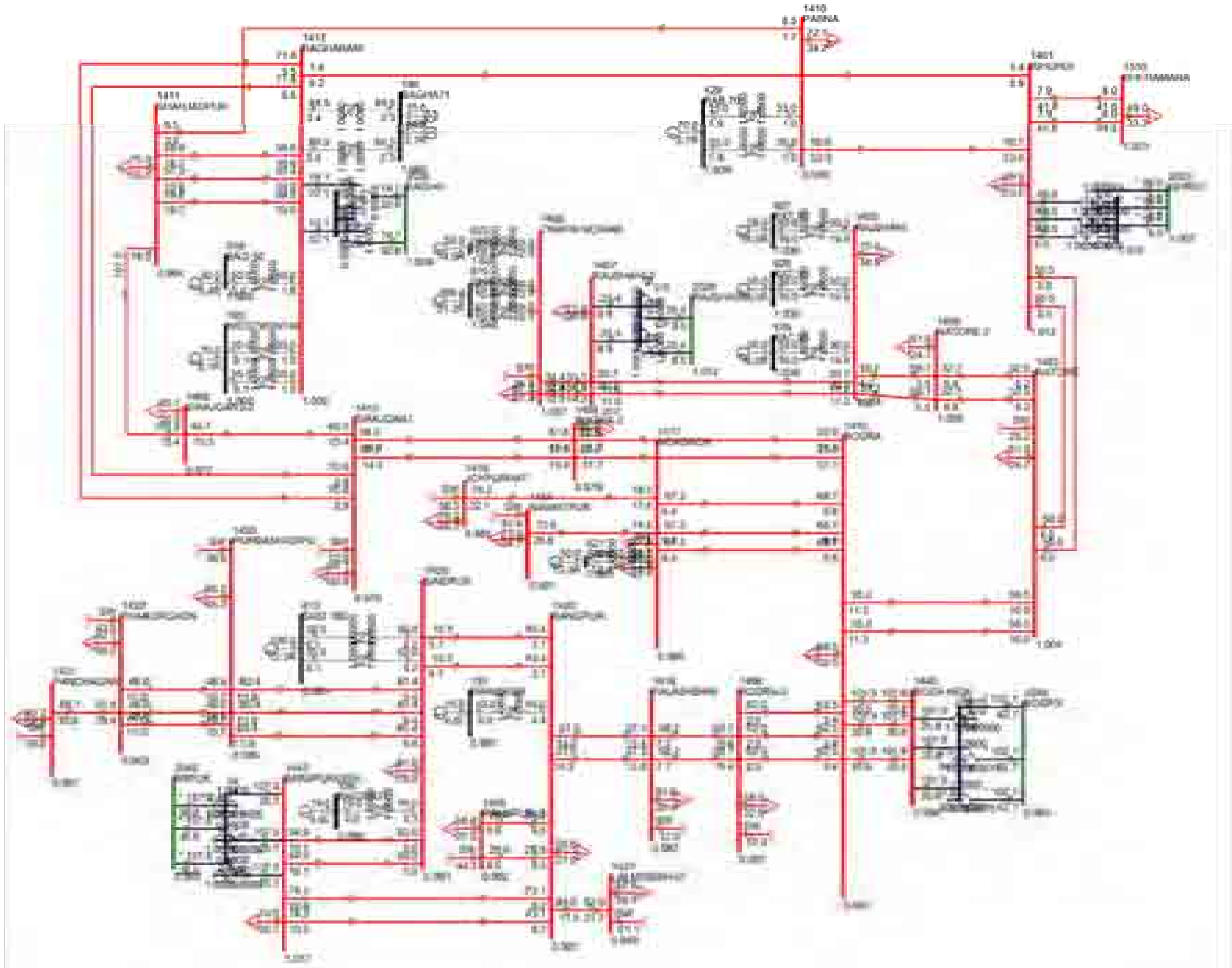
Source: PSMP Study Team

APFig. 9-10 132kV Central power flow (2015, pattern west)



Source: PSMP Study Team

APFig. 9-11 132kV Western power flow (2015, pattern west)



Source: PSMP Study Team

APFig. 9-12 132kV Northern power flow (2015, pattern west)

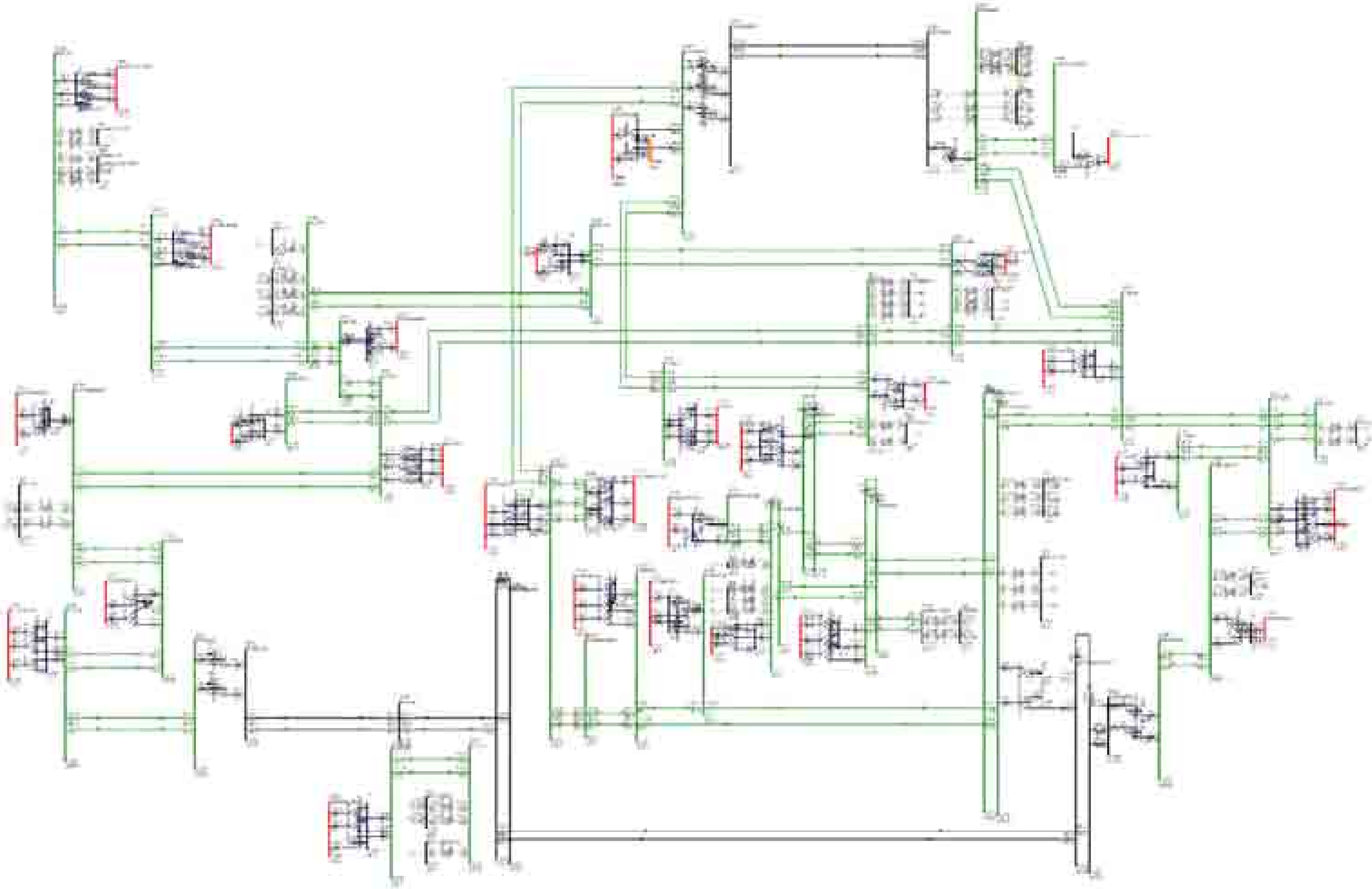
APTable 9-5 Results of short-circuit and ground-fault current analysis (2015) (kA)

Substation		I"k		Asym Ib		Substation		I"k		Asym Ib	
Name	Voltage	3PH	LG	3PH	LG	Name	Voltage	3PH	LG	3PH	LG
KAPTAI	132kV	9.2	6.7	9.1	6.9	FENCHUGANJ	132kV	16.6	14.4	16.9	15.7
CHANDRAGHONA	132kV	9.2	6.4	9.2	6.4	FENCHUGANJ P	132kV	16.4	14.2	16.7	16.0
HATHAZARI	132kV	27.7	27.1	27.6	28.1	SYLHET	132kV	9.7	7.7	9.4	8.4
BAROIRHAT	132kV	12.5	7.9	12.5	7.9	CHHATAK	132kV	5.6	3.7	5.5	3.7
MODUNAGHAT	132kV	26.1	23.0	25.3	23.0	SYLHET NEW	132kV	10.8	8.3	10.2	8.4
SIKALBAHA	132kV	27.8	25.9	27.6	27.2	FENCHUGANJ A	132kV	16.6	14.4	16.9	15.7
DOHAZARI	132kV	10.9	8.0	10.6	8.3	SYLHET NEW-2	132kV	12.8	10.0	12.1	10.0
COX'S BAZAR	132kV	3.4	2.0	3.4	2.0	SYLHET-2	132kV	7.1	5.0	6.9	5.0
HALISHAHAR	132kV	21.2	17.4	20.5	17.5	GOALPARA	132kV	23.7	22.1	24.1	23.9
AGRABAD	132kV	22.0	18.1	21.5	18.1	KHULNA CENTR	132kV	24.3	23.1	24.9	24.7
KULSHI	132kV	26.7	24.8	25.8	25.0	GOALSWITCH	132kV	23.7	22.0	23.9	23.1
ABULKHAIR	132kV	19.3	14.9	19.2	14.9	CHUADANGA	132kV	4.0	2.4	4.0	2.4
BARAULIA	132kV	22.1	18.1	21.8	18.1	NOAPARA	132kV	13.1	9.1	13.0	9.1
BAKULIA	132kV	24.4	20.8	23.5	20.8	JESSORE	132kV	12.1	9.0	11.8	9.2
JULDA	132kV	23.8	20.2	22.8	20.3	JHENAIDAH	132kV	15.7	13.3	15.7	13.4
SHAHMIRPUR	132kV	23.1	19.2	22.2	19.2	KUSHTIA (BOT	132kV	13.3	9.0	13.3	9.0
RANGAMATI	132kV	4.9	3.0	4.9	3.0	MAGURA	132kV	5.4	3.3	5.4	3.3
FENI	132kV	11.0	6.7	11.0	6.7	BHERAMARA	132kV	23.7	20.5	24.1	20.8
CHOWMUHANI	132kV	8.1	4.9	8.1	4.9	FARIDPUR	132kV	6.7	4.7	6.6	4.9
KHAGRACHARI	132kV	2.1	1.2	2.1	1.2	GOPALGANJ	132kV	4.7	3.9	5.3	5.0
RAMGANJ	132kV	7.6	4.8	7.5	4.8	MADARIPUR	132kV	7.4	5.4	7.2	5.4
CHOUDDAGRAM	132kV	11.4	7.0	11.4	7.0	BARISAL	132kV	9.2	9.7	9.3	9.9
COMILLA (N)	132kV	26.4	21.8	26.3	22.1	BANDARIA	132kV	5.6	3.5	5.6	3.5
COMILLA (S)	132kV	15.1	10.3	15.0	10.3	BAGHERHAT	132kV	8.6	5.4	8.6	5.4
CHANDPUR	132kV	9.6	7.3	9.5	8.2	BARISAL(N)	132kV	9.4	10.4	9.6	11.0
DAUDKANDI	132kV	21.0	14.5	20.8	14.5	MONGLA	132kV	3.9	2.3	3.9	2.3
KAPTAI-2	132kV	9.5	7.2	9.5	7.5	GOLLAMARI	132kV	19.5	16.4	18.7	16.4
BAKULIA-2	132kV	22.8	18.8	22.3	18.8	PATUAKHALI	132kV	3.4	2.2	3.4	2.2
CHANDPUR-2	132kV	10.1	6.7	9.9	6.7	KHULNA (S)	132kV	24.1	23.2	24.0	24.7
CHOUDDAGRA-2	132kV	11.8	7.6	11.8	7.6	SATKHIRA	132kV	3.9	2.3	3.9	2.3
FENI-2	132kV	10.9	6.7	10.9	6.7	MADARIPUR-2	132kV	4.8	3.2	4.8	3.2
KULSHI-2	132kV	24.0	20.3	23.4	20.3	JESSORE-2	132kV	6.5	4.1	6.5	4.1
AGRABAD-2	132kV	21.9	18.1	21.6	18.1	KHULNA CEN-2	132kV	13.5	9.7	13.5	9.7
HALISHAHAR-2	132kV	6.7	5.9	6.7	5.9	ISHURDI	132kV	26.8	24.2	26.9	24.5
DOHAZARI-2	132kV	15.1	11.1	14.8	11.1	NATORE	132kV	15.3	10.3	15.3	10.3
COMILLA (S-2	132kV	17.7	12.5	17.7	12.5	NIAMATPUR	132kV	3.0	1.8	3.0	1.8
HARIPUR	132kV	42.7	34.0	43.5	35.2	RAJSHAHI	132kV	15.4	13.0	15.2	13.2
SIDDHIRGANJ	132kV	57.0	48.5	57.0	50.2	CHAPAI NOWAB	132kV	8.8	7.2	9.1	8.3
MOGHBAZAR	132kV	28.4	19.8	28.4	19.8	RAJSHAHI-2	132kV	16.0	14.5	15.7	14.6
MANIKNAGAR	132kV	28.9	21.6	29.1	21.9	PABNA	132kV	13.2	9.3	12.9	9.4
ULLON	132kV	40.9	31.1	40.9	31.1	SHAHJADPUR	132kV	19.2	15.0	18.9	15.1
DHANMONDI	132kV	33.8	26.2	33.8	26.2	BAGHABARI	132kV	22.6	19.8	23.4	21.8
RAMPURA	132kV	40.5	32.0	40.6	32.2	SIRAJGANJ	132kV	12.9	8.6	12.9	8.6
NARINDA	132kV	25.8	19.5	25.8	19.6	BOGRA	132kV	19.3	17.6	19.3	17.7
MATUAIL	132kV	25.4	16.4	25.4	16.4	JOYPURHAT	132kV	3.0	1.8	3.0	1.8
BANGABHABAN	132kV	25.4	19.7	25.5	19.8	NOAGAON	132kV	8.4	6.0	8.3	6.0
SHYAMPUR	132kV	28.0	22.8	28.1	23.1	PALASHBARI	132kV	9.7	6.5	9.7	6.5
MADANGANJ	132kV	34.8	25.6	33.9	25.8	RANGPUR	132kV	10.7	8.1	10.6	8.1

HASNABAD	132kV	34.1	28.0	34.0	28.3	LALMONIRHAT	132kV	3.7	2.3	3.7	2.3
SITALAKHYA	132kV	21.5	13.9	21.5	13.9	SAIDPUR	132kV	10.4	8.6	10.3	9.0
MEGHNAGHAT	132kV	25.4	18.4	24.7	19.0	PURBASHADIPU	132kV	7.4	5.3	7.3	5.3
GULSHAN	132kV	24.3	19.8	24.3	19.8	PANCHAGAR	132kV	2.4	1.4	2.4	1.4
MUNSIGANJ	132kV	13.2	8.0	13.2	8.0	THAKURGAON	132kV	4.9	3.2	4.9	3.2
KAMRANGIRCHA	132kV	22.5	15.7	22.3	15.7	BOGA NEW	132kV	19.3	17.6	19.3	17.8
KERANIGANJ	132kV	28.0	21.5	27.2	21.8	BARAPUKURIA	132kV	13.7	13.6	15.4	15.2
MIRPUR	132kV	27.8	19.7	27.7	19.7	RANGPUR-2	132kV	7.1	4.8	7.1	4.8
NEW TONGI	132kV	35.0	27.3	34.9	27.3	BOGRA-3	132kV	12.7	9.2	12.7	9.2
KALYANPUR	132kV	29.4	22.2	29.1	22.2	BOGRA-2	132kV	11.9	7.9	11.9	7.9
UTTARA	132kV	22.2	14.7	22.2	14.7	SIRAJGANJ-2	132kV	11.0	7.1	11.0	7.1
BASHUNDHARA	132kV	29.6	20.5	29.6	20.5	NATORE-2	132kV	13.3	9.3	13.3	9.3
TONGI	132kV	38.2	30.9	38.1	31.3	RAOZN	230kV	17.0	14.6	15.9	15.2
KABIRPUR	132kV	27.3	18.5	27.2	18.5	HATHZR	230kV	20.6	20.3	19.5	20.8
MANIKGANJ	132kV	9.0	5.3	9.0	5.3	MANIKNAGAR	230kV	32.6	25.3	32.4	25.4
TANGAIL	132kV	9.2	5.5	9.2	5.5	SIDDHIRGANJ	230kV	45.1	39.6	44.7	41.1
GHORASAL	132kV	32.2	22.5	32.7	23.1	COMIN	230kV	28.3	22.8	28.2	22.9
NARSINGDI	132kV	22.6	15.7	22.6	15.7	ASHUGNJ	230kV	26.7	21.3	26.3	21.4
JOYDEBPUR	132kV	25.4	17.2	25.3	17.2	SIKALBAHA	230kV	19.7	17.8	18.9	18.3
BHULTA	132kV	15.4	9.2	15.4	9.2	GHRSL	230kV	40.9	33.4	38.8	35.4
AMINBAZAR	132kV	33.3	27.3	33.3	27.8	TONGI	230kV	31.2	24.6	31.1	24.7
SAVAR	132kV	18.1	12.9	17.7	13.0	HARIPR	230kV	47.1	42.0	46.6	43.4
PURBACHAL	132kV	31.0	21.1	31.0	21.1	HASNBD	230kV	31.9	26.8	31.7	26.9
MADARTEK	132kV	34.0	25.1	34.0	25.1	MEGHNAGHAT	230kV	46.7	40.1	45.4	41.0
MOHAMMADPUR	132kV	23.9	17.2	23.9	17.2	HARIPUR360	230kV	41.7	36.3	40.6	36.9
DHAKA UNIVER	132kV	13.7	12.0	13.8	12.0	RAMPR	230kV	33.1	25.3	33.2	25.4
CANTONMENT	132kV	13.9	12.1	13.9	12.1	ISHRDI	230kV	22.4	21.1	22.1	21.2
OLD AIRPORT	132kV	15.7	13.7	15.8	14.0	KULSHI	230kV	16.2	14.2	15.8	14.3
KALIAKOIR	132kV	24.7	19.3	24.8	20.0	ANOWARA	230kV	17.0	14.0	16.6	14.1
SRIPUR	132kV	17.8	14.0	17.9	14.2	RAJSHAHI	230kV	11.1	9.1	11.1	9.2
HARIPUR-2	132kV	57.1	47.4	55.6	48.0	SHAMPUR	230kV	29.8	24.5	29.7	24.6
SAVAR-2	132kV	12.7	8.3	12.6	8.3	BAGHA	230kV	20.3	16.0	20.3	16.1
MATUAIL-2	132kV	36.3	25.4	36.2	25.4	KHULN	230kV	15.4	14.3	15.4	14.6
KAMRANGIRC-2	132kV	24.7	18.1	24.2	18.2	AMINBZ	230kV	31.7	29.0	31.8	29.2
OLD AIRPOR-2	132kV	14.7	12.8	14.7	12.9	SRJGNJ	230kV	22.9	17.8	22.7	18.8
MOHAMMADPU-2	132kV	27.9	21.1	27.7	21.1	BOGRS	230kV	14.7	13.0	14.6	13.0
JOYDEBPUR-2	132kV	15.1	9.2	15.1	9.2	BRPUK	230kV	11.6	11.7	11.6	13.2
TANGAIL-2	132kV	12.3	7.7	12.3	7.7	BHERAMARA	230kV	21.4	20.3	21.0	20.6
MANIKGANJ-2	132kV	12.9	8.4	12.9	8.4	OLDAIRPORT	230kV	24.4	22.0	24.4	22.0
KABIRPUR-2	132kV	17.3	10.9	17.3	10.9	KALIAKAIR	230kV	29.5	25.3	29.5	25.5
TONGI-2	132kV	32.5	23.8	32.5	23.8	JHENIDA	230kV	14.5	14.1	14.5	14.1
KALYANPUR-2	132kV	31.0	24.3	30.8	24.3	MONGLA	230kV	13.8	11.2	13.9	11.3
SHYAMPUR-2	132kV	21.9	14.6	21.9	14.6	SRIPUR	230kV	18.4	13.7	18.4	13.8
MOGHBAZAR-2	132kV	33.4	24.4	33.4	24.4	BIBIYANA	230kV	17.3	12.7	18.2	14.2
SIDDHIRGAN-2	132kV	50.4	39.4	49.3	39.5	BHOLA	230kV	6.0	5.8	8.1	7.7
UTTARA-2	132kV	29.0	21.1	29.0	21.1	BARISAL	230kV	5.6	6.2	5.6	6.5
GULSHAN-2	132kV	37.0	29.5	37.1	29.5	FENCHUGANJ	230kV	12.8	9.0	13.0	9.1
BASHUNDHA-3	132kV	30.8	24.8	30.8	24.8	KERANIGANJ	230kV	29.0	22.9	29.0	22.9
BASHUNDHA-2	132kV	28.8	19.4	28.8	19.4	MEGHNAGHAT2	230kV	46.7	40.1	45.4	41.0
NARINDA-2	132kV	27.2	20.5	27.3	20.7	HARIPR2	230kV	47.1	42.0	46.6	43.4
ASHUGANJ	132kV	27.1	22.2	26.8	23.1	SIDDHIRGANJ2	230kV	45.1	39.6	44.7	41.1
KISHOREGANJ	132kV	10.3	6.4	10.3	6.4	RAMPR2	230kV	33.1	25.3	33.2	25.4
MYMENSINGH	132kV	13.6	11.2	13.5	11.8	MEGHNAGHAT	400kV	16.4	10.7	17.4	11.2

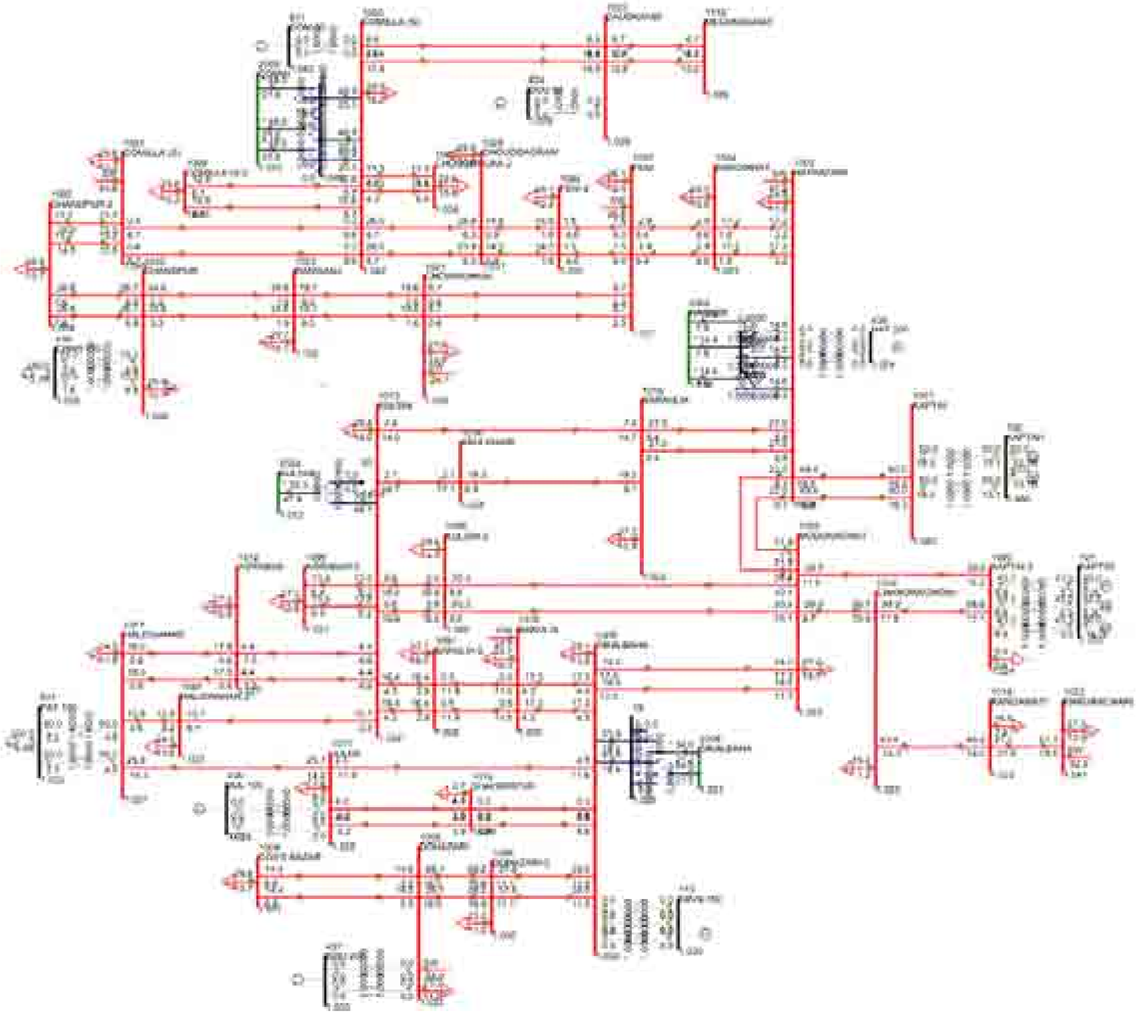
JAMALPUR	132kV	6.8	5.3	6.8	6.0	ANOWARA	400kV	8.8	6.1	9.0	6.4
NETRAKONA	132kV	6.5	4.2	6.5	4.2	AMINBAZAR	400kV	15.7	10.5	16.4	10.9
BHALUKA	132kV	8.8	5.6	8.8	5.6	KALIAKAIR	400kV	11.9	8.4	12.3	8.9
SHERPUR	132kV	4.6	3.2	4.5	3.2	MONGLA	400kV	8.7	6.4	8.7	6.5
RPC	132kV	14.0	11.9	15.6	15.1	BIBIYANA	400kV	10.3	8.0	10.9	9.2
B.BARIA	132kV	20.9	14.5	20.7	14.5	ZAJIRA	400kV	12.0	8.1	12.2	8.2
SHAHJIBAZAR	132kV	14.1	9.8	13.7	9.9	AMINBAZAR2	400kV	15.7	10.5	16.4	10.9
SREEMANGAL	132kV	10.7	6.8	10.7	6.8	MEGHNAGHAT2	400kV	16.4	10.7	17.4	11.2

Source: PSMP Study Team



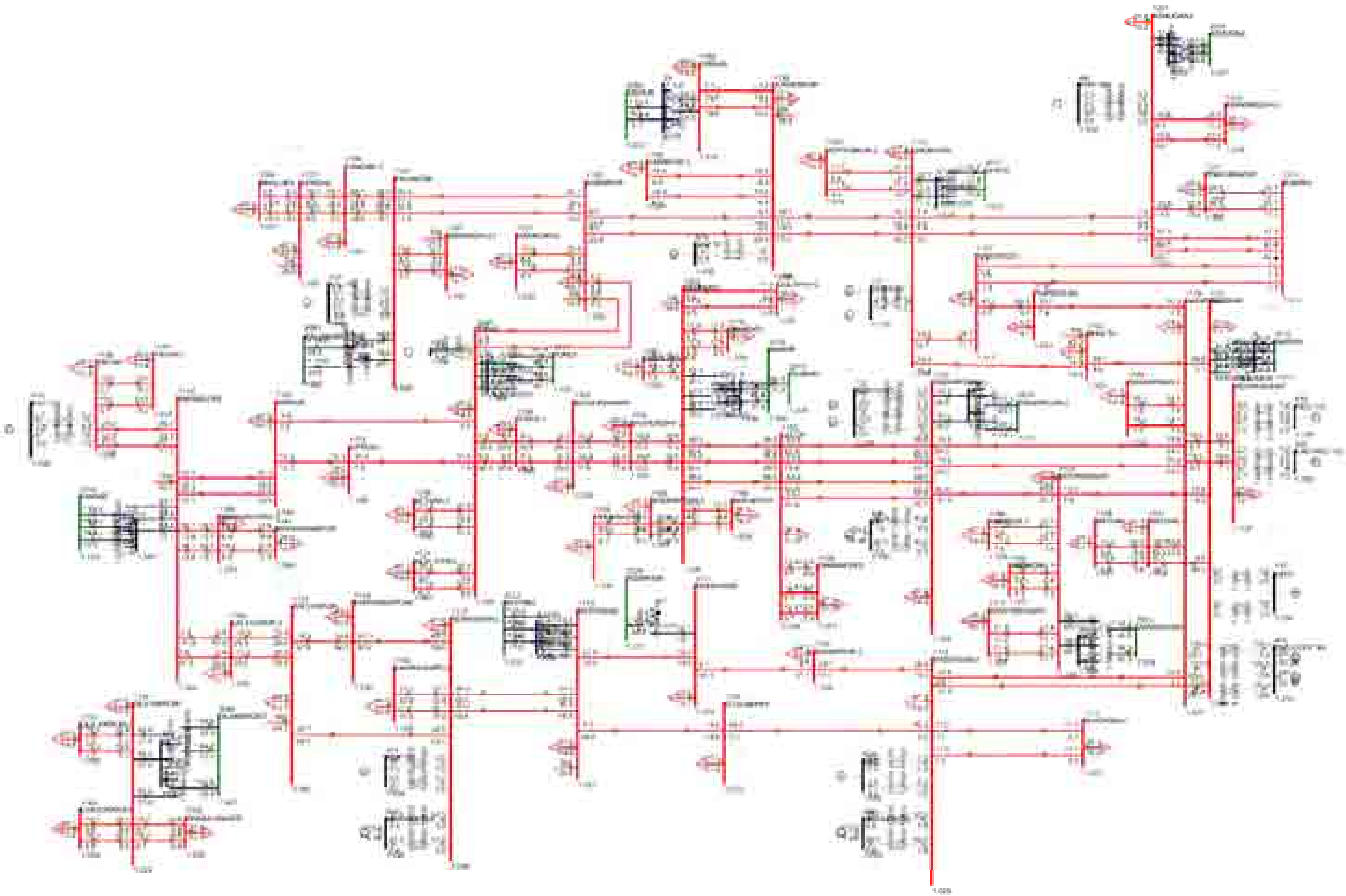
Source: PSMP Study Team

APFig. 9-13 400kV, 230kV power flow (2015, light load)



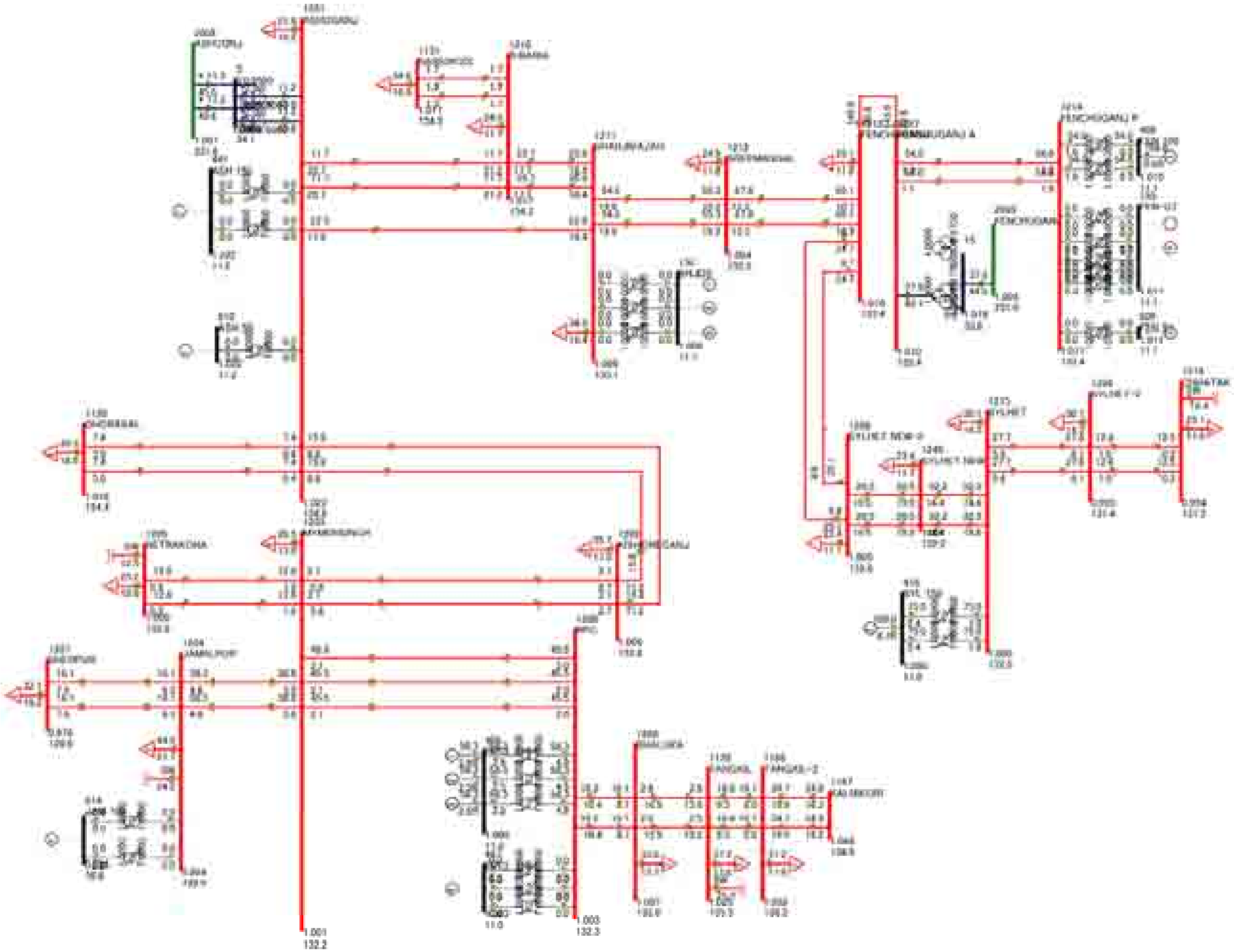
Source: PSMP Study Team

APFig. 9-14 132kV Southern power flow (2015, light load)



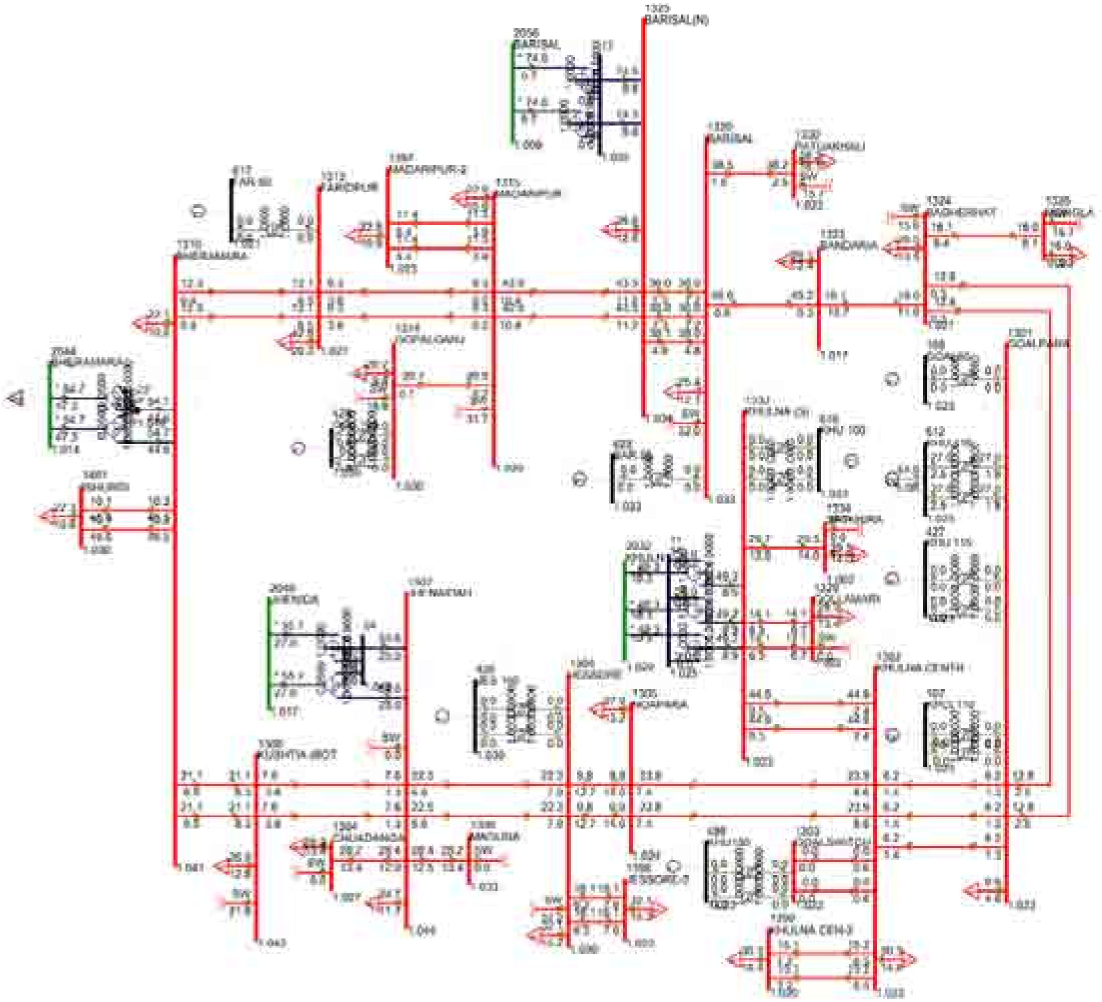
Source: PSMP Study Team

APFig. 9-15 132kV Dhaka power flow (2015, light load)



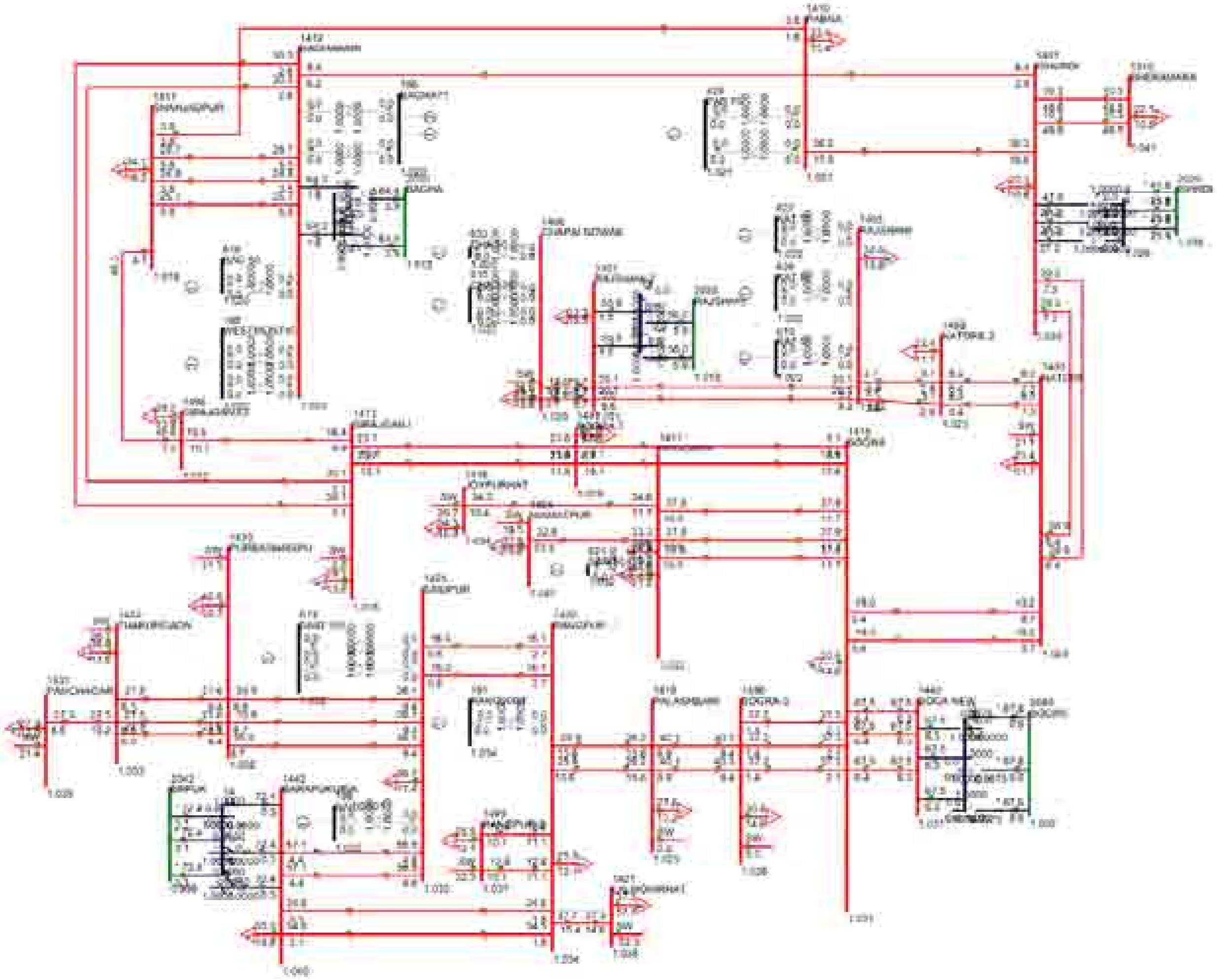
Source: PSMP Study Team

APFig. 9-16 132kV Central power flow (2015, light load)



Source: PSMP Study Team

APFig. 9-17 132kV Western power flow (2015, light load)



Source: PSMP Study Team

APFig. 9-18 132kV Northern power flow (2015, light load)

APTable 9-6 The transmission line for which construction is necessary by 2015

Voltage	From Substation	To Substation	2010		2015	
			cct.	Length (km)	cct.	Length (km)
132kV	ABULKHAIR	BARAULIA			1	4
132kV	AGRABAD	KULSHI			2	14
132kV	AMINBAZAR	KALYANPUR-2			2	4
132kV	AGRABAD	MOHAMMADPU-2			2	5
132kV	AMINBAZAR	SAVAR			2	26
132kV	ASHUGANJ	B.BARIA			2	24
132kV	AMINBAZAR	KISHOREGANJ	2	104	2	104
132kV	ASHUGANJ	SHAHJIBAZAR	3	156	1	52
132kV	B.BARIA	SHAHJIBAZAR			2	80
132kV	BAGHABARI	SIRAJGANJ	2	84	2	84
132kV	BAGHERHAT	MONGLA	1	28	1	28
132kV	BAKULIA	BAKULIA-2			2	15.5
132kV	BANDARIA	BAGHERHAT	1	39	1	39
132kV	BARISAL	BANDARIA	1	50	1	50
132kV	BANDARIA	BARISAL(N)			3	12
132kV	BARISAL	PATUAKHALI	1	40	1	40
132kV	BAROIRHAT	FENI			2	118
132kV	BASHUNDHARA	BASHUNDHA-2			2	22
132kV	BAROIRHAT	TONGI	2	16		
132kV	BASHUNDHARA	TONGI-2			2	8
132kV	BHALUKA	RPC			2	80
132kV	BHERAMARA	FARIDPUR	2	240	2	240
132kV	BHALUKA	ISHURDI	2	20	2	20
132kV	BOGRA	BOGA NEW	2	2	3	3
132kV	BHALUKA	BOGRA-2			2	66
132kV	BOGRA	BOGRA-3			3	75
132kV	BHALUKA	NOAGAON	2	104	3	156
132kV	BOGRA	PALASHBARI	2	100		
132kV	CANTONMENT	OLD AIRPORT			2	12
132kV	CHANDPUR	CHANDPUR-2			2	61
132kV	CHANDRAGHONA	KAPTAI-2			1	8
132kV	CHANDPUR	MODUNAGHAT	1	31	1	31
132kV	CHANDRAGHONA	RANGAMATI			1	20
132kV	CHAPAI NOWAB	RAJSHAHI-2			2	88
132kV	CHHATAK	SYLHET-2			2	32.5
132kV	CHOUDDAGRAM	COMILLA (N)			2	80
132kV	CHHATAK	FENI-2			2	23.5
132kV	CHOWMUHANI	CHANDPUR	2	272		
132kV	CHHATAK	RAMGANJ			2	60
132kV	CHUADANGA	JHENAIDAH	1	39	1	39
132kV	COMILLA (N)	CHANDPUR	1	77		

Voltage	From Substation	To Substation	2010		2015	
			cct.	Length (km)	cct.	Length (km)
132kV	CHUADANGA	CHOUDDAGRA-2			2	40
132kV	COMILLA (N)	COMILLA (S)	1	16	2	32
132kV	CHUADANGA	COMILLA (S-2			2	16
132kV	COMILLA (N)	DAUDKANDI			2	60
132kV	CHUADANGA	HARIPUR	2	138		
132kV	COMILLA (S)	CHANDPUR	1	61		
132kV	CHUADANGA	CHANDPUR-2			2	61
132kV	DAUDKANDI	MEGHNAGHAT			2	24
132kV	DHAKA UNIVER	OLD AIRPORT			2	13
132kV	DOHAZARI	COX'S BAZAR	2	174	2	175
132kV	DHAKA UNIVER	DOHAZARI-2			2	32
132kV	FARIDPUR	MADARIPUR	2	132	2	132
132kV	FARIDPUR	FENCHUGANJ P	2	8		
132kV	FENCHUGANJ	SYLHET NEW-2			2	23
132kV	FENCHUGANJ P	FENCHUGANJ A			2	8
132kV	FENCHUGANJ	SYLHET	2	58		
132kV	FENI	CHOWMUHANI	2	64	2	64
132kV	FENCHUGANJ	COMILLA (N)	2	128		
132kV	FENI	FENI-2			2	23.5
132kV	GHORASAL	ASHUGANJ	2	100	2	100
132kV	FENI	BHULTA	1	14	1	14
132kV	GHORASAL	JOYDEBPUR	2	52	2	59
132kV	FENI	JOYDEBPUR-2			2	30
132kV	GHORASAL	NARSINGDI	1	14	1	14
132kV	GOALPARA	BAGHERHAT	1	43	2	86
132kV	GHORASAL	KHULNA CENTR	2	4	3	6
132kV	GOLLAMARI	KHULNA (S)	2	8.4	2	8.4
132kV	GOPALGANJ	MADARIPUR	1	46	1	46
132kV	HALISHAHAR	AGRABAD			2	13
132kV	GOPALGANJ	HALISHAHAR-2			1	7
132kV	HALISHAHAR	JULDA	1	7	1	7
132kV	GOPALGANJ	KULSHI	3	42		
132kV	HARIPUR	BHULTA	1	30	1	30
132kV	GOPALGANJ	MADANGANJ	1	13	1	13
132kV	HARIPUR	MANIKNAGAR	2	53.2	1	26
132kV	GOPALGANJ	MATUAIL	1	10		
132kV	HARIPUR	MATUAIL-2			1	5
132kV	GOPALGANJ	NARSINGDI	1	32		
132kV	HARIPUR	SHYAMPUR	1	32		
132kV	GOPALGANJ	SIDDHIRGANJ	2	4		
132kV	HARIPUR-2	MATUAIL-2			1	5
132kV	GOPALGANJ	SIDDHIRGAN-2			2	2
132kV	HASNABAD	KALYANPUR	1	21		
132kV	GOPALGANJ	KAMRANGIRCHA	1	11		
132kV	HASNABAD	KERANIGANJ			2	26

Voltage	From Substation	To Substation	2010		2015	
			cct.	Length (km)	cct.	Length (km)
132kV	GOPALGANJ	SITALAKHYA	1	12	1	12
132kV	HATHAZARI	BARAULIA	2	20	2	20
132kV	GOPALGANJ	BAROIRHAT			2	60
132kV	HATHAZARI	FENI	2	178		
132kV	GOPALGANJ	MODUNAGHAT	2	18	2	18
132kV	ISHURDI	BAGHABARI			1	63
132kV	GOPALGANJ	NATORE	2	80	2	80
132kV	ISHURDI	PABNA	1	16	1	16
132kV	JAMALPUR	SHERPUR			2	60
132kV	JESSORE	JESSORE-2			2	60
132kV	JAMALPUR	JHENAIDAH	2	100	2	100
132kV	JHENAIDAH	KUSHTIA (BOT	2	90	2	90
132kV	JAMALPUR	MAGURA	1	26	1	26
132kV	JOYDEBPUR	KABIRPUR-2			2	15.5
132kV	JAMALPUR	SRIPUR			2	64
132kV	JOYPURHAT	NOAGAON	1	46	1	46
132kV	JULDA	SHAHMIRPUR	2	12	2	12
132kV	KABIRPUR	JOYDEBPUR	2	30	2	31
132kV	JULDA	KALIAKOIR			2	40
132kV	KABIRPUR	MANIKGANJ	2	63	2	63
132kV	JULDA	TANGAIL	2	99		
132kV	KALIAKOIR	MANIKGANJ-2			2	31.5
132kV	JULDA	TANGAIL-2			2	50
132kV	KALYANPUR	AMINBAZAR	2	8		
132kV	JULDA	KALYANPUR-2			2	4
132kV	KAMRANGIRCHA	KALYANPUR	1	12	1	12
132kV	JULDA	KERANIGANJ			1	4
132kV	KAPTAI	CHANDRAGHONA	1	8		
132kV	JULDA	HATHAZARI	2	78	2	78
132kV	KAPTAI	MODUNAGHAT	1	39		
132kV	KERANIGANJ	KALYANPUR			1	17
132kV	KAPTAI	KAMRANGIRC-2			2	4
132kV	KHULNA (S)	SATKHIRA	1	46	1	46
132kV	KHULNA CENTR	GOALSWITCH			2	5
132kV	KHULNA (S)	KHULNA (S)	2	18	2	18
132kV	KHULNA CENTR	KHULNA CEN-2			2	28
132kV	KHULNA (S)	NOAPARA	2	56	2	56
132kV	KISHOREGANJ	MYMENSINGH	2	118	2	117.8
132kV	KULSHI	ABULKHAIR			1	8.9
132kV	KISHOREGANJ	AGRABAD-2			2	7
132kV	KULSHI	BAKULIA	2	31		
132kV	KISHOREGANJ	BAKULIA-2			2	15.5
132kV	KULSHI	BARAULIA	2	26	1	13
132kV	KISHOREGANJ	HALISHAHAR-2			1	7
132kV	KULSHI	KULSHI-2			2	13

Voltage	From Substation	To Substation	2010		2015	
			cct.	Length (km)	cct.	Length (km)
132kV	KUSHTIA (BOT	BHERAMARA	2	54	2	54
132kV	MADANGANJ	HARIPUR-2			1	13
132kV	KUSHTIA (BOT	MUNSIGANJ			2	40
132kV	MADANGANJ	SHYAMPUR-2			1	9.5
132kV	KUSHTIA (BOT	SITALAKHYA	1	10	1	10
132kV	MADARIPUR	BARISAL	2	124		
132kV	KUSHTIA (BOT	BARISAL(N)			2	116
132kV	MADARIPUR	MADARIPUR-2			2	58
132kV	MANIKNAGAR	BANGABHABAN	2	10	2	4
132kV	MADARIPUR	MATUAIL	1	24		
132kV	MANIKNAGAR	NARINDA	2	6	2	6
132kV	MADARIPUR	NARINDA-2			2	3
132kV	MATUAIL	MATUAIL-2			2	10
132kV	MEGHNAGHAT	HARIPUR-2			2	42
132kV	MIRPUR	AMINBAZAR	2	20	2	19
132kV	MEGHNAGHAT	TONGI	1	15	1	14.5
132kV	MIRPUR	UTTARA	1	13	1	13
132kV	MODUNAGHAT	KAPTAI-2			1	39
132kV	MIRPUR	KULSHI	2	26		
132kV	MODUNAGHAT	KULSHI-2			2	13
132kV	MIRPUR	SIKALBAHA	2	32	2	32
132kV	MOGHBAZAR	MOGHBAZAR-2			2	4.5
132kV	MIRPUR	RAMPURA	1	4.5		
132kV	MOGHBAZAR	ULLON	1	6		
132kV	MOHAMMADPUR	MOHAMMADPU-2			2	5
132kV	MYMENSINGH	JAMALPUR	2	110	2	109.8
132kV	MOHAMMADPUR	NETRAKONA	2	68	2	68
132kV	MYMENSINGH	RPC			3	12
132kV	NARSINGDI	B.BARIA			2	110
132kV	MYMENSINGH	PURBACHAL			1	1
132kV	NATORE	BOGRA	2	140	2	140
132kV	MYMENSINGH	NATORE-2			2	42
132kV	NATORE	RAJSHAHI	2	84		
132kV	NEW TONGI	TONGI	2	2	2	2
132kV	NIAMATPUR	NOAGAON	1	46	1	46
132kV	NOAPARA	JESSORE	2	56	2	56
132kV	OLD AIRPORT	OLD AIRPOR-2			2	6.5
132kV	PABNA	SHAHJADPUR	1	42	1	42
132kV	PALASHBARI	BOGRA-3			2	50
132kV	PABNA	RANGPUR	2	106	2	106
132kV	PANCHAGAR	THAKURGAON			1	45
132kV	PURBACHAL	HARIPUR-2			1	4.5
132kV	PURBASHADIPU	THAKURGAON	2	88	3	132
132kV	RAJSHAHI	CHAPAI NOWAB	2	108		
132kV	PURBASHADIPU	NATORE-2			2	42

Voltage	From Substation	To Substation	2010		2015	
			cct.	Length (km)	cct.	Length (km)
132kV	RAJSHAHI	RAJSHAHI-2			2	20
132kV	RAMGANJ	CHANDPUR			2	90
132kV	RAMPURA	BASHUNDHA-2			2	22
132kV	RAMGANJ	BASHUNDHA-3			2	11
132kV	RAMPURA	BASHUNDHARA	2	22		
132kV	RAMGANJ	GULSHAN	2	6.6	2	6.6
132kV	RAMPURA	GULSHAN-2			2	3.3
132kV	RAMGANJ	MADARTEK			2	4
132kV	RAMPURA	MOGHBAZAR-2			2	4.5
132kV	RANGAMATI	KHAGRACHARI			1	60
132kV	RANGPUR	BARAPUKURIA	2	80	2	80
132kV	RANGAMATI	LALMONIRHAT	1	37	1	37
132kV	RANGPUR	RANGPUR-2			2	40
132kV	RANGAMATI	SAIDPUR	2	82	2	82
132kV	SAIDPUR	BARAPUKURIA	2	72	2	72
132kV	RANGAMATI	PURBASHADIPU	2	50	3	75
132kV	SAVAR	SAVAR-2			2	20
132kV	SHAHJADPUR	BAGHABARI	2	16	3	24
132kV	SAVAR	SIRAJGANJ	1	34		
132kV	SHAHJADPUR	SIRAJGANJ-2			1	17
132kV	SHAHJIBAZAR	SREEMANGAL	2	72	2	73
132kV	SHYAMPUR	HASNABAD	1	15	1	15
132kV	SHAHJIBAZAR	SHYAMPUR-2			1	9.5
132kV	SIDDHIRGANJ	HARIPUR-2			2	4
132kV	SHAHJIBAZAR	MANIKNAGAR			1	10
132kV	SIDDHIRGANJ	ULLON	2	32	4	64
132kV	SIKALBAHA	BAKULIA	2	8	2	8
132kV	SIDDHIRGANJ	DOHAZARI	2	64		
132kV	SIKALBAHA	DOHAZARI-2			2	32
132kV	SIDDHIRGANJ	JULDA	1	5	1	5
132kV	SIKALBAHA	SHAHMIRPUR	2	12	2	12
132kV	SIRAJGANJ	BOGRA	2	132		
132kV	SIKALBAHA	BOGRA-2			2	66
132kV	SIRAJGANJ	SIRAJGANJ-2			1	17
132kV	SREEMANGAL	FENCHUGANJ	2	98	2	98
132kV	SYLHET	CHHATAK	2	64		
132kV	SREEMANGAL	SYLHET NEW			2	20
132kV	SYLHET	SYLHET-2			2	32.5
132kV	SYLHET NEW	SYLHET NEW-2			2	23
132kV	TANGAIL	BHALUKA			2	120
132kV	SYLHET NEW	TANGAIL-2			2	50
132kV	TONGI	KABIRPUR	2	46	2	49
132kV	SYLHET NEW	TONGI-2			2	8
132kV	TONGI	UTTARA-2			2	7
132kV	ULLON	DHANMONDI	2	12	3	16.5

Voltage	From Substation	To Substation	2010		2015	
			cct.	Length (km)	cct.	Length (km)
132kV	TONGI	RAMPURA	2	8	3	12
132kV	UTTARA	TONGI	1	7	1	7
132kV Total				6116.7		7384.8
230kV	AMINBZ	KALIAKAIR			2	76
230kV	AMINBZ	OLDAIRPORT			3	30
230kV	ASHUGNJ	GHRSL	2	88	2	88
230kV	ASHUGNJ	SRIPUR			2	140
230kV	ASHUGNJ	SRJGNJ	2	286		
230kV	BAGHA	SRJGNJ	2	76	2	76
230kV	BHERAMARA	JHENIDA			2	150
230kV	BHOLA	BARISAL			2	120
230kV	BIBIYANA	FENCHUGANJ			2	64
230kV	BOGRS	BRPUK	2	212	2	212
230kV	COMIN	ASHUGNJ	2	158	2	158
230kV	COMIN	BIBIYANA			2	320
230kV	COMIN	MEGH	2	116		
230kV	COMIN	MEGHNAGHAT			2	116
230kV	GHRSL	ISHRDI	2	356	2	356
230kV	GHRSL	RAMPR	2	100	2	100
230kV	GHRSL	TONGI	2	54	2	54
230kV	HARIPR	HARIPUR360	2	4.8	2	4.8
230kV	HARIPR	MEGH	2	24		
230kV	HARIPR	MEGHNAGHAT			2	24
230kV	HARIPR	RAMPR	2	56	2	56
230kV	HARIPR	SIDDHIRGANJ			1	2
230kV	HASNBD	AMINBZ	2	42	2	42
230kV	HASNBD	MEGH	2	52		
230kV	HASNBD	MEGHNAGHAT			1	26
230kV	HASNBD	SHAMPUR			1	10
230kV	HATHZR	COMIN	2	300	2	300
230kV	HATHZR	KULSHI			2	40
230kV	HATHZR	SIKALBAHA			2	50
230kV	ISHRDI	BAGHA	2	110	2	110
230kV	ISHRDI	BHERAMARA			2	20
230kV	ISHRDI	KHULN	2	370		
230kV	ISHRDI	RAJSHAHI			2	140
230kV	KHULN	JHENIDA			2	200
230kV	KHULN	MONGLA			2	80
230kV	MANIKNAGAR	SIDDHIRGANJ			2	20
230kV	MEGHNAGHAT	SHAMPUR			1	16
230kV	RAOZN	HATHZR	2	45	3	67.5
230kV	SIDDHIRGANJ	HARIPR			1	2
230kV	SIKALBAHA	ANOWARA			2	40
230kV	SRJGNJ	BOGRS	2	144	2	144
230kV	SRJGNJ	SRIPUR			2	146

Voltage	From Substation	To Substation	2010		2015	
			cct.	Length (km)	cct.	Length (km)
230kV	TONGI	AMINBZ	2	51		
230kV	TONGI	KALIAKAIR			2	76
230kV Total				2644.8		3676.3
400kV	AMINBAZAR	MEGHNAGHAT			1	50
400kV	AMINBAZAR	ZAJIRA			1	56.25
400kV	KALIAKAIR	BIBIYANA			2	336
400kV	MEGHNAGHAT	AMINBAZAR			1	50
400kV	MEGHNAGHAT	ANOWARA			2	520
400kV	MONGLA	ZAJIRA			2	272
400kV	ZAJIRA	AMINBAZAR			1	56.25
400kV Total						1340.5

Source: PSMP Study Team

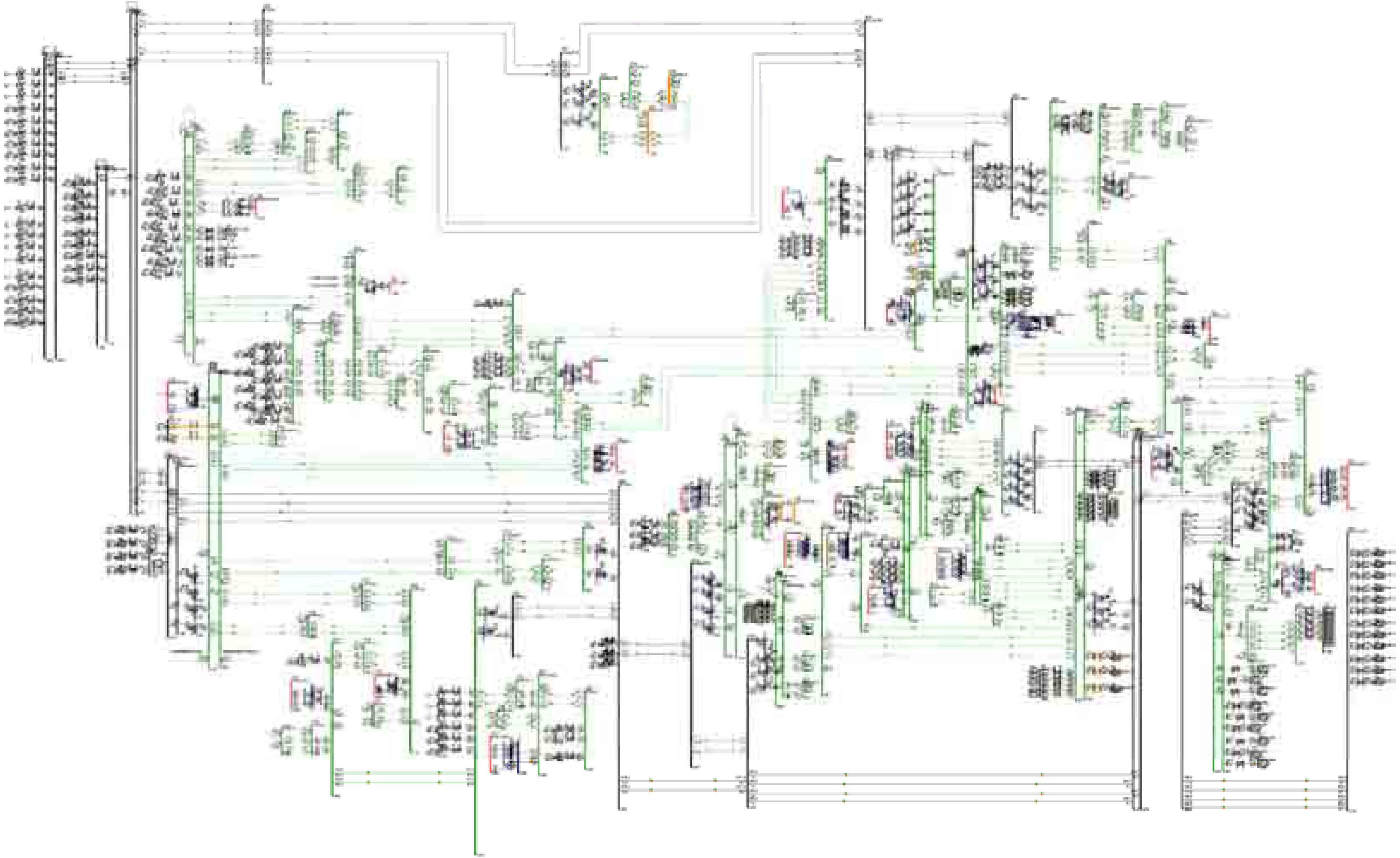
APTable 9-7 The substation for which construction is necessary by 2015

Voltage	East or West	Region	Name	Type
132/33kV	East	Southern	Dohazari	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Halishahar	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Agrabad	132/33kV(2x100MW, GIS)
132/33kV	East	Southern	Agrabad	132/33kV(2x100MW, GIS)
132/33kV	East	Southern	Kulsi	132/33kV(2x100MW, GIS)
132/33kV	East	Southern	Baroirhat, Ctg	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Feni	132/33kV(2x100MW, GIS)
132/33kV	East	Southern	Ramganj	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Comilla (S)-2	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Chouddagram	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Chouddagram	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Chandpur	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Rangamati	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Khagrachari	132/33kV(2x100MW, AIS)
132/33kV	East	Southern	Bakulia	132/33kV(2x100MW, GIS)
132/33kV	East	Southern	Daudkandi	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Siddhirganj	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Moghbazar	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Narinda	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Shyampur	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Hasnabad	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Kalyanpur	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Basundhara-2	132/33kV(2x100MW, GIS)

Voltage	East or West	Region	Name	Type
132/33kV	East	Dhaka	Basundhara-3	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Tongi	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Kabirpur	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Manikganj	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Tangail	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Joydebpur	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Uttara-2	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Cantonment	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Nabinagar(Md.pur)	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Nabinagar(Md.pur)	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	OldAirport	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	OldAirport	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	DhakaUniversity	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Kamrangirchar	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Madartek	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Gulshan-2	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Matuail	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Meghnaghat	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Savar	132/33kV(2x100MW, GIS)
132/33kV	East	Dhaka	Purbachal	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Munshiganj	132/33kV(2x100MW, AIS)
132/33kV	East	Dhaka	Sreepur	132/33kV(2x100MW, AIS)
132/33kV	West	Western	Khulna(C)	132/33kV(2x100MW, AIS)
132/33kV	East	Central	Bhaluka	132/33kV(2x100MW, AIS)
132/33kV	East	Central	Sherpur	132/33kV(2x100MW, AIS)
132/33kV	East	Central	Sylhet	132/33kV(2x100MW, AIS)
132/33kV	East	Central	Sylhet New	132/33kV(2x100MW, AIS)
132/33kV	East	Central	Sylhet New	132/33kV(2x100MW, GIS)
132/33kV	East	Central	Brahmanbaria	132/33kV(2x100MW, GIS)
132/33kV	West	Western	Jessore	132/33kV(2x100MW, AIS)
132/33kV	West	Western	Magura	132/33kV(2x100MW, AIS)
132/33kV	West	Western	Chuadanga	132/33kV(2x100MW, AIS)
132/33kV	West	Western	Madaripur	132/33kV(2x100MW, AIS)
132/33kV	West	Western	Barisal (N)	132/33kV(2x100MW, AIS)
132/33kV	West	Northern	Natore	132/33kV(2x100MW, AIS)
132/33kV	West	Northern	Rajshahi New	132/33kV(2x100MW, AIS)
132/33kV	West	Northern	Sirajganj	132/33kV(2x100MW, AIS)

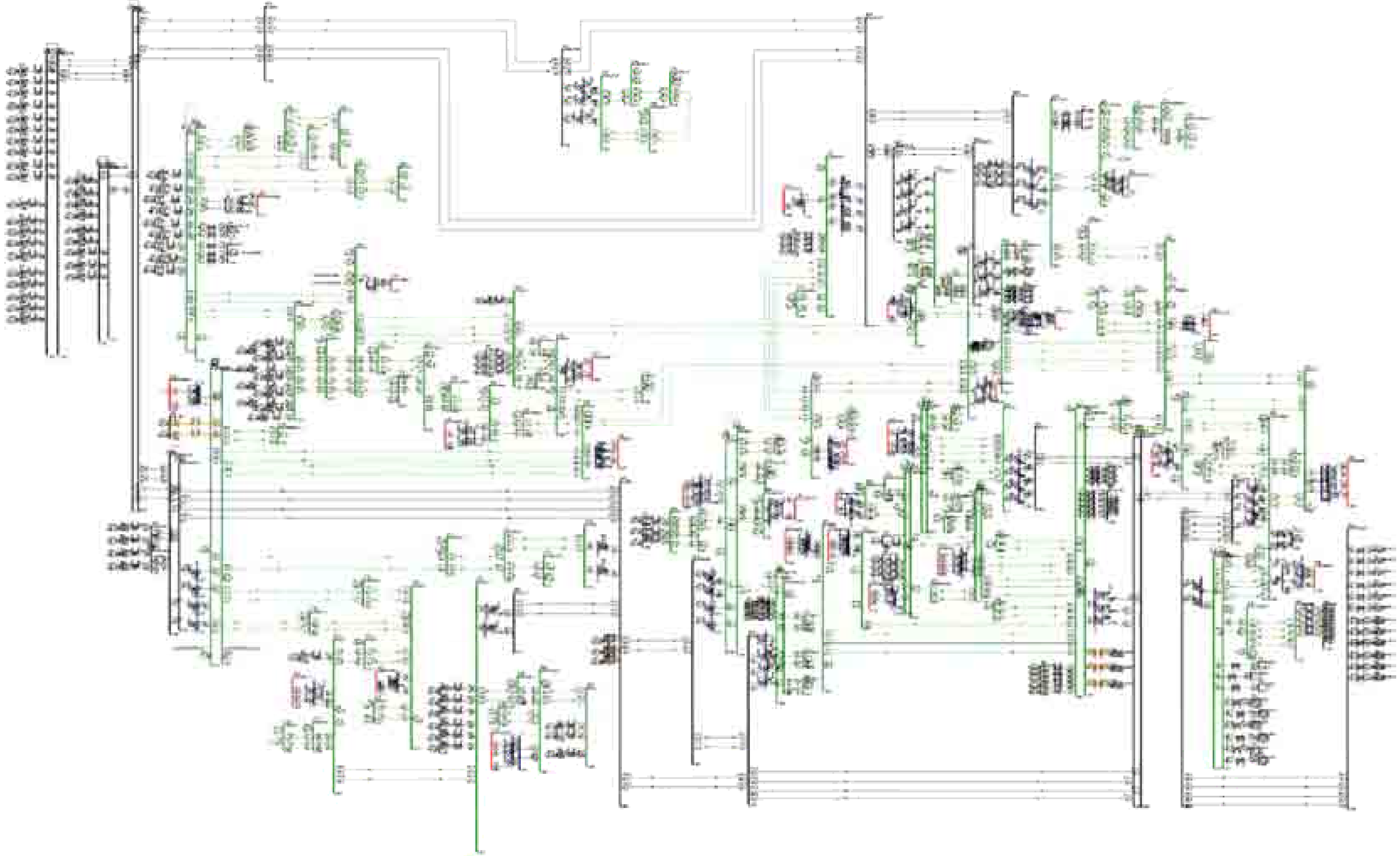
Voltage	East or West	Region	Name	Type
132/33kV	West	Northern	Bogra	132/33kV(2x100MW, AIS)
132/33kV	West	Northern	Bogra	132/33kV(2x100MW, AIS)
132/33kV	West	Northern	Rangpur	132/33kV(2x100MW, AIS)
132/33kV	West	Northern	Panchaghar	132/33kV(2x100MW, AIS)
132/33kV	West	Northern	Joypurhat	132/33kV(2x100MW, AIS)
230/132kV	East	Southern	KULSHI	230/132kV(2x500MW, GIS)
230/132kV	East	Southern	SIKALBAHA	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	KALIAKAIR	230/132kV(2x300MW, AIS)
230/132kV	East	Dhaka	OLDAIRPORT	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	SHAMPUR	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	SIDDHIRGANJ	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	SRIPUR	230/132kV(2x300MW, AIS)
230/132kV	East	Central	FENCHUGANJ	230/132kV(2x300MW, AIS)
230/132kV	West	Western	BARISAL	230/132kV(2x300MW, AIS)
230/132kV	West	Western	BHERAMARA	230/132kV(2x300MW, AIS)
230/132kV	West	Western	JHENIDA	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	RAJSHAHI	230/132kV(2x300MW, AIS)
400/230kV	East	Southern	ANOWARA	400/230kV(2x500MVA, AIS)
400/230kV	East	Dhaka	AMINBAZAR	400/230kV(3x500MVA, AIS)
400/230kV	East	Dhaka	KALIAKAIR	400/230kV(3x500MVA, AIS)
400/230kV	East	Dhaka	MEGHNAGHAT	400/230kV(3x500MVA, AIS)
400/230kV	East	Central	BIBIYANA	400/230kV(1x500MVA, AIS)
400/230kV	West	Western	MONGLA	400/230kV(3x500MVA, AIS)

Source: PSMP Study Team



Source: PSMP Study Team

APFig. 9-19 400kV, 230kV power flow (2030, pattern east)



Source: PSMP Study Team

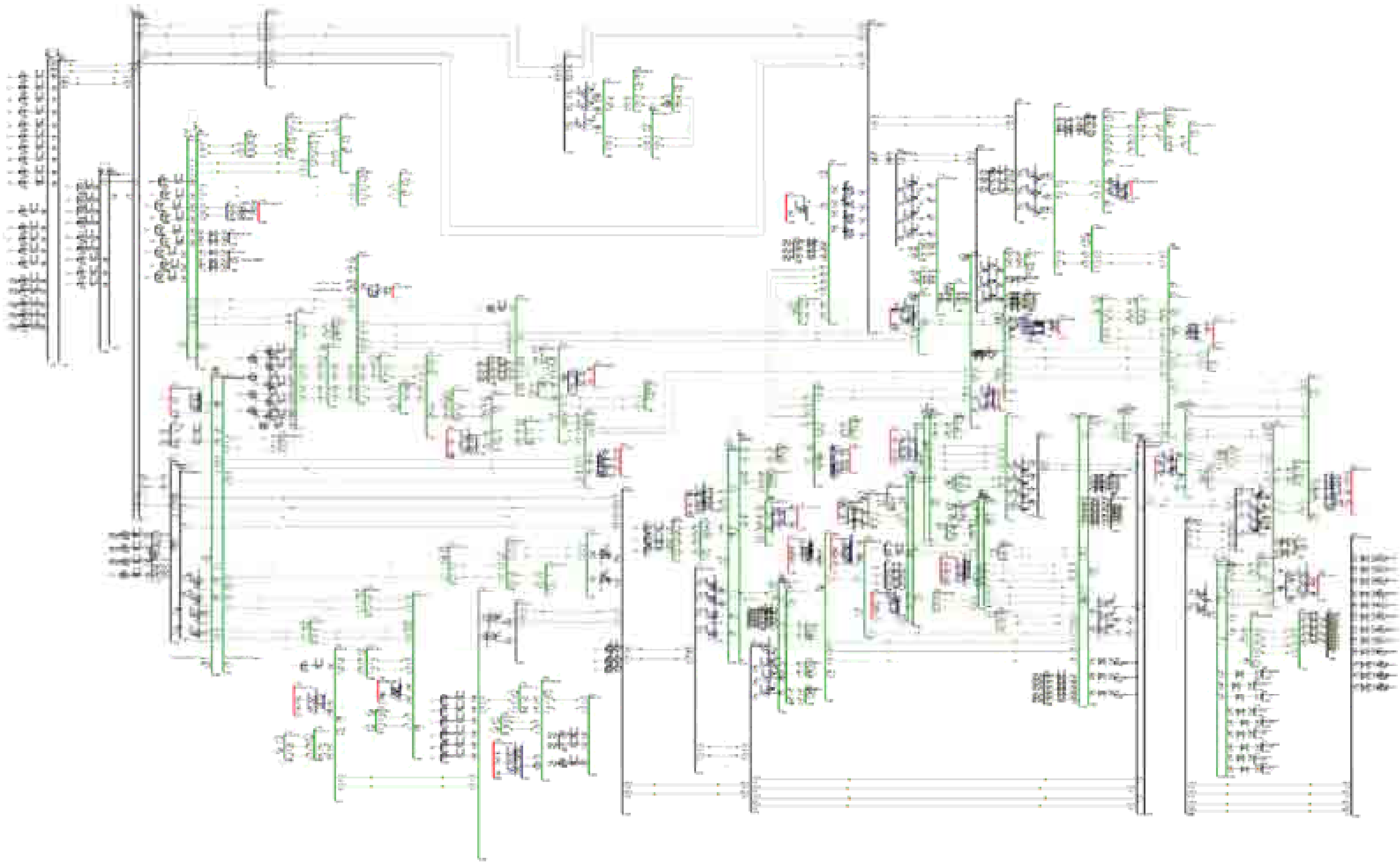
APFig. 9-20 400kV, 230kV power flow (2030, pattern west)

APTable 9-8 Results of short-circuit and ground-fault current analysis (2030) (kA)

Substation		I"k		Asym Ib		Substation		I"k		Asym Ib	
Name	Voltage	3PH	LG	3PH	LG	Name	Voltage	3PH	LG	3PH	LG
HATHZR	230kV	34.6	28.9	34.4	29.0	RAMPR-3	230kV	21.4	17.3	21.5	17.4
MANIKNAGAR	230kV	34.1	26.5	34.1	26.5	RAMPR-4	230kV	31.4	20.9	31.4	20.9
SIDDHIRGANJ	230kV	51.9	45.0	52.1	46.1	RAMPR-5	230kV	31.4	20.9	31.4	20.9
COMIN	230kV	36.5	26.4	36.4	26.4	ISHRDI-2	230kV	16.2	9.8	16.2	9.8
ASHUGNJ	230kV	44.0	38.4	43.4	39.8	BHERAMARA-2	230kV	41.9	30.0	42.0	30.0
SIKALBAHA	230kV	48.5	43.5	48.7	45.2	JHENIDA-2	230kV	24.4	20.8	24.4	20.8
GHRSL	230kV	34.5	28.7	33.2	28.9	JHENIDA-3	230kV	24.4	20.8	24.4	20.8
TONGI	230kV	27.9	23.7	27.7	23.8	KHULN-2	230kV	11.3	9.9	11.3	9.9
HARIPR	230kV	56.1	49.5	57.1	50.7	KHULN-3	230kV	18.5	15.9	18.5	16.0
HASNBD	230kV	33.7	27.5	33.6	27.6	KHULN-4	230kV	16.9	12.3	16.8	12.3
MEGHNAGHAT	230kV	54.3	43.2	55.3	46.0	KHULN-5	230kV	13.8	9.3	13.8	9.3
HARIPUR360	230kV	47.3	40.7	47.1	40.8	ASHUGNJ-2	230kV	13.3	7.8	13.3	7.8
RAMPR	230kV	21.5	18.0	21.6	18.4	ASHUGNJ-3	230kV	8.7	4.9	8.7	4.9
ISHRDI	230kV	48.0	37.9	48.1	38.1	ASHUGNJ-4	230kV	8.7	4.9	8.7	4.9
KULSHI	230kV	42.5	36.3	41.9	36.4	ASHUGNJ-5	230kV	9.9	5.6	9.9	5.6
ANOWARA	230kV	48.7	40.4	51.9	46.4	JAMALPUR	230kV	16.9	10.7	17.1	11.1
RAJSHAHI	230kV	19.3	13.9	19.1	14.0	COMIN-2	230kV	34.9	22.0	34.9	22.0
SHAMPUR	230kV	28.9	23.8	28.9	23.9	COMIN-3	230kV	15.8	9.3	15.8	9.3
BAGHA	230kV	29.3	21.0	29.1	21.1	COMIN-4	230kV	14.9	8.6	14.9	8.6
KHULN	230kV	21.8	18.3	21.5	18.4	COMIN-5	230kV	23.7	14.9	23.7	14.9
AMINBZ	230kV	37.1	33.1	37.0	33.8	COMIN-6	230kV	13.4	7.6	13.4	7.6
SRJGNJ	230kV	34.3	24.4	33.6	24.9	GHRSL-2	230kV	29.2	21.6	28.9	21.7
BOGRS	230kV	37.3	25.0	37.3	25.0	RAJSHAHI-2	230kV	18.6	11.6	18.6	11.6
BRPUK	230kV	40.0	33.2	43.8	42.5	RAJSHAHI-3	230kV	23.4	15.1	23.3	15.1
BHERAMARA	230kV	53.1	42.4	54.4	43.9	MAWA-2	230kV	25.1	18.3	24.2	18.4
OLDAIRPORT	230kV	27.5	23.5	27.4	23.5	BRPUK-2	230kV	14.6	8.6	14.6	8.6
KALIAKAIR	230kV	31.7	26.3	32.1	27.6	BRPUK-3	230kV	12.7	7.3	12.7	7.3
JHENIDA	230kV	24.7	22.0	24.6	22.0	BRPUK-4	230kV	18.2	11.2	18.2	11.2
MONGLA	230kV	30.0	24.4	30.4	28.0	BRPUK-5	230kV	13.7	8.0	13.7	8.0
SRIPUR	230kV	19.4	14.5	19.4	14.5	BRPUK-6	230kV	15.3	9.1	15.4	9.1
BIBIYANA	230kV	22.1	18.1	22.7	19.6	BRPUK-7	230kV	9.8	5.5	9.8	5.5
BHOLA	230kV	8.5	7.2	8.9	8.4	BARISAL-2	230kV	13.2	9.5	13.1	9.5
BARISAL(N)	230kV	9.6	9.4	9.4	9.5	BARISAL-3	230kV	6.1	4.5	6.1	4.5
FENCHUGANJ	230kV	14.3	11.4	14.2	11.5	FENCHUGANJ-2	230kV	12.3	9.2	12.3	9.2
COXS BAZAR	230kV	11.7	7.0	11.6	7.0	FENCHUGANJ-3	230kV	9.7	6.6	9.7	6.6
NOAGAON	230kV	23.4	14.2	23.4	14.2	FENCHUGANJ-4	230kV	8.0	5.1	8.0	5.1
KERANIGANJ	230kV	37.1	29.8	38.4	32.6	TAKERHAT	230kV	15.2	7.9	15.2	7.9
BHULTA	230kV	22.4	18.5	22.6	19.1	TAKERHAT-2	230kV	13.5	7.2	13.5	7.2
DIGHIPARA	230kV	42.1	31.8	43.3	39.2	TAKERHAT-3	230kV	11.7	6.1	11.7	6.1
MAWA	230kV	22.3	16.1	21.4	17.2	ZAJIRA	230kV	19.9	10.4	20.5	10.9
AMINBZ2	230kV	37.1	33.1	37.0	33.8	KERANIGANJ2	230kV	37.1	29.8	38.4	32.6

Substation		I"k		Asym Ib		Substation		I"k		Asym Ib	
Name	Voltage	3PH	LG	3PH	LG	Name	Voltage	3PH	LG	3PH	LG
MEGHNAGHAT2	230kV	55.0	47.4	56.9	50.3	ANOWARA2	230kV	48.7	40.4	51.9	46.4
HARIPR2	230kV	56.1	49.5	57.1	50.7	BHERAMARA2	230kV	53.1	42.4	54.4	43.9
SIDDHIRGANJ2	230kV	51.9	45.0	52.1	46.1	BRPUK2	230kV	40.0	33.2	43.8	42.5
RAMPR2	230kV	21.5	18.0	21.6	18.4	MEGHNAGHAT	400kV	36.7	29.0	38.8	29.9
MYANMMER	230kV	9.1	7.1	10.3	9.0	ANOWARA	400kV	28.1	23.1	32.0	25.1
TONGI-2	230kV	20.3	14.5	20.3	14.5	AMINBAZAR	400kV	31.3	24.7	32.1	25.2
TONGI-3	230kV	24.7	17.6	24.7	17.6	KALIAKAIR	400kV	26.4	22.7	26.9	23.3
HATHZR-2	230kV	30.2	21.0	30.1	21.0	MONGLA	400kV	16.4	10.6	17.0	10.8
SIKALBAHA-2	230kV	32.7	22.5	32.3	22.5	BIBIYANA	400kV	14.4	12.0	14.8	13.0
KULSHI-2	230kV	40.6	32.4	40.1	32.5	ZAJIRA	400kV	38.9	30.8	40.0	31.7
KULSHI-3	230kV	43.2	36.4	42.5	36.5	PKDP	400kV	46.6	42.1	52.5	47.8
HARIPR-2	230kV	40.9	28.6	40.8	28.6	ROOPPUR	400kV	47.8	29.4	42.6	31.2
HARIPR-3	230kV	41.3	30.4	41.1	30.4	MATARBARI	400kV	26.4	23.5	30.8	29.5
HASNBD-2	230kV	29.9	21.6	29.9	21.6	SIKALBAHA	400kV	28.0	22.4	31.1	23.8
HASNBD-3	230kV	29.9	21.6	29.9	21.6	BHULTA	400kV	24.6	19.8	25.0	20.1
HASNBD-4	230kV	29.9	21.6	29.9	21.6	MEGHNAGHAT2	400kV	36.7	29.0	38.8	29.9
OLDAIRPORT-2	230kV	31.6	26.3	31.3	26.3	PKDP2	400kV	46.6	42.1	52.5	47.8
JOYDEBPUR	230kV	29.0	21.4	29.3	21.9	ROOPPUR2	400kV	47.8	29.4	42.6	31.2
KALIAKAIR-2	230kV	15.9	9.8	15.9	9.8	KHARASPIR	400kV	40.5	35.5	44.2	39.1
KALIAKAIR-3	230kV	15.9	9.8	15.9	9.8	PHULBARI	400kV	45.6	42.0	52.5	51.9
KALIAKAIR-4	230kV	19.8	13.3	19.8	13.3	PHULBARI2	400kV	45.6	42.0	52.5	51.9
BOGRS-3	230kV	35.4	23.4	34.9	23.4	BHERAMARA	400kV	49.6	31.6	45.7	33.3
BOGRS-5	230kV	23.7	14.3	23.7	14.3	BOGRA	400kV	27.6	21.4	28.0	21.5
BOGRS-2	230kV	17.3	10.2	17.3	10.2	DHAKA WEST	400kV	37.7	30.4	39.4	31.4
BOGRS-4	230kV	23.7	14.3	23.7	14.3	ASHUGANJ	400kV	21.0	16.3	21.6	16.7
BAGHA-2	230kV	21.4	13.4	21.4	13.4	JOYDEBPUR	400kV	23.7	20.0	24.2	20.6
BAGHA-3	230kV	21.4	13.4	21.4	13.4	JAMALPUR	400kV	20.2	16.7	20.4	16.9
MANIKNAGAR-2	230kV	41.2	31.2	41.0	31.2	BHERAMARA2	400kV	49.6	31.6	45.7	33.3
RAMPR-2	230kV	14.0	9.6	13.9	9.6	KHARASPIR2	400kV	40.5	35.5	44.2	39.1

Source :PSMP Study Team



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APFig. 9-21 400kV, 230kV power flow (2030, light load)

APTable 9-9 The transmission line for which construction is necessary by 2030

Voltage	From Substation	To Substation	2010		2030	
			cct.	Length (km)	cct.	Length (km)
230kV	AMINBZ	KERANIGANJ			2	42
230kV	AMINBZ	MAWA-2			2	40
230kV	AMINBZ	OLDAIRPORT			1	10
230kV	AMINBZ	OLDAIRPORT-2			3	15
230kV	AMINBZ	TONGI-3			2	27
230kV	ANOWARA	COXS BAZAR			1	95
230kV	ANOWARA	SIKALBAHA-2			2	20
230kV	ASHUGNJ	ASHUGNJ-2			2	104
230kV	ASHUGNJ	GHRSL	2	88	2	88
230kV	ASHUGNJ	SRIPUR			2	140
230kV	ASHUGNJ	SRJGNJ	2	286		
230kV	ASHUGNJ-3	ASHUGNJ-4			2	109.8
230kV	ASHUGNJ-3	JAMALPUR			2	177.8
230kV	ASHUGNJ-4	ASHUGNJ-5			2	68
230kV	ASHUGNJ-5	JAMALPUR			2	109.8
230kV	BAGHA	BAGHA-2			1	19
230kV	BAGHA	BAGHA-3			1	19
230kV	BAGHA	ISHRDI-2			2	55
230kV	BAGHA	SRJGNJ	2	76	2	76
230kV	BARISAL(N)	BARISAL-2			2	117
230kV	BARISAL(N)	BARISAL-3			2	117
230kV	BHERAMARA	JHENIDA-3			2	75
230kV	BHERAMARA	TAKERHAT-2			1	120
230kV	BHERAMARA-2	BHERAMARA			2	10
230kV	BHOLA	BARISAL(N)			2	120
230kV	BHULTA	RAMPR-3			2	4
230kV	BIBIYANA	COMIN-3			2	160
230kV	BIBIYANA	FENCHUGANJ			2	64
230kV	BOGRS	BOGRS-3			4	135
230kV	BOGRS	BOGRS-4			2	52
230kV	BOGRS	BOGRS-5			2	52
230kV	BOGRS	BRPUK	2	212	2	212
230kV	BRPUK	BRPUK-2			2	122
230kV	BRPUK	BRPUK-6			2	80

Voltage	From Substation	To Substation	2010		2030	
			cct.	Length (km)	cct.	Length (km)
230kV	BRPUK-2	BRPUK-3			2	88
230kV	BRPUK-3	BRPUK-5			2	72
230kV	BRPUK-4	BRPUK			2	72
230kV	BRPUK-4	BRPUK-5			2	72
230kV	BRPUK-6	BRPUK-7			2	74
230kV	COMIN	ASHUGNJ	2	158	4	316
230kV	COMIN	COMIN-2			2	58
230kV	COMIN	COMIN-3			2	160
230kV	COMIN	COMIN-4			2	79
230kV	COMIN	COMIN-5			2	32
230kV	COMIN	COMIN-6			2	240
230kV	COMIN	MEGH	2	116		
230kV	COMIN-5	COMIN-6			2	122
230kV	COXS BAZAR	ANOWARA			1	95
230kV	COXS BAZAR	MYANMMER			4	760
230kV	DIGHIPARA	BOGRS-2			2	67.5
230kV	DIGHIPARA	BOGRS-3			4	135
230kV	DIGHIPARA	BRPUK			2	101.25
230kV	FENCHUGANJ	FENCHUGANJ-2			4	87.332
230kV	FENCHUGANJ-2	FENCHUGANJ-3			2	43.666
230kV	FENCHUGANJ-3	FENCHUGANJ-4			2	43.666
230kV	GHRSL	GHRSL-2			2	29.5
230kV	GHRSL	ISHRDI	2	356	2	356
230kV	GHRSL	RAMPR	2	100		
230kV	GHRSL	TONGI	2	54	2	54
230kV	HARIPR	HARIPUR360	2	4.8	2	4.8
230kV	HARIPR	MEGH	2	24		
230kV	HARIPR	MEGHNAGHAT			3	36
230kV	HARIPR	RAMPR	2	56		
230kV	HARIPR	RAMPR-4			2	28
230kV	HARIPR	RAMPR-5			2	28
230kV	HARIPR	SIDDHIRGANJ			1	2
230kV	HASNBD	AMINBZ	2	42		
230kV	HASNBD	MEGH	2	52		
230kV	HASNBD	MEGHNAGHAT			3	78
230kV	HASNBD	SHAMPUR			1	10

Voltage	From Substation	To Substation	2010		2030	
			cct.	Length (km)	cct.	Length (km)
230kV	HASNBD-4	KERANIGANJ			2	13
230kV	HATHZR	COMIN	2	300	2	300
230kV	HATHZR	KULSHI			2	40
230kV	HATHZR	SIKALBAHA			2	50
230kV	ISHRDI	BAGHA	2	110	2	110
230kV	ISHRDI	BHERAMARA			4	40
230kV	ISHRDI	KHULN	2	370		
230kV	ISHRDI	RAJSHAHI-3			2	70
230kV	JHENIDA	JHENIDA-2			2	75
230kV	JHENIDA	JHENIDA-3			2	75
230kV	JHENIDA	KHULN-2			2	95
230kV	JHENIDA	KHULN-3			2	95
230kV	JHENIDA-2	BHERAMARA			2	75
230kV	JOYDEBPUR	GHRSL-2			2	29.5
230kV	JOYDEBPUR	KALIAKAIR-2			2	56.25
230kV	JOYDEBPUR	KALIAKAIR-3			2	56.25
230kV	KALIAKAIR	KALIAKAIR-4			2	38
230kV	KERANIGANJ	HASNBD-2			2	13
230kV	KERANIGANJ	HASNBD-3			2	13
230kV	KHULN	KHULN-3			2	95
230kV	KHULN	KHULN-4			2	26.666
230kV	KHULN	MONGLA			2	80
230kV	KHULN-4	KHULN-5			2	26.666
230kV	KULSHI	KULSHI-3			2	8
230kV	MANIKNAGAR	SIDDHIRGANJ			2	20
230kV	MAWA	MAWA-2			4	80
230kV	MEGHNAGHAT	COMIN-2			2	58
230kV	MEGHNAGHAT	HARIPR			3	36
230kV	MEGHNAGHAT	HARIPR-2			2	12
230kV	MEGHNAGHAT	HARIPR-3			2	12
230kV	MONGLA	BARISAL-2			2	117
230kV	NOAGAON	BOGRS-4			2	52
230kV	NOAGAON	BOGRS-5			2	52
230kV	NOAGAON	RAJSHAHI-2			2	70.876
230kV	OLDAIRPORT	AMINBZ			2	20
230kV	RAJSHAHI	RAJSHAHI-2			2	70.876

Voltage	From Substation	To Substation	2010		2030	
			cct.	Length (km)	cct.	Length (km)
230kV	RAJSHAHI	RAJSHAHI-3			2	70
230kV	RAMPR	BHULTA			4	16
230kV	RAMPR	RAMPR-2			2	50
230kV	RAOZN	HATHZR	2	45		
230kV	SHAMPUR	MEGHNAGHAT			1	16
230kV	SIDDHIRGANJ	HARIPR			1	2
230kV	SIDDHIRGANJ	MANIKNAGAR-2			2	10
230kV	SIKALBAHA	ANOWARA			4	80
230kV	SIKALBAHA	HATHZR-2			2	25
230kV	SIKALBAHA	KULSHI			2	16
230kV	SIKALBAHA	KULSHI-2			2	8
230kV	SIKALBAHA	KULSHI-3			2	8
230kV	SRJGNJ	BAGHA-2			1	19
230kV	SRJGNJ	BAGHA-3			1	19
230kV	SRJGNJ	BOGRS	2	144	4	288
230kV	SRJGNJ	SRIPUR			2	146
230kV	TAKERHAT	TAKERHAT-2			2	101.25
230kV	TAKERHAT	TAKERHAT-3			2	38.25
230kV	TAKERHAT	ZAJIRA			2	67.5
230kV	TAKERHAT-2	BHERAMARA			1	120
230kV	TONGI	AMINBZ	2	51		
230kV	TONGI	KALIAKAIR			4	152
230kV	TONGI	TONGI-2			2	27
230kV Total				2644.8		9360.198
400kV	AMINBAZAR	DHAKA WEST			2	67.5
400kV	AMINBAZAR	ZAJIRA			2	112.5
400kV	ANOWARA	MATARBARI			4	180
400kV	ANOWARA	SIKALBAHA			4	80
400kV	ASHUGANJ	JOYDEBPUR			2	56.25
400kV	BHULTA	MEGHNAGHAT			1	25.875
400kV	BOGRA	JAMALPUR			2	130.5
400kV	KALIAKAIR	BIBIYANA			2	336
400kV	KALIAKAIR	BOGRA			2	270
400kV	KALIAKAIR	JAMALPUR			2	162
400kV	KALIAKAIR	JOYDEBPUR			2	56.25
400kV	MEGHNAGHAT	BHULTA			1	25.875

Voltage	From Substation	To Substation	2010		2030	
			cct.	Length (km)	cct.	Length (km)
400kV	MEGHNAGHAT	DHAKA WEST			4	99
400kV	MEGHNAGHAT	SIKALBAHA			1	240
400kV	MONGLA	ZAJIRA			2	272
400kV	PKDP	BHERAMARA			4	810
400kV	PKDP	BOGRA			4	450
400kV	PKDP	KHARASPIR			2	20
400kV	PKDP	PHULBARI			4	40
400kV	ROOPPUR	BHERAMARA			4	49.5
400kV	SIKALBAHA	MEGHNAGHAT			1	240
400kV	ZAJIRA	BHERAMARA			4	675
400kV	ZAJIRA	DHAKA WEST			2	81
400kV Total						4479.25

Source :PSMP Study Team

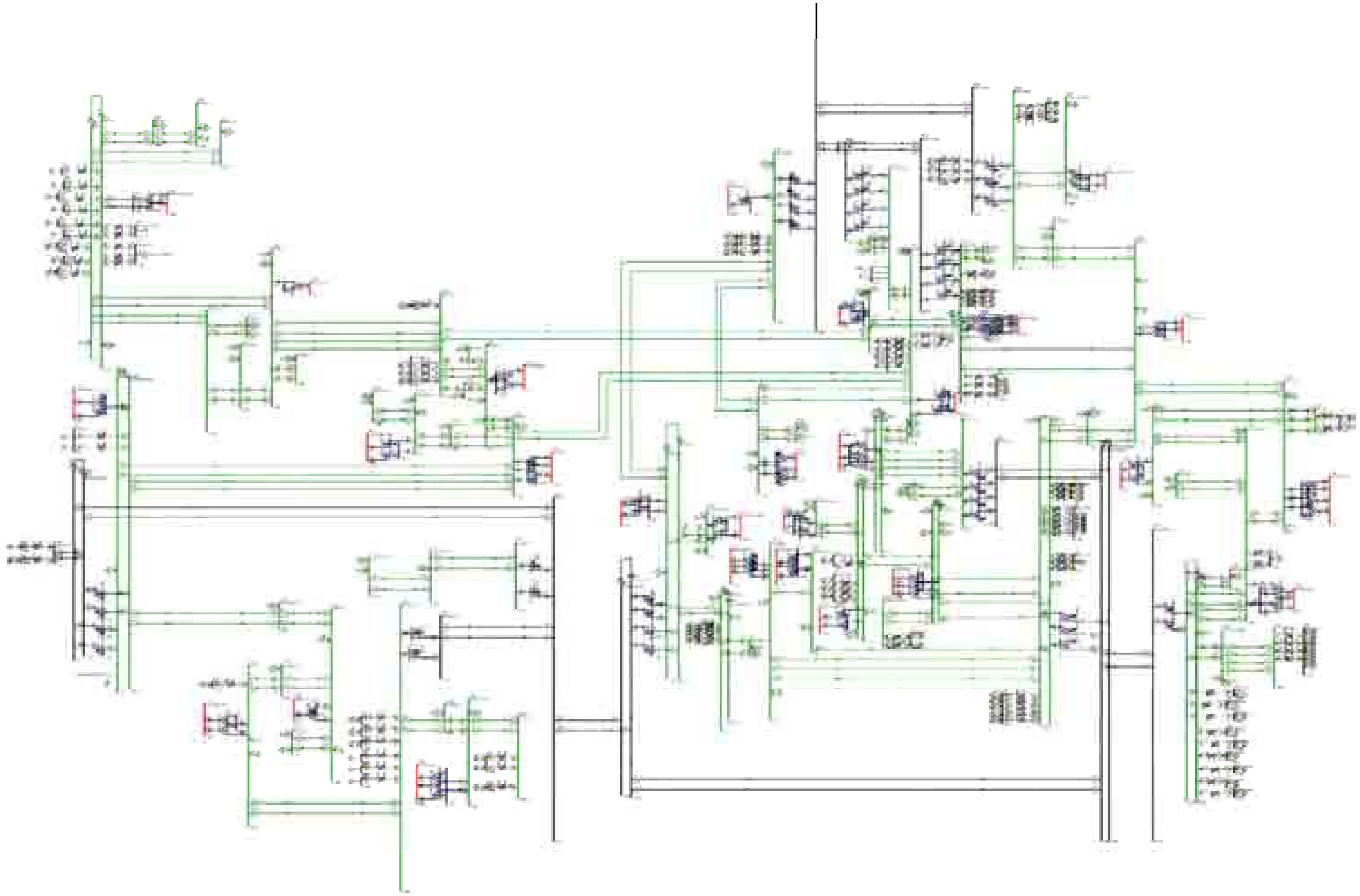
APTable 9-10 The substation for which construction is necessary by 2030

Voltage	East or West	Area	New Substation	Type
230/132kV	East	Southern	HATHZR-2	230/132kV(2x500MW, GIS)
230/132kV	East	Southern	COMIN-2	230/132kV(2x300MW, AIS)
230/132kV	East	Southern	COMIN-3	230/132kV(2x300MW, AIS)
230/132kV	East	Southern	COMIN-4	230/132kV(2x300MW, AIS)
230/132kV	East	Southern	COMIN-5	230/132kV(2x300MW, AIS)
230/132kV	East	Southern	COMIN-6	230/132kV(2x300MW, AIS)
230/132kV	East	Southern	COMIN-7	230/132kV(2x300MW, AIS)
230/132kV	East	Southern	COMIN-8	230/132kV(2x300MW, AIS)
230/132kV	East	Southern	SIKALBAHA	230/132kV(2x500MW, GIS)
230/132kV	East	Southern	ANOWARA	230/132kV(2x500MW, GIS)
230/132kV	East	Southern	Cox's bazar	230/132kV(2x500MW, GIS)
230/132kV	East	Southern	KULSHI	230/132kV(2x500MW, GIS)
230/132kV	East	Southern	KULSHI-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	MANIKNAGAR	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	MANIKNAGAR-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	GHRSL-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	TONGI-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	TONGI-3	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	HARIPR-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	HARIPR-3	230/132kV(2x500MW, GIS)

Voltage	East or West	Area	New Substation	Type
230/132kV	East	Dhaka	HARIPR-4	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	HASNBD-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	HASNBD-4	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	RAMPR-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	RAMPR-3	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	RAMPR-4	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	RAMPR-5	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	SHAMPUR	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	AMINBZ-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	AMINBZ-3	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	OLDAIRPORT	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	OLDAIRPORT-2	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	KALIAKAIR	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	KALIAKAIR-3	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	KALIAKAIR-4	230/132kV(2x500MW, GIS)
230/132kV	East	Dhaka	SRIPUR	230/132kV(2x300MW, AIS)
230/132kV	East	Central	ASHUGNJ-2	230/132kV(2x300MW, AIS)
230/132kV	East	Central	ASHUGNJ-3	230/132kV(2x300MW, AIS)
230/132kV	East	Central	ASHUGNJ-4	230/132kV(2x300MW, AIS)
230/132kV	East	Central	ASHUGNJ-5	230/132kV(2x300MW, AIS)
230/132kV	East	Central	ASHUGNJ-6	230/132kV(2x300MW, AIS)
230/132kV	East	Central	ASHUGNJ-7	230/132kV(2x300MW, AIS)
230/132kV	East	Central	FENCHUGANJ	230/132kV(2x300MW, AIS)
230/132kV	East	Central	FENCHUGANJ-2	230/132kV(2x300MW, AIS)
230/132kV	East	Central	FENCHUGANJ-3	230/132kV(2x300MW, AIS)
230/132kV	East	Central	FENCHUGANJ-4	230/132kV(2x300MW, AIS)
230/132kV	East	Central	FENCHUGANJ-5	230/132kV(2x300MW, AIS)
230/132kV	West	Western	KHULN-2	230/132kV(2x300MW, AIS)
230/132kV	West	Western	KHULN-3	230/132kV(2x300MW, AIS)
230/132kV	West	Western	BHERAMARA	230/132kV(2x300MW, AIS)
230/132kV	West	Western	BHERAMARA-2	230/132kV(2x300MW, AIS)
230/132kV	West	Western	JHENIDA	230/132kV(2x300MW, AIS)
230/132kV	West	Western	JHENIDA-2	230/132kV(2x300MW, AIS)
230/132kV	West	Western	JHENIDA-3	230/132kV(2x300MW, AIS)
230/132kV	West	Western	BARISAL	230/132kV(2x300MW, AIS)
230/132kV	West	Western	BARISAL-2	230/132kV(2x300MW, AIS)
230/132kV	West	Western	BARISAL-3	230/132kV(2x300MW, AIS)

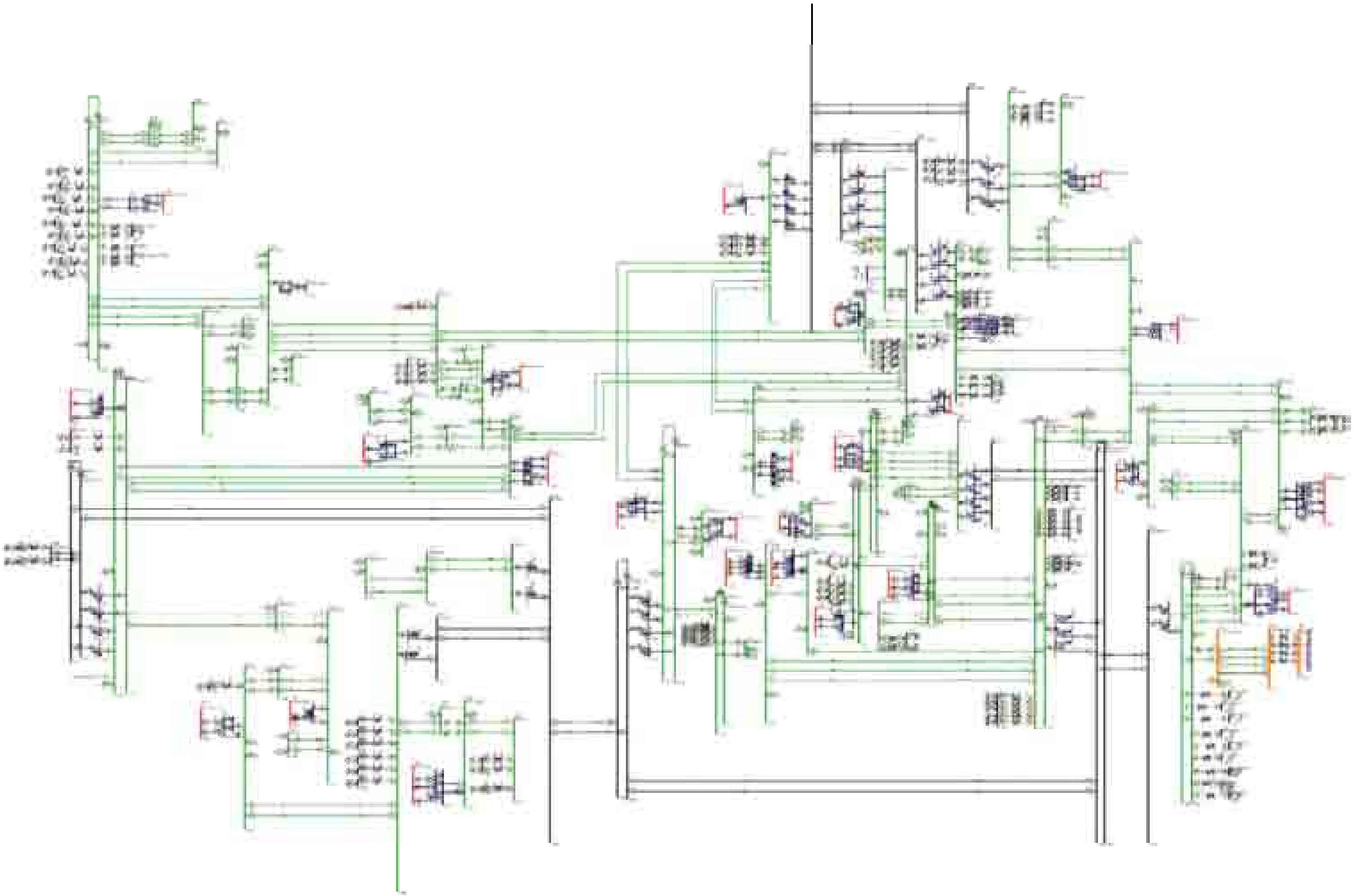
Voltage	East or West	Area	New Substation	Type
230/132kV	West	Western	ZAJIRA	230/132kV(2x300MW, AIS)
230/132kV	West	Western	ZAJIRA-2	230/132kV(2x300MW, AIS)
230/132kV	West	Western	ZAJIRA-3	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	ISHRDI-2	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	RAJSHAHI	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	RAJSHAHI-2	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	RAJSHAHI-3	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BAGHA-2	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BAGHA-3	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BOGRS-2	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BOGRS-3	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BOGRS-4	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BOGRS-5	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BOGRS-6	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BOGRS-7	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BOGRS(NOAGAON)	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BRPUK-2	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BRPUK-3	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BRPUK-5	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BRPUK-6	230/132kV(2x300MW, AIS)
230/132kV	West	Northern	BRPUK-7	230/132kV(2x300MW, AIS)
400/230kV	East	Southern	ANOWARA	400/230kV(2x500MW, AIS)
400/230kV	East	Southern	SIKALBAHA	400/230kV(4x500MW, AIS)
400/230kV	East	Dhaka	AMINBAZAR	400/230kV(4x500MW, AIS)
400/230kV	East	Dhaka	DHAKA WEST	400/230kV(3x500MW, AIS)
400/230kV	East	Dhaka	MEGHNAGHAT2	400/230kV(3x500MW, AIS)
400/230kV	East	Dhaka	BHULTA	400/230kV(4x500MW, AIS)
400/230kV	East	Dhaka	KALIAKAIR	400/230kV(4x500MW, AIS)
400/230kV	East	Dhaka	JOYDEBPUR	400/230kV(4x500MW, AIS)
400/230kV	East	Central	JAMALPUR	400/230kV(3x500MW, AIS)
400/230kV	East	Central	BIBIYANA	400/230kV(3x500MW, AIS)
400/230kV	East	Central	ASHUGANJ	400/230kV(3x500MW, AIS)
400/230kV	West	Western	ZAJIRA	400/230kV(2x500MW, AIS)
400/230kV	West	Western	MONGLA	400/230kV(2x500MW, AIS)
400/230kV	West	Western	BHERAMARA	400/230kV(4x500MW, AIS)

Source: PSMP Study Team



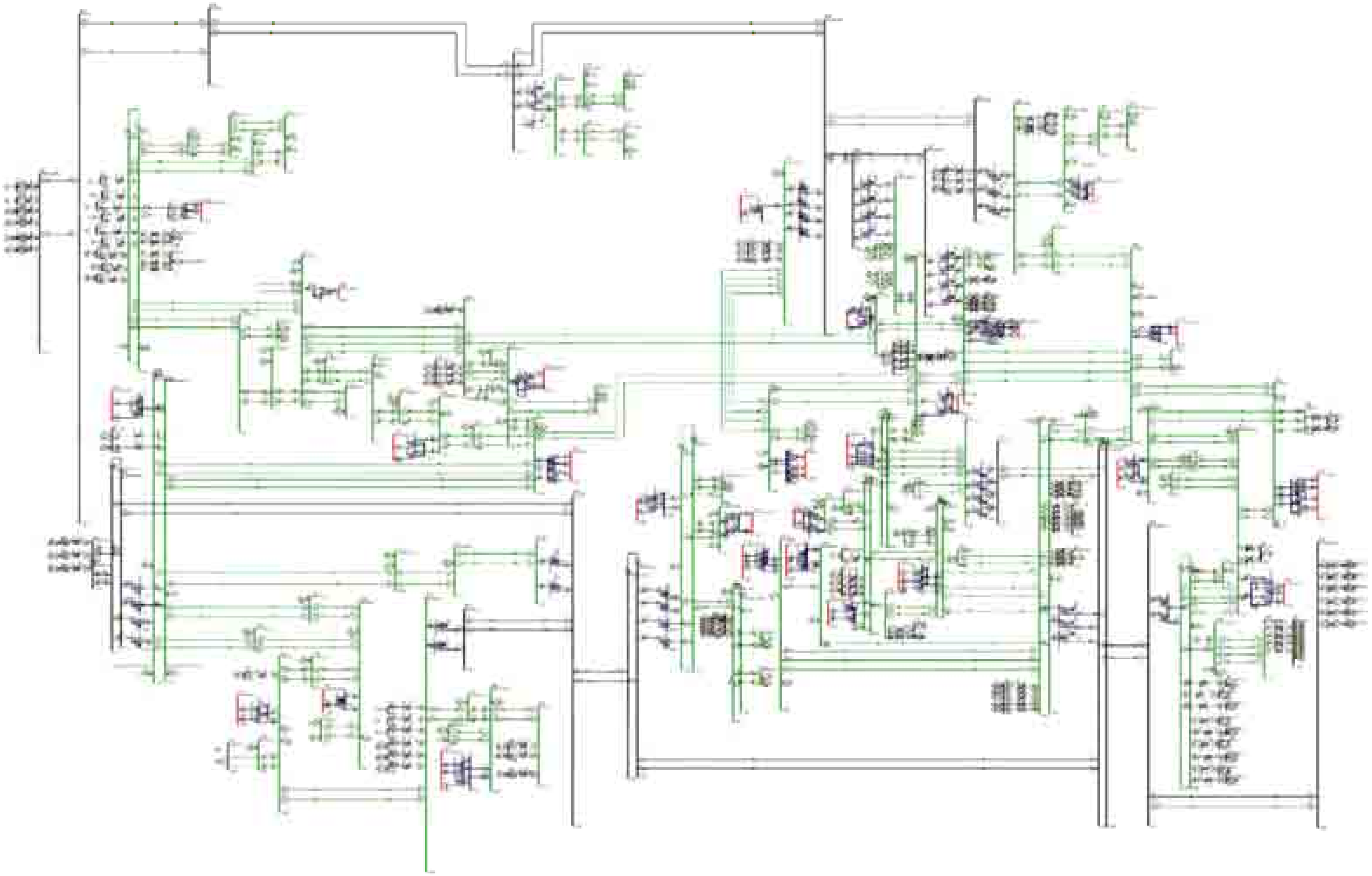
Source: PSMP Study Team

APFig. 9-22 400kV, 230kV power flow (2020, pattern east)



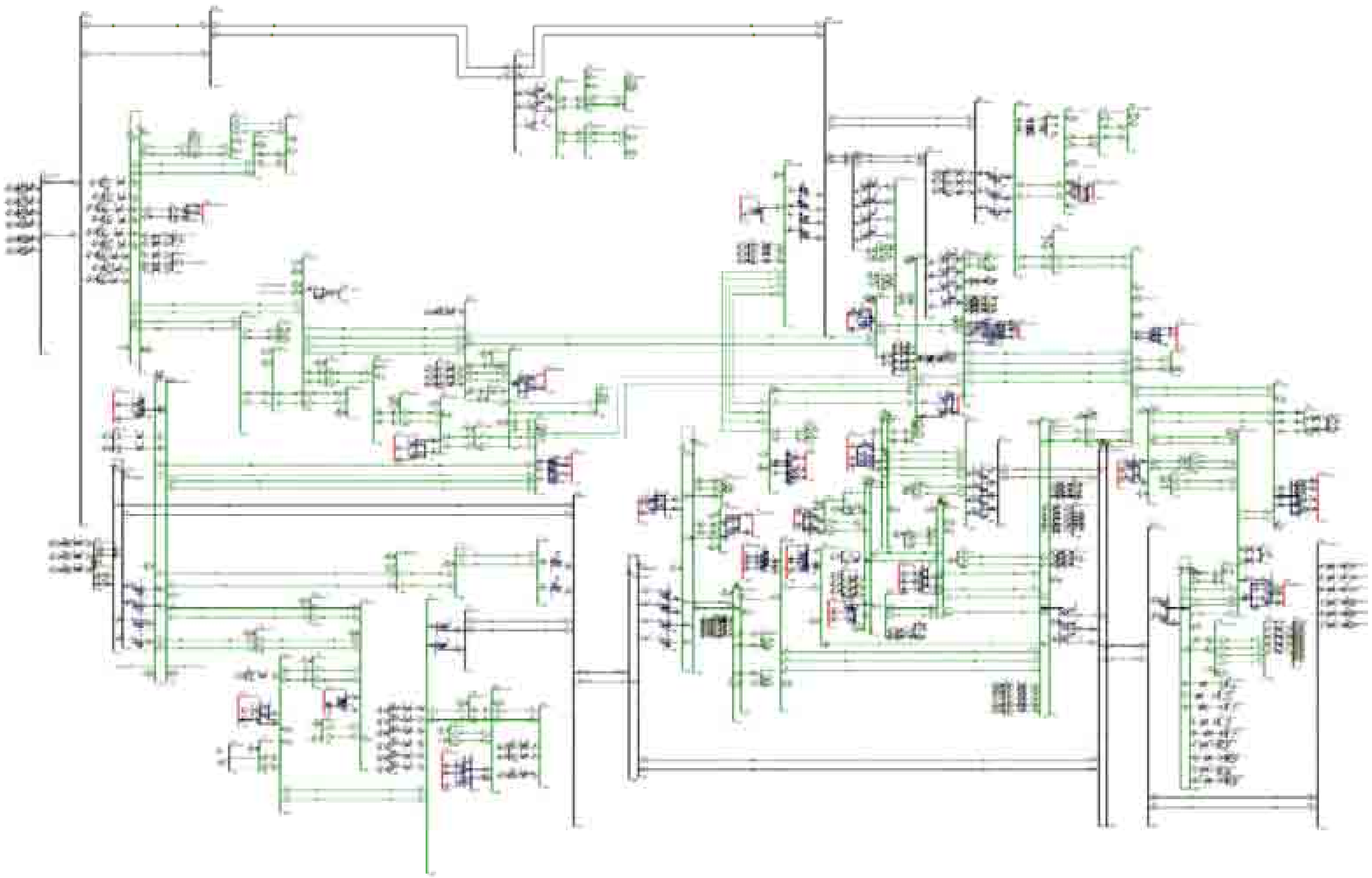
Source: PSMP Study Team

APFig. 9-23 400kV, 230kV power flow (2020, pattern west)



Source: PSMP Study Team

APFig. 9-24 400kV, 230kV power flow (2025, pattern east)



Source: PSMP Study Team

APFig. 9-25 400kV, 230kV power flow (2025, pattern west)

Chapter 10 Financing for Materialization of the Master Plan APPENDEX

10.1 Appendix-1 FINANCIAL MODEL FOR THE MASTER PLAN

AP Table 10-1 ECONOMIC ASSUMPTIONS

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Fiscal Year ending at June of	**Unit**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Inflation																								
Local Inflation (end of June)	% p.a.	0.10	0.02	0.09	0.06																			
Local inflation (average for fiscal year)	% p.a.	0.10	0.07	0.07	0.06																			
US inflation (average, calendar yr)	% p.a.	0.04	0.00	0.02	0.03																			
Inflation in Japan (average, calendar yr)	% p.a.	0.01	-0.01	-0.01	0.01																			
Price index																								
Local prices (average: 1995-96=100)		193.5	206.4	221.5	234.2																			
Local prices (end of June: 1996=100)		203.4	208.0	226.1	239.0																			
US prices (average: 1982-84=100)		215.3	214.5	218.6	224.0																			
Japanese prices (average: 2005=100)		101.7	100.3	99.3	100.3																			
Exchange rate																								
Taka/US$ (average)	Taka	68.60	68.80	69.59	68.08																			
Change from previous year	% p.a.	-0.01	0.00	0.01	-0.02																			
Taka/JPY (average)	Taka	0.62	0.70	0.82	0.81																			
Change from previous year	% p.a.	0.07	0.13	0.17	-0.01																			
Electricity Tariff																								
Average Billing Rate of BPDB	Tk/kWh	2.36	2.56	2.75	2.90																			
Ave Bulk Wholesale Tariff	Tk/kWh	2.37	2.37	2.37																				
Fuel price (constant price in US $)																								
Domestic Coal	US Cents/MM kcal	1,399.64	1,399.64	1,467.41	1,530.46	1,595.08	1,654.98	1,714.87	1,773.19	1,829.93	1,885.10	1,940.26	1,992.28	2,044.29	2,096.30	2,146.74	2,195.60	2,244.46	2,293.33	2,339.03	2,386.32	2,432.03	2,477.74	
Imported Coal	US Cents/MM kcal	1,454.02	1,454.02	1,538.73	1,617.54	1,698.32	1,773.19	1,848.06	1,920.96	1,991.88	2,060.84	2,129.80	2,194.82	2,259.83	2,324.85	2,387.90	2,448.97	2,510.05	2,571.13	2,628.26	2,687.37	2,744.50	2,801.64	
Heavy Fuel Oil (Furnace Oil)	US Cents/MM kcal	3,657.02	4,760.69	4,842.66	4,924.63	5,006.60	5,088.57	5,170.54	5,329.59	5,488.64	5,647.68	5,806.73	5,965.78	6,055.27	6,144.75	6,234.24	6,323.73	6,413.21	6,502.70	6,592.19	6,681.67	6,771.16	6,860.65	
High Speed Diesel Oil	US Cents/MM kcal	5,607.43	7,299.73	7,425.41	7,551.10	7,676.79	7,802.47	7,928.16	8,172.03	8,415.91	8,659.78	8,903.65	9,147.53	9,284.74	9,421.95	9,559.17	9,696.38	9,833.59	9,970.80	10,108.02	10,245.23	10,382.44	10,519.66	
Natural Gas (Domestic)																								
Natural Gas (Import)	US Cents/MM kcal	2,743.00	3,570.52	3,632.00	3,693.47	3,754.95	3,816.43	3,877.91	3,997.19	4,116.48	4,235.76	4,355.05	4,474.33	4,541.45	4,608.56	4,675.68	4,742.79	4,809.91	4,877.02	4,944.14	5,011.25	5,078.37	5,145.48	
Fuel price (constant price in BD Taka)																								
Domestic Coal	Tk/MM kcal	974.01	974.01	1,021.17	1,065.05	1,110.02	1,151.70	1,193.38	1,233.96	1,273.45	1,311.84	1,350.23	1,386.43	1,422.62	1,458.82	1,493.92	1,527.92	1,561.92	1,595.93	1,627.73	1,660.64	1,692.45	1,724.26	
	Taka/Ton	5,941.46	5,941.46	6,229.14	6,496.79	6,771.10	7,025.37	7,279.61	7,527.17	7,768.03	8,002.23	8,236.38	8,457.21	8,677.99	8,898.77	9,112.89	9,320.30	9,527.71	9,735.16	9,929.16	10,129.90	10,323.94	10,517.98	
Imported Coal	Tk/MM kcal	1,011.85	1,011.85	1,070.80	1,125.65	1,181.86	1,233.96	1,286.06	1,336.80	1,386.15	1,434.14	1,482.13	1,527.38	1,572.62	1,617.86	1,661.74	1,704.24	1,746.74	1,789.25	1,829.01	1,870.14	1,909.90	1,949.66	
	Taka/Ton	5,160.45	5,160.45	5,461.09	5,740.80	6,027.49	6,293.21	6,558.93	6,817.66	7,069.36	7,314.11	7,558.85	7,789.61	8,020.34	8,251.10	8,474.87	8,691.61	8,908.39	9,125.17	9,327.93	9,537.72	9,740.48	9,943.27	
Heavy Fuel Oil (Furnace Oil)	Tk/MM kcal	2,544.92	3,312.96	3,370.01	3,427.05	3,484.09	3,541.14	3,598.18	3,708.86	3,819.54	3,930.22	4,040.90	4,151.59	4,213.86	4,276.13	4,338.41	4,400.68	4,462.95	4,525.23	4,587.51	4,649.77	4,712.05	4,774.33	
	Taka/Litre	24.29	31.63	32.17	32.71	33.26	33.80	34.35	35.40	36.46	37.52	38.57	39.63	40.23	40.82	41.41	42.01	42.60	43.20	43.79	44.39	44.98	45.58	
High Speed Diesel Oil	Tk/MM kcal	3,902.21	5,079.88	5,167.34	5,254.81	5,342.28	5,429.74	5,517.21	5,686.92	5,856.63	6,026.34	6,196.05	6,365.77	6,461.25	6,556.74	6,652.23	6,747.71	6,843.20	6,938.68	7,034.17	7,129.66	7,225.14	7,320.63	
	Taka/Litre	34.95	45.50	46.28	47.06	47.85	48.63	49.41	50.93	52.45	53.97	55.49	57.01	57.87	58.72	59.58	60.43	61.29	62.14	63.00	63.85	64.71	65.56	
Natural Gas (Domestic)	Tk/MM kcal	308.73	333.42																					
	Taka/10^3 cft	73.91	79.82																					
Natural Gas (Import)	Tk/MM kcal	1,908.85	2,484.72	2,527.51	2,570.29	2,613.07	2,655.85	2,698.64	2,781.64	2,864.66	2,947.67	3,030.68	3,113.69	3,160.40	3,207.10	3,253.81	3,300.51	3,347.22	3,393.92	3,440.63	3,487.33	3,534.04	3,580.74	
	Taka/10^3 cft	456.98	594.84	605.09	615.33	625.57	635.81	646.05	665.93	685.80	705.67	725.54	745.42	756.60	767.78	778.96	790.14	801.32	812.50	823.69	834.87	846.05	857.23	

Source: PSMP Study Team

Conversion Factor			
Coal (Domestic)	1 kg=	6100	kcal
Coal (Imported)	1 kg=	5100	kcal
Furnace Oil	1 litre=	9546	kcal
High Speed Diesel Oil	1 litre=	8956	kcal

Natural gas (MM kcal/GJ)	1MMkcal=	4.1868	GJ
	1 M cal=	8.454*10^6	cubic meter
Natural gas (GJ/MM BTU)	1MMBTU=	1.0551	GJ
Natural gas (BTU per cubic feet)	1SCF=	1029	1,000 BTU
	1 cubic	10.33994	mmcfd
BPDB	1 cubic	239.4	Kcal
BPDB	1 cubic	950	BTU

AP Table 10-2 COST for GENERATION SUMMARY (Tk million) (1/6)

Total Generation Capacoty (MW)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
New-PUBLIC	0	0	0	0	460	1,132	2,092	3,527	4,187	4,637	5,687	5,687	5,687	5,687	5,787	5,787	5,787	5,787	5,787	5,787	5,787	5,787	5,787	5,787
New-PUBLIC excl. Hydro/RE	0	0	0	0	460	1,132	2,092	3,527	4,187	4,637	5,687	5,687	5,687	5,687	5,687	5,687	5,687	5,687	5,687	5,687	5,687	5,687	5,687	5,687
New-IPP	0	0	0	0	0	400	565	1,215	3,015	4,215	6,165	6,915	6,915	7,665	7,665	7,665	7,665	7,665	7,665	7,665	7,665	7,665	6,900	6,900
New-RENTAL	0	0	0	194	1,771	1,771	1,771	1,628	1,058	1,058	51	51	51	51	51	51	51	51	51	0	0	0	0	0
New- PUBL/PRIV undeternied	0	0	0	0	0	0	0	0	0	0	0	600	2,000	2,200	2,900	3,600	4,900	6,100	6,200	8,200	10,500	12,600	16,000	17,600
New-Nuclear	0	0	0	0	0	0	0	0	0	0	0	1,000	1,000	2,000	2,000	2,000	2,000	3,000	4,000	4,000	4,000	4,000	4,000	4,000
New-Renewable	0	0	0	0	0	0	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
New-Intl Conn	0	0	0	0	0	0	500	500	500	500	500	1,000	1,000	1,000	1,500	2,250	3,250	3,250	3,500	3,500	3,500	3,500	3,500	3,500
Sub-Total for New Plants	0	0	0	194	2,231	3,303	5,039	6,981	8,871	10,521	12,514	15,364	16,764	18,714	20,014	21,464	23,764	25,964	27,314	29,263	31,563	33,663	36,298	37,898
Exist-PUBLIC	0	0	3,108	3,108	3,108	3,108	3,108	3,104	2,725	2,725	2,474	2,474	2,474	2,384	2,384	2,086	1,779	1,591	1,413	1,135	960	960	785	607
Exist-PUBLIC excl. Hydro/RE	0	0	2,878	2,878	2,878	2,878	2,878	2,874	2,495	2,495	2,244	2,244	2,244	2,154	2,154	1,856	1,549	1,361	1,183	905	730	730	555	377
Exist-IPP			0	1,271	1,271	1,271	1,271	1,271	1,271	1,271	985	985	985	985	985	985	985	985	985	985	985	625	175	175
Exist-RENTAL			0	559	559	421	421	421	421	421	421	421	421	421	421	421	421	421	0	0	0	0	0	0
Sub-Total for Existing Plants	0	0	3,108	4,938	4,938	4,800	4,800	4,796	4,417	4,417	3,880	3,880	3,880	3,790	3,790	3,492	3,185	2,997	2,398	2,120	1,945	1,585	960	782
Grand Total	0	0	3,108	5,132	7,169	8,103	9,839	11,777	13,288	14,938	16,394	19,244	20,644	22,504	23,804	24,956	26,949	28,961	29,712	31,383	33,508	35,248	37,258	38,680

2. CAPITAL COST excl. IDC (NEW plants: PUBLIC)

Capital Cost excl. IDC (Taka Million)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
New-GEN PUBLIC	0	1,677	8,050	32,112	104,545	126,013	99,115	85,185	66,730	46,584	25,143	27,091	30,411	28,066	30,988	33,954	25,146	25,143	25,143	25,143	25,143	25,143	25,143	25,143
New-GEN PUBLIC excl. Hydro/RE	0	1,677	8,050	32,112	79,402	95,025	73,972	60,042	41,587	21,441	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New-Related Facilities	0	0	0	0	25,929	63,306	106,897	124,928	140,509	133,870	124,921	77,134	60,049	68,275	106,528	83,390	41,197	51,789	83,821	70,035	23,654	22,993	20,536	19,325
New-Related Facilities excl. Fuel Devt	0	0	0	0	11,322	12,011	12,157	12,756	26,869	17,961	5,574	8,629	8,490	17,418	57,614	57,300	16,869	27,968	62,742	49,910	3,820	3,375	3,208	2,874
New-Private (IPP + RENTAL)	0	4,199	46,812	95,800	40,514	83,458	141,403	125,847	77,141	61,170	24,113	10,334	24,113	0	0	0	0	0	0	0	0	0	0	0
New-Others (PUBL/PRIV Unclassified +	0	0	0	0	0	0	0	6,681	39,249	70,147	61,921	72,095	70,154	103,480	109,326	88,595	128,665	178,909	228,193	254,421	208,554	123,536	32,151	0
Grand Total for Master Plan	0	5,877	54,862	127,913	170,988	272,777	347,416	342,640	323,628	311,770	236,098	186,654	184,727	199,821	246,843	205,938	195,009	255,841	337,157	349,599	257,351	171,672	77,829	44,468

3. O&M COST (NEW plants: PUBLIC)

O&M Cost (Taka Million)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Generation																								
O&M Fixed	0	0	0	0	411	1,922	3,468	6,216	7,279	7,640	10,500	10,598	10,696	10,794	11,110	11,279	11,310	11,475	11,502	11,600	11,698	11,796	11,895	11,993
O&M Variable	0	0	0	0	83	569	1,050	1,752	2,184	2,525	3,345	3,541	3,737	3,933	4,130	4,411	4,558	4,803	4,915	5,111	5,307	5,503	5,700	5,949
O&M Total	0	0	0	0	495	2,491	4,601	8,051	9,546	10,248	13,928	14,223	14,517	14,811	15,323	15,856	16,160	16,571	16,710	17,004	17,277	17,593	17,887	18,235
ADMIN	0	0	0	0	49	249	452	797	946	1,016	1,384	1,414	1,443	1,473	1,524	1,569	1,587	1,628	1,642	1,671	1,701	1,730	1,759	1,794
Generation excl. Hydro																								
O&M Fixed	0	0	5,554	6,884	7,073	8,475	9,922	12,572	12,971	13,234	15,590	17,814	22,412	24,726	25,152	26,875	30,844	34,755	34,508	40,862	48,272	54,745	65,497	70,466
O&M Variable	0	0	1,368	1,354	1,856	2,142	2,427	2,932	3,001	3,146	3,635	3,635	4,619	5,111	5,155	5,133	5,889	6,288	6,157	7,507	9,093	10,484	12,787	13,932
O&M Total	0	0	6,921	7,022	8,928	10,617	12,487	15,642	16,110	16,518	19,362	21,595	27,178	29,983	30,569	32,394	37,410	41,721	41,345	49,050	58,045	65,910	78,964	85,079
ADMIN	0	0	692	702	752	920	1,108	1,564	1,611	1,652	1,936	2,160	2,718	2,998	3,057	3,239	3,727	4,158	4,120	4,891	5,790	6,577	7,882	8,494
Related Facilities																								
O&M Fixed	0	0	0	0	130	281	457	1,364	1,563	2,187	2,746	3,575	4,403	5,222	6,084	6,947	10,691	11,974	13,364	14,915	19,028	19,253	18,764	18,068
O&M Variable	0	0	0	0	260	561	914	1,775	2,174	3,422	4,540	6,196	7,852	9,490	11,216	12,941	16,532	17,254	20,033	23,136	26,080	25,758	24,779	23,387
O&M Total	0	0	0	0	390	842	1,371	3,139	3,737	5,609	7,286	9,770	12,255	14,711	17,300	19,889	27,224	29,228	33,396	38,052	45,108	45,011	43,542	41,455
ADMIN	0	0	0	0	39	84	137	314	374	561	729	977	1,225	1,471	1,730	1,989	2,722	2,923	3,340	3,805	4,511	4,501	4,354	4,145
Related Facilities excl. Fuel Devt																								
O&M Fixed	0	0	0	0	23	53	81	837	872	1,318	1,670	1,710	1,749	1,786	1,823	1,858	4,957	5,602	5,676	6,261	9,759	10,216	10,128	10,000
O&M Variable	0	0	0	0	46	107	162	721	791	1,682	2,387	2,466	2,545	2,619	2,693	2,763	5,064	4,509	4,658	5,827	7,541	7,683	7,506	7,251
O&M Total	0	0	0	0	70	160	244	1,559	1,663	2,999	4,057	4,175	4,294	4,405	4,516	4,621	10,021	10,111	10,334	12,088	17,300	17,899	17,634	17,251
ADMIN	0	0	0	0	7	16	24	156	166	300	406	418	429	441	452	462	1,002	1,011	1,033	1,209	1,730	1,790	1,763	1,725
PUBL/PRIV Unclassified																								
O&M Fixed	0	0	0	0	0	0	0	0	0	0	0	2,225	6,823	9,331	9,541	11,840	16,363	20,542	20,752	27,710	35,500	41,973	53,104	58,461
O&M Variable	0	0	0	0	0	0	0	0	0	0	0	0	985	1,521	1,565	1,609	2,579	3,028	3,072	4,564	6,238	7,630	10,021	11,203
O&M Total	0	0	0	0	0	0	138	138	138	138	138	2,371	7,953	10,998	11,367	13,835	19,620	24,247	24,504	32,954	42,419	50,283	63,806	70,344
ADMIN	0	0	0	0	0	0	14	14	14	14	14	237	795	1,100	1,137	1,383	1,948	2,411	2,436	3,281	4,228	5,014	6,367	7,020
Existing Plant (Hypothetically Constructed)																								
O&M Fixed			5,554	6,884	6,662	6,651	6,651	6,651	6,085	6,085	5,678	5,678	5,678	5,483	5,483	4,836	4,348	4,014	3,627	3,024	2,644	2,644	2,264	1,877
O&M Variable			1,368	1,354	1,772	1,770	1,770	1,770	1,602	1,602	1,468	1,468	1,468	1,423	1,423	1,272	1,107	1,009	918	776	687	687	598	508
O&M Total			6,921	8,238	8,434	8,420	8,420	8,420	7,687	7,687	7,146	7,146	7,146	6,906	6,906	6,108	5,456	5,023	4,546	3,800	3,331	3,331	2,862	2,386
ADMIN			692	702	702	701	701	842	769	769	715	715	715	691	691	611	546	502	455	380	333	333	286	239

4. FUEL COST (PUBLIC Undertakings)

4-1. Fuel Cost (Coal)

A. New Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	0	0	0	0	250	250	250	850	850	850	850	850	850	850	850	850	850	850	850	850	850
Net Annual Energy Output (GWh)			0	0	0	0	0	1,647	1,647	1,632	5,360	4,699	4,610	4,560	4,658	4,788	4,341	4,239	4,404	4,352	4,354	4,204	3,989	4,041
Fuel Cost			0	0	0	0	0	4,518	4,682	4,797	15,315	13,877	14,058	14,320	15,048	15,898	14,798	14,813	15,758	15,941	16,291	16,077	15,572	16,092

Source: PSMP Study Team

AP Table 10-3 COST for GENERATION SUMMARY (Tk million) (2/6)

A-1. New Plants (PUBL/PRIV Unclassified)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	0	0	0	0	0	0	0	0	600	1,800	1,800	2,400	3,000	4,200	5,400	5,400	7,200	9,400	11,400	14,600	16,200
Net Annual Energy Output (GWh)			0	0	0	0	0	0	0	0	0	0	7,822	7,746	11,706	11,628	18,468	21,324	21,833	31,416	44,259	55,521	72,438	81,348
Fuel Cost			0	0	0	0	0	0	0	0	0	0	21,250	21,607	33,506	34,130	56,530	66,589	69,744	104,368	151,006	191,545	254,926	292,151

B. Existing Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Net Annual Energy Output (GWh)			1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,294	1,139	956	940	949	995	1,036	888	954	975	969	933	939	895	905
Fuel Cost			3,306	3,306	3,466	3,615	3,767	3,909	4,050	4,112	3,735	3,229	3,268	3,388	3,645	3,892	3,416	3,753	3,921	3,982	3,911	4,015	3,900	4,018

C. New and Existing Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			200	200	200	200	200	450	450	450	1,050	1,650	2,850	2,850	3,450	4,050	5,250	6,450	6,450	8,250	10,450	12,450	15,650	17,250
Net Annual Energy Output (GWh)			1,318	1,318	1,318	1,318	1,318	2,965	2,965	2,926	6,499	5,655	13,372	13,255	17,359	17,452	23,697	26,517	27,212	36,737	49,546	60,664	77,322	86,294
Fuel Cost			3,306	3,306	3,466	3,615	3,767	8,427	8,732	8,909	19,050	17,107	38,576	39,316	52,199	53,919	74,744	85,156	89,423	124,292	171,208	211,638	274,399	312,261

4-2. Fuel Cost (Gas)
A. New Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	0	460	512	1,402	2,437	3,097	3,547	3,998	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997	3,997
Net Annual Energy Output (GWh)			0	0	3,429	3,832	9,438	15,277	15,838	16,712	14,499	12,770	12,977	13,010	13,377	14,313	13,076	13,556	14,019	14,171	13,839	14,149	12,923	13,764
Fuel Cost			0	0	21,966	24,385	53,268	83,608	84,707	89,536	78,822	71,859	75,050	77,317	80,632	87,269	81,274	85,305	89,297	91,501	90,701	94,009	87,368	94,131

B. Existing Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			2,468	2,468	2,468	2,468	2,468	2,468	2,140	2,140	1,990	1,990	1,990	1,954	1,954	1,656	1,349	1,161	983	705	530	530	355	177
Net Annual Energy Output (GWh)			13,656	13,656	13,656	14,495	11,262	9,415	6,887	6,469	6,361	6,353	6,354	6,242	5,262	4,684	3,842	3,248	2,645	1,813	1,814	1,227	607	616
Fuel Cost			71,957	93,665	95,278	102,643	81,146	69,348	50,136	48,476	48,982	50,345	51,769	52,111	44,498	40,224	34,065	29,127	24,122	16,933	16,685	11,439	5,712	5,847

C. New and Existing Plants

Fuel Cost	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			2,468	2,468	2,928	2,980	3,870	4,905	5,237	5,687	5,988	5,987	5,987	5,951	5,951	5,653	5,346	5,158	4,980	4,702	4,527	4,527	4,352	4,174
Net Annual Energy Output (GWh)			13,656	13,656	17,085	18,327	20,700	24,692	22,725	23,181	20,860	19,123	19,331	19,252	18,639	18,997	16,918	16,804	16,664	15,984	15,653	15,376	13,530	14,380
Fuel Cost			71,957	93,665	117,244	127,027	134,415	152,956	134,843	138,013	127,805	122,204	126,818	129,428	125,131	127,493	115,339	114,432	113,419	108,433	107,386	105,448	93,080	99,978

4-3. Fuel Cost (Oil-HFO)
A. New Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	0	0	620	690	840	840	840	840	840	840	840	840	840	840	840	840	840	840	840	840	840
Net Annual Energy Output (GWh)			0	0	0	1,686	1,271	1,339	1,238	1,231	1,231	1,231	1,231	1,231	1,231	1,248	1,231	1,260	1,289	1,295	1,295	1,181	1,397	1,345
Fuel Cost			0	0	0	11,896	9,119	9,769	9,177	9,406	9,687	9,967	10,248	10,529	10,687	10,994	11,003	11,423	11,852	12,073	12,239	11,311	13,558	13,229

A-1. New Plants (PUBL/PRIV Unclassified)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	0	0	0	0	0	0	0	0	0	200	400	500	600	700	700	800	1,000	1,100	1,200	1,400	1,400
Net Annual Energy Output (GWh)			0	0	0	0	0	0	0	0	0	0	294	587	734	894	1,029	1,050	1,232	1,542	1,696	1,884	2,646	2,242
Fuel Cost			0	0	0	0	0	0	0	0	0	0	2,452	5,030	6,384	7,890	9,214	9,537	11,349	14,402	16,059	18,081	25,734	22,093

B. Existing Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			87	87	87	87	87	87	87	87	54	54	54	0	0	0	0	0	0	0	0	0	0	0
Net Annual Energy Output (GWh)			321	321	321	297	294	291	291	291	178	178	178	0	0	0	0	0	0	0	0	0	0	0
Fuel Cost			2,452	3,192	3,247	3,055	3,075	3,093	3,143	3,240	2,014	2,072	2,131	0	0	0	0	0	0	0	0	0	0	0

C. New and Existing Plants

Fuel Cost	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			87	87	87	707	777	927	927	927	894	894	1,094	1,240	1,340	1,440	1,540	1,540	1,640	1,840	1,940	2,040	2,240	2,240
Net Annual Energy Output (GWh)			321	321	321	1,983	1,565	1,630	1,529	1,522	1,409	1,409	1,703	1,818	1,965	2,142	2,260	2,310	2,521	2,837	2,991	3,065	4,043	3,587
Fuel Cost			2,452	3,192	3,247	14,951	12,193	12,862	12,320	12,646	11,700	12,040	14,831	15,559	17,071	18,885	20,217	20,961	23,200	26,475	28,298	29,392	39,292	35,323

4-4. Fuel Cost (Oil-HSD)
A. New Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Annual Energy Output (GWh)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Cost			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

B. Existing Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			123	123	123	123	123	119	68	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Annual Energy Output (GWh)			275	275	275	279	264	152	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Cost			4,188	5,452	5,546	5,556	5,503	3,220	3,310	3,412	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: PSMP Study Team

AP Table 10-4 COST for GENERATION SUMMARY (Tk million) (3/6)

C. New and Existing Plants

Fuel Cost	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			123	123	123	123	123	119	68	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Annual Energy Output (GWh)			275	275	275	279	264	152	150	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Cost			4,188	5,452	5,546	5,556	5,503	3,220	3,310	3,412	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4-5. Hydro/RE & Intl Conn Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)																								
New Plants			0	0	0	0	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100
New Plants (PUBL/PRIV Unclassified)			0	0	0	0	500	500	500	500	500	1,000	1,000	1,000	1,500	2,250	3,250	3,250	3,500	3,500	3,500	3,500	3,500	3,500
Existing Plants			230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230
Total			230	230	230	230	730	730	730	730	730	1,230	1,230	1,230	1,830	2,580	3,580	3,580	3,830	3,830	3,830	3,830	3,830	3,830
Net Annual Energy Output (GWh)																								
New Plants			0	0	0	0	0	0	0	0	0	0	0	0	333	333	333	333	333	333	333	333	333	333
New Plants (PUBL/PRIV Unclassified)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Plants			414	806	766	766	766	766	766	766	766	766	766	766	766	766	766	766	766	766	766	766	766	766
Total			414	806	766	766	766	766	766	766	766	766	766	766	1,099	1,099	1,099	1,099	1,099	1,099	1,099	1,099	1,099	1,099

4-6. Fuel Cost (Total)

A. New Plants incl. Unclassified and Hydro

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	0	460	1,132	2,092	3,527	4,187	4,637	5,688	6,287	7,687	7,887	8,687	9,387	10,687	11,887	11,987	13,987	16,287	18,387	21,787	23,387
Net Annual Energy Output (GWh)			0	0	3,429	5,518	10,709	18,263	18,723	19,575	21,090	18,700	26,934	27,134	32,039	33,204	38,478	41,762	43,110	53,109	65,776	77,272	93,726	103,073
Fuel Cost			0	0	21,966	36,281	62,387	97,895	98,566	103,739	103,823	95,704	123,058	128,804	146,257	156,181	172,818	187,668	197,999	238,286	286,297	331,023	397,159	437,696

B. Existing Plants incl. Hydro

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			3,108	3,108	3,108	3,108	3,108	3,104	2,725	2,725	2,474	2,474	2,474	2,384	2,384	2,086	1,779	1,591	1,413	1,135	960	960	785	607
Net Annual Energy Output (GWh)			15,984	16,376	16,336	17,155	13,904	11,942	9,412	8,970	8,444	8,253	8,238	7,957	7,023	6,486	5,496	4,968	4,386	3,548	3,513	2,932	2,268	2,287
Fuel Cost			81,903	105,615	107,537	114,868	93,491	79,570	60,639	59,240	54,731	55,646	57,167	55,499	48,143	44,116	37,481	32,880	28,043	20,915	20,595	15,454	9,612	9,866

C. New and Existing Plants incl. Hydro

Fuel Cost	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)	0	0	3,108	3,108	3,568	4,240	5,200	6,631	6,912	7,362	8,162	8,761	10,161	10,271	11,071	11,473	12,466	13,478	13,400	15,122	17,247	19,347	22,572	23,994
Net Annual Energy Output (GWh)	0	0	15,984	16,376	19,765	22,673	24,613	30,205	28,135	28,545	29,534	26,953	35,172	35,091	39,062	39,690	43,974	46,730	47,496	56,657	69,289	80,204	95,994	105,360
Fuel Cost			81,903	105,615	129,502	151,149	155,878	177,465	159,205	162,979	158,555	151,350	180,225	184,302	194,400	200,297	210,300	220,549	226,043	259,201	306,892	346,477	406,771	447,562

5. ELECTRICITY PURCHASE (Tk million)

A. New Private Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	194	1,771	2,171	2,947	3,454	4,684	5,884	6,827	9,077	9,077	10,827	11,327	12,077	13,077	14,077	15,327	15,276	15,276	15,276	14,511	14,511
Net Annual Energy Output (GWh)			0	1,168	5,284	6,303	8,722	11,805	20,028	26,589	32,398	40,994	40,996	50,114	54,004	60,348	63,135	69,807	79,232	79,099	78,882	78,741	75,162	76,395
Non-Fuel Cost			0	4,908	46,638	52,784	56,469	60,877	62,465	87,531	94,006	117,806	117,767	141,582	140,556	138,623	135,148	149,987	165,805	161,843	158,928	155,444	144,646	141,632
Fuel Cost			0	5,875	36,750	44,485	53,115	66,935	95,429	112,713	123,871	145,939	149,389	170,533	191,468	225,132	242,744	252,397	272,731	274,855	274,862	277,247	257,057	265,907
Total Cost			0	10.783	83.388	97.270	109.584	127.812	157.894	198.069	217.877	263.745	267.156	312.116	332.024	363.755	377.893	402.384	438.536	436.698	433.790	432.691	401.702	407.539

B. Existing Private Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	1,830	1,830	1,692	1,692	1,692	1,692	1,692	1,406	1,406	1,406	1,406	1,406	1,406	1,406	1,406	985	985	985	625	175	175
Net Annual Energy Output (GWh)			0	10,794	10,794	10,799	9,833	7,945	5,091	4,602	3,655	3,524	3,550	3,556	3,602	3,725	3,612	3,633	3,048	3,059	3,057	1,871	522	534
Non-Fuel Cost			0	16,498	17,773	15,573	15,370	15,136	14,851	14,734	10,545	10,532	10,534	10,535	10,542	10,556	10,544	10,546	8,455	8,455	8,455	6,525	2,611	2,612
Fuel Cost			0	54,833	55,777	56,609	51,502	41,916	27,857	25,869	20,416	20,325	21,047	21,660	22,267	23,309	23,013	23,461	18,511	18,838	19,085	12,331	3,579	3,710
Total Cost			0	71.331	73.550	72.182	66.873	57.052	42.708	40.603	30.961	30.858	31.581	32.195	32.809	33.864	33.557	34.007	26.965	27.294	27.540	18.856	6.190	6.322

C. New + Existing Private Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity (MW)			0	2,024	3,601	3,863	4,639	5,146	6,376	7,576	8,233	10,483	10,483	12,233	12,733	13,483	14,483	15,483	16,312	16,261	16,261	15,901	14,686	14,686
Net Annual Energy Output (GWh)			0	11,962	16,078	17,102	18,555	19,750	25,119	31,191	36,053	44,518	44,546	53,670	57,606	64,073	66,747	73,440	82,280	82,158	81,939	80,612	75,684	76,929
Non-Fuel Cost			0	21,405	64,411	68,358	71,840	76,012	77,316	102,266	104,551	128,338	128,302	152,118	151,097	149,179	145,692	160,533	174,259	170,299	167,384	161,969	147,257	144,245
Fuel Cost			0	60,708	92,527	101,094	104,617	108,852	123,286	138,582	144,287	166,265	170,435	192,193	213,735	248,440	265,757	275,859	291,242	293,693	293,946	289,578	260,636	269,616
Total Cost			0	82.114	156.938	169.452	176.456	184.864	200.602	238.672	248.838	294.603	298.737	344.311	364.833	397.619	411.449	436.392	465.501	463.992	461.330	451.547	407.893	413.861

6. EQUITY & LOAN

6-1 EQUITY & LOAN (GEN)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cap Cost before IDC	0	1,677	8,050	32,112	104,545	126,013	99,115	85,185	66,730	46,584	25,143	27,091	30,411	28,066	30,988	33,954	25,146	25,143	25,143	25,143	25,143	25,143	25,143	25,143
Cumulative Cap Cost	0	1,677	9,727	41,840	146,385	272,398	371,513	456,698	523,428	570,012	595,155	622,246	652,657	680,722	711,711	745,665	770,811	795,954	821,097	846,239	871,382	896,525	921,668	946,811
Equity	0	302	1,449	5,780	18,818	22,682	17,841	15,333	12,011	8,385	4,526	4,876	5,474	5,052	5,578	6,112	4,526	4,526	4,526	4,526	4,526	4,526	4,526	4,526
Equity (cumulative)	0	302	1,751	7,531	26,349	49,032	66,872	82,206	94,217	102,602	107,128	112,004	117,478	122,530	128,108	134,220	138,746	143,272	147,797	152,323	156,849	161,375	165,900	170,426
Dividend	0	0	0	0	229	1,067	2,055	3,517	4,310	4,872	6,156	6,428	6,699	6,975	7,352	7,686	8,053	8,325	8,596	8,868	8,698	8,969	9,113	9,385
Loan (Balance) incl. IDC	0	1,428	8,363	36,829	127,943	235,963	322,062	393,155	450,924	491,080	502,310	512,361	517,459	516,574	514,677	508,610	493,594	477,313	459,610	439,944	422,900	404,430	385,556	365,281
Donor Loan	0	1,221	7,152	30,915	107,455	199,819	273,475	334,183	383,608	417,989	427,691	436,585	441,076	440,459	438,960	433,898	421,185	407,397	392,392	375,711	361,077	345,225	329,027	311,633
Local Loan	0	207	1,211	5,914	20,488	36,143	48,587	58,972	67,316	73,092	74,619	75,776	76,382	76,115	75,717	74,712	72,409	69,917	67,217	64,232	61,823	59,206	56,529	53,649

Source: PSMP Study Team

AP Table 10-5 COST for GENERATION SUMMARY (Tk million) (4/6)

6-2 EQUITY & LOAN (GEN) excl. Hydro & Transmission

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cap Cost before IDC	0	1,677	8,050	32,112	79,402	95,025	73,972	60,042	41,587	21,441	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cumulative Cap Cost	0	1,677	9,727	41,840	121,242	216,267	290,239	350,281	391,868	413,309	413,309	413,309	413,309	413,309	413,309	413,309	413,309	413,309	413,309	413,309	413,309	413,309	413,309	413,309
Equity	0	302	1,449	5,780	14,292	17,104	13,315	10,808	7,486	3,859	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equity (cumulative)	0	302	1,751	7,531	21,824	38,928	52,243	63,051	70,536	74,396	74,396	74,396	74,396	74,396	74,396	74,396	74,396	74,396	74,396	74,396	74,396	74,396	74,396	74,396
Dividend	0	0	0	0	229	795	1,449	2,640	3,161	3,451	4,464	4,464	4,464	4,464	4,464	4,464	4,464	4,464	4,464	4,464	4,022	4,022	3,895	3,895
Loan (Balance) incl. IDC	0	1,428	8,363	36,829	106,531	188,559	253,736	303,814	340,569	359,711	351,327	341,832	325,865	307,120	286,824	261,062	235,301	209,539	183,777	158,016	136,604	115,656	95,706	75,756
Donor Loan	0	1,221	7,152	30,915	89,151	159,308	215,093	257,849	289,322	305,751	298,698	290,893	277,384	261,499	244,287	222,399	200,511	178,623	156,735	134,848	116,482	98,514	81,397	64,281
Local Loan	0	207	1,211	5,914	17,380	29,251	38,643	45,965	51,247	53,960	52,629	50,939	48,481	45,621	42,537	38,663	34,789	30,916	27,042	23,168	20,122	17,143	14,309	11,475

6-3 EQUITY & LOAN (RF)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cap Cost before IDC	0	0	0	0	25,929	63,306	106,897	124,928	140,509	133,870	124,921	77,134	60,049	68,275	106,528	83,390	41,197	51,789	83,821	70,035	23,654	22,993	20,536	19,325
Cumulative Cap Cost	0	0	0	0	25,929	89,235	196,132	321,060	461,570	595,440	720,361	797,494	857,544	925,818	1,032,347	1,115,736	1,156,934	1,208,723	1,292,544	1,362,579	1,386,233	1,409,225	1,429,761	1,449,086
Equity	0	0	0	0	4,667	11,395	19,241	22,487	25,292	24,097	22,486	13,884	10,809	12,289	19,175	15,010	7,416	9,322	15,088	12,606	4,258	4,139	3,696	3,479
Equity (cumulative)	0	0	0	0	4,667	16,062	35,304	57,791	83,083	107,179	129,665	143,549	154,358	166,647	185,822	200,833	208,248	217,570	232,658	245,264	249,522	253,661	257,357	260,836
Dividend	0	0	0	0	0	192	413	936	1,207	1,762	2,287	5,806	7,076	7,441	7,794	10,381	11,858	12,171	12,502	13,148	14,716	14,971	15,220	15,441
Loan (Balance) incl. IDC	0	0	0	0	21,672	74,841	165,798	273,672	397,724	519,043	634,582	702,696	752,861	809,133	895,462	955,525	959,033	964,872	996,256	1,015,057	977,611	931,799	814,433	841,323
Donor Loan	0	0	0	0	18,513	63,943	141,696	233,960	340,144	444,083	543,171	601,543	644,402	692,505	766,456	817,835	820,800	825,759	852,561	868,638	836,533	797,275	696,793	710,164
Local Loan	0	0	0	0	3,158	10,898	24,102	39,712	57,580	74,959	91,411	101,154	108,459	116,628	129,006	137,690	138,232	139,113	143,695	146,419	141,078	134,524	117,640	131,159

6-4 EQUITY & LOAN (RF) excl. Fuel Development

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cap Cost before IDC	0	0	0	0	11,322	12,011	12,157	12,756	26,869	17,961	5,574	8,629	8,490	17,418	57,614	57,300	16,869	27,968	62,742	49,910	3,820	3,375	3,208	2,874
Cumulative Cap Cost	0	0	0	0	11,322	23,334	35,491	48,247	75,115	93,077	98,651	107,280	115,770	133,188	190,802	248,102	264,971	292,939	355,681	405,591	409,412	412,787	415,995	418,869
Equity	0	0	0	0	2,038	2,162	2,188	2,296	4,836	3,233	1,003	1,553	1,528	3,135	10,370	10,314	3,036	5,034	11,294	8,984	688	608	577	517
Equity (cumulative)	0	0	0	0	2,038	4,200	6,388	8,684	13,521	16,754	17,757	19,310	20,839	23,974	34,344	44,658	47,695	52,729	64,023	73,006	73,694	74,302	74,879	75,396
Dividend	0	0	0	0	0	35	77	383	430	745	1,005	1,065	1,125	1,183	1,237	1,292	2,487	2,537	2,612	3,030	4,380	4,422	4,458	4,493
Loan (Balance) incl. IDC	0	0	0	0	9,463	19,760	30,434	41,095	63,818	79,025	83,504	90,320	95,645	108,288	153,119	197,990	207,072	225,510	273,378	311,001	307,445	297,157	218,584	276,785
Donor Loan	0	0	0	0	8,084	16,889	26,024	35,131	54,551	67,548	71,375	77,197	81,611	92,280	130,594	168,995	176,769	192,548	233,489	265,701	262,661	253,864	186,635	235,019
Local Loan	0	0	0	0	1,379	2,871	4,410	5,964	9,267	11,477	12,130	13,123	14,034	16,008	22,525	28,995	30,303	32,963	39,890	45,299	44,784	43,293	31,949	41,766

6-5 EQUITY & LOAN (RF) for Renewable and International Connection

6-6 EQUITY & LOAN Hypothetically Constructed for Existing Plants

Equity & Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cap Cost before IDC																								
Cumulative Cap Cost	0	107,024	100,521	94,018	87,543	81,068	74,593	68,118	62,259	56,399	51,094	45,788	40,483	35,518	30,553	26,124	22,191	18,583	15,334	12,579	10,176	7,773	5,723	4,031
Equity																								
Equity (cumulative)	0	27,845	30,639	30,611	30,611	30,611	30,611	30,611	27,735	27,735	25,514	25,514	25,514	24,291	24,291	21,700	19,307	17,769	15,975	13,509	11,746	11,746	9,982	8,188
Dividend	0	0	1,671	1,838	1,837	1,837	1,837	1,831	1,664	1,664	1,531	1,531	1,531	1,457	1,457	1,302	1,158	1,066	959	811	705	705	599	491
Loan (Balance) incl. IDC	0	79,179	75,451	70,675	65,900	61,125	56,349	50,735	45,229	39,797	34,669	29,541	24,557	19,683	14,402	9,630	5,179	3,306	2,479	2,479	2,479	2,479	2,479	0
Donor Loan	0	67,592	64,408	60,331	56,254	52,176	48,099	43,316	38,617	33,980	29,604	25,227	20,974	16,814	12,306	8,234	4,421	2,822	2,116	2,116	2,116	2,116	2,116	0
Local Loan	0	11,587	11,042	10,344	9,646	8,948	8,250	7,419	6,612	5,816	5,065	4,314	3,583	2,869	2,095	1,396	758	484	363	363	363	363	363	0

6-7 EQUITY & LOAN for UNDECIDED Undertakings

Equity & Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cap Cost before IDC	0	0	0	0	0	0	0	6,681	39,249	70,147	61,921	72,095	70,154	103,480	109,326	88,595	128,665	178,909	228,193	254,421	208,554	123,536	32,151	0
Cumulative Cap Cost	0	0	0	0	0	0	0	6,681	45,929	116,076	177,997	250,093	320,246	423,727	533,052	621,647	750,312	929,221	1,157,414	1,411,835	1,620,389	1,743,925	1,776,076	1,776,076
Equity	0	0	0	0	0	0	0	1,203	7,065	12,626	11,146	12,977	12,628	18,626	19,679	15,947	23,160	32,204	41,075	45,796	37,540	22,237	5,787	0
Equity (cumulative)	0	0	0	0	0	0	0	1,203	8,267	20,894	32,040	45,017	57,644	76,271	95,949	111,897	135,056	167,260	208,335	254,130	291,670	313,907	319,694	319,694
Dividend	0	0	0	0	0	0	0	0	0	0	0	722	2,244	2,414	3,175	3,937	5,420	6,772	6,857	9,147	11,689	13,803	17,445	19,182
Loan (Balance) incl. IDC	0	0	0	0	0	0	0	5,689	39,243	106,128	179,934	239,554	292,303	369,491	467,711	548,160	654,116	795,501	983,922	1,188,426	1,351,560	1,436,515	1,423,730	1,378,270
Donor Loan	0	0	0	0	0	0	0	4,864	33,530	90,735	153,987	205,075	250,096	316,042	400,147	469,095	559,617	680,482	841,885	1,016,814	1,155,525	1,226,339	1,212,985	1,175,720
Local Loan	0	0	0	0	0	0	0	826	5,713	15,393	25,947	34,479	42,207	53,449	67,565	79,065	94,499	115,019	142,037	171,612	196,035	210,177	210,744	202,550

9. DONOR LOAN

9-1 DONOR LOAN (GEN)

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	1,221	7,152	30,915	107,455	199,819	273,475	334,183	383,608	417,989	427,691	436,585	441,076	440,459	438,960	433,898	421,185	407,397	392,392	375,711	361,077	345,225	329,027	311,633
Interest Payment	0	0	0	0	619	2,851	5,502	9,472	11,616	13,130	16,612	17,094	17,393	17,427	17,595	17,541	17,337	16,833	16,282	15,682	15,014	14,429	13,795	13,147
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	1,032	5,926	10,477	17,377	20,951	23,475	29,347	30,544	31,741	32,956	34,633	32,586	33,805	34,150	35,346
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	1.032	6.958	17.435	34.812	55.762	79.237	108.584	139.128	170.868	203.824	238.457	271.044	304.848	338.998	374.344

9-2 DONOR LOAN (GEN) excl. Hydro

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	1,221	7,152	30,915	89,151	159,308	215,093	257,849	289,322	305,751	298,698	290,893	277,384	261,499	244,287	222,399	200,511	178,623	156,735	134,848	116,482	98,514	81,397	64,281
Interest Payment	0	0	0	0	619	2,133	3,899	7,151	8,577	9,373	12,137	11,948	11,636	11,095	10,460	9,771	8,896	8,020	7,145	6,269	5,394	4,659	3,941	3,256
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	1,032	4,729	7,805	13,509	15,885	17,212	21,888	21,888	21,888	21,888	21,888	18,366	17,968	17,116	17,116
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	1,032	5,761	13,566	27,075	42,960	60,172	82,060	103,948	125,836	147,723	169,611	187,977	205,945	223,061	240,177

Source: PSMP Study Team

AP Table 10-6 COST for GENERATION SUMMARY (Tk million) (5/6)

9-3 DONOR LOAN (RF)

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	0	0	0	18,513	63,943	141,696	233,960	340,144	444,083	543,171	601,543	644,402	692,505	766,456	817,835	820,800	825,759	852,561	868,638	836,533	797,275	696,793	710,164
Interest Payment	0	0	0	0	0	509	1,092	2,502	3,219	4,696	6,092	16,135	19,609	20,413	21,131	28,595	32,197	31,947	31,511	31,918	34,746	33,461	29,567	30,195
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	0	848	1,820	4,170	5,365	7,827	10,153	26,948	32,859	34,477	36,032	48,994	55,675	57,054	58,518
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	0	848	2,668	6,838	12,203	20,030	30,183	57,131	89,990	124,467	160,500	209,493	265,168	322,221	380,739

9-4 DONOR LOAN (RF) excl. Fuel Development

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	0	0	0	8,084	16,889	26,024	35,131	54,551	67,548	71,375	77,197	81,611	92,280	130,594	168,995	176,769	192,548	233,489	265,701	262,661	253,864	186,635	235,019
Interest Payment	0	0	0	0	0	92	203	1,041	1,165	2,006	2,702	2,855	2,999	3,084	3,149	3,160	6,244	6,186	6,183	7,155	10,628	10,506	7,831	9,789
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	0	153	339	1,735	1,941	3,344	4,503	4,769	5,032	5,288	5,526	5,768	11,207	11,428	11,759
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	0	153	492	2,227	4,168	7,512	12,015	16,784	21,815	27,103	32,629	38,398	49,605	61,033	72,792

9-5 DONOR LOAN (Pub/PRIV Unclassified)

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	0	0	0	0	0	0	4,864	33,530	90,735	153,987	205,075	250,096	316,042	400,147	469,095	559,617	680,482	841,885	1,016,814	1,155,525	1,226,339	1,212,985	1,175,720
Interest Payment	0	0	0	0	0	0	0	0	0	0	0	2,009	6,230	8,568	8,795	10,906	15,026	18,659	18,455	24,210	30,656	35,761	44,829	48,357
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	0	0	1,218	1,218	1,218	1,218	1,218	4,567	11,981	16,256	16,824	20,531	27,587	33,865	33,215
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	0	0	1,218	2,436	3,655	4,873	6,091	10,658	22,639	38,895	55,719	76,250	103,837	137,702	33,215

9-6 DONOR LOAN Hypothetically Constructed for Existing Plants

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	67,592	64,408	60,331	56,254	52,176	48,099	43,316	38,617	33,980	29,604	25,227	20,974	16,814	12,306	8,234	4,421	2,822	2,116	2,116	2,116	2,116	2,116	0
Interest Payment	0	0	2,704	2,576	2,413	2,250	2,087	1,924	1,730	1,545	1,359	1,184	1,009	793	638	469	318	177	113	85	85	85	85	85
Loan Repayment (Instalment)	0	0	3,184	4,077	4,077	4,077	4,077	4,783	4,636	4,636	4,377	4,377	4,207	4,160	4,160	3,901	3,627	1,599	705	0	0	0	0	0
Repayment (Cumulative)	0	0	3,184	7,261	11,338	15,416	19,493	24,276	28,912	33,548	37,925	42,301	46,555	50,715	55,222	59,123	62,750	64,349	65,054	65,054	65,054	65,054	65,054	65,054

10. LOCAL LOAN

10-1 LOCAL LOAN (GEN)

Local Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	207	1,211	5,914	20,488	36,143	48,587	58,972	67,316	73,092	74,619	75,776	76,382	76,115	75,717	74,712	72,409	69,917	67,217	64,232	61,823	59,206	56,529	53,649
Interest Payment	0	0	0	0	79	460	798	1,303	1,575	1,768	2,210	2,262	2,287	2,284	2,298	2,284	2,251	2,179	2,102	2,018	1,926	1,855	1,775	1,695
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	175	1,236	2,146	3,118	3,724	4,153	5,146	5,350	5,554	5,762	6,047	5,472	5,680	5,739	5,943
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	175	1,411	3,558	6,675	10,399	14,552	19,698	25,048	30,603	36,365	42,412	47,883	53,563	59,302	65,245

10-2 LOCAL LOAN (GEN) excl. Hydro & Transmission

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	207	1,211	5,914	17,380	29,251	38,643	45,965	51,247	53,960	52,629	50,939	48,481	45,621	42,537	38,663	34,789	30,916	27,042	23,168	20,122	17,143	14,309	11,475
Interest Payment	0	0	0	0	79	368	593	1,006	1,186	1,287	1,637	1,604	1,550	1,474	1,385	1,290	1,171	1,052	933	814	695	605	514	429
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	175	1,032	1,691	2,458	2,860	3,084	3,874	3,874	3,874	3,874	3,874	3,047	2,979	2,834	2,834
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	175	1,207	2,898	5,356	8,215	11,300	15,173	19,047	22,921	26,794	30,668	33,715	36,694	39,528	42,362

10-3 LOCAL LOAN (RF)

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	0	0	0	3,158	10,898	24,102	39,712	57,580	74,959	91,411	101,154	108,459	116,628	129,006	137,690	138,232	139,113	143,695	146,419	141,078	134,524	117,640	131,159
Interest Payment	0	0	0	0	0	65	140	319	411	600	778	2,039	2,477	2,585	2,682	3,607	4,065	4,035	3,981	4,033	4,393	4,232	3,742	3,823
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	0	145	310	550	754	1,333	1,729	4,540	5,535	5,811	6,076	8,222	9,355	9,590	9,839
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	0	145	455	1,005	1,758	3,091	4,820	9,360	14,895	20,706	26,783	35,005	44,359	53,949	63,788

10-4 LOCAL LOAN (RF) excl. Fuel Development

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	0	0	0	1,379	2,871	4,410	5,964	9,267	11,477	12,130	13,123	14,034	16,008	22,525	28,995	30,303	32,963	39,890	45,299	44,784	43,293	31,949	41,766
Interest Payment	0	0	0	0	0	12	26	132	148	256	344	364	382	398	411	413	804	797	796	918	1,359	1,344	1,005	1,252
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	0	26	58	134	170	568	765	810	855	899	940	981	1,902	1,939	1,996
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	0	26	84	218	388	956	1,721	2,531	3,386	4,285	5,225	6,206	8,107	10,047	12,042

10-5 LOCAL LOAN (PUB/PRIV Unclassified)

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	0	0	0	0	0	0	826	5,713	15,393	25,947	34,479	42,207	53,449	67,565	79,065	94,499	115,019	142,037	171,612	196,035	210,177	210,744	202,550
Interest Payment	0	0	0	0	0	0	0	0	0	0	0	254	789	1,085	1,114	1,381	1,903	2,363	2,337	3,066	3,881	4,528	5,675	6,245
Loan Repayment (Instalment)	0	0	0	0	0	0	0	0	0	0	0	202	202	202	202	202	767	2,020	2,742	2,839	3,465	4,656	5,716	5,812
Repayment (Cumulative)	0	0	0	0	0	0	0	0	0	0	0	202	404	607	809	1,011	1,778	3,798	6,540	9,379	12,845	17,501	23,217	29,029

10-6 LOCAL LOAN Hypothetically Constructed for Existing Plants

Donor Loan	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Balance incl.IDC	0	11,587	11,042	10,344	9,646	8,948	8,250	7,419	6,612	5,816	5,065	4,314	3,583	2,869	2,095	1,396	758	484	363	363	363	363	363	0
Interest Payment	0	0	355	339	317	296	274	253	227	202	178	155	132	102	82	60	41	23	15	11	11	11	15	15
Loan Repayment (Instalment)	0	0	545	698	698	698	698	819	796	796	751	751	722	714	714	670	622	274	121	0	0	0	0	0
Repayment (Cumulative)	0	0	545	1,243	1,941	2,639	3,337	4,168	4,964	5,760	6,511	7,263	7,993	8,707	9,481	10,151	10,773	11,047	11,168	11,168	11,168	11,168	11,168	11,168

Source: PSMP Study Team

AP Table 10-7 COST for GENERATION SUMMARY (Tk million) (6/6)

11. DEPRECIATION & RESIDUAL VALUE

11-1 DEPRECIATION & SALVAGE VALUE (GEN)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Depreciation			0	0	790	4,382	7,336	12,038	14,311	15,783	19,377	19,837	20,296	20,763	21,452	22,018	22,639	23,099	23,559	24,019	21,479	21,600	21,334	21,794
Salvage Value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,999	564	1,209	0	0
Total			0	0	790	4,382	7,336	12,038	14,311	15,783	19,377	19,837	20,296	20,763	21,452	22,018	22,639	23,099	23,559	29,017	22,043	22,809	21,334	21,794
Cum Depreciation			0	0	790	5,172	12,508	24,546	38,857	54,640	74,017	93,853	114,150	134,913	156,365	178,383	201,023	224,122	247,680	276,698	298,741	321,551	342,885	364,679

11-2 DEPRECIATION & SALVAGE VALUE (GEN) excl. Hydro & Transmission

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Depreciation			0	0	790	3,923	6,310	10,552	12,365	13,377	16,512	16,512	16,512	16,512	16,512	16,512	16,512	16,512	16,512	16,512	13,512	13,174	12,448	12,448
Salvage Value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,999	564	1,209	0	0
Total			0	0	790	3,923	6,310	10,552	12,365	13,377	16,512	16,512	16,512	16,512	16,512	16,512	16,512	16,512	16,512	21,510	14,077	14,383	12,448	12,448
Cum Depreciation			0	0	790	4,712	11,022	21,574	33,939	47,317	63,828	80,340	96,851	113,363	129,875	146,386	162,898	179,409	195,921	217,431	231,508	245,891	258,339	270,788

11-3 DEPRECIATION & SALVAGE VALUE (RF)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Depreciation			0	0	0	543	1,165	2,664	3,429	5,003	6,491	17,072	20,816	21,844	22,840	30,920	35,175	36,058	36,995	38,883	43,411	44,132	44,833	45,458
Salvage Value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			0	0	0	543	1,165	2,664	3,429	5,003	6,491	17,072	20,816	21,844	22,840	30,920	35,175	36,058	36,995	38,883	43,411	44,132	44,833	45,458
Cum Depreciation			0	0	0	543	1,708	4,372	7,800	12,803	19,294	36,366	57,181	79,026	101,865	132,786	167,961	204,019	241,014	279,897	323,308	367,440	412,272	457,730

11-4 DEPRECIATION & SALVAGE VALUE (RF) excl. Fuel Development

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Depreciation			0	0	0	98	217	1,105	1,237	2,132	2,873	3,043	3,212	3,376	3,528	3,683	7,143	7,284	7,495	8,741	12,656	12,772	12,875	12,973
Salvage Value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			0	0	0	98	217	1,105	1,237	2,132	2,873	3,043	3,212	3,376	3,528	3,683	7,143	7,284	7,495	8,741	12,656	12,772	12,875	12,973
Cum Depreciation			0	0	0	98	315	1,420	2,656	4,789	7,662	10,705	13,917	17,292	20,821	24,504	31,647	38,931	46,426	55,167	67,823	80,595	93,470	106,443

11-5 DEPRECIATION & SALVAGE VALUE (PUB/PRIV Unclassified)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Depreciation			0	0	0	0	0	0	0	0	0	0	0	2,122	7,067	8,035	10,508	12,981	17,575	21,553	22,037	29,237	36,948	43,399
Salvage Value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			0	0	0	0	0	0	0	0	0	0	0	2,122	7,067	8,035	10,508	12,981	17,575	21,553	22,037	29,237	36,948	43,399
Cum Depreciation			0	0	0	0	0	0	0	0	0	0	0	2,122	9,189	17,224	27,732	40,713	58,288	79,841	101,878	131,116	168,064	211,463

11-6 DEPRECIATION & SALVAGE VALUE Hypothetically Constructed for Existing Plants

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Depreciation			6,206	6,206	6,178	6,178	6,178	6,178	5,562	5,562	5,008	5,008	5,008	4,668	4,668	4,132	3,636	3,310	2,952	2,458	2,106	2,106	1,753	1,394
Salvage Value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			6,206	6,206	6,178	6,178	6,178	6,178	5,562	5,562	5,008	5,008	5,008	4,668	4,668	4,132	3,636	3,310	2,952	2,458	2,106	2,106	1,753	1,394
Cum Depreciation			6,206	12,411	18,589	24,767	30,945	37,122	42,684	48,247	53,255	58,263	63,271	67,939	72,607	76,739	80,374	83,685	86,636	89,094	91,200	93,306	95,058	96,453

12. Unit Generation Cost (Tk/kWh)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
New Generation Plants					7.17	8.45	7.52	7.03	7.25	7.44	7.39	8.32	7.33	7.89	7.51	7.80	7.66	7.78	7.94	7.64	7.24	7.06	6.91	6.88
Existing Plants				7.66	7.80	7.84	8.13	8.29	8.32	8.55	8.37	8.65	8.83	8.81	8.91	8.76	8.85	8.65	8.46	8.02	7.73	7.51	6.71	6.33
Electricity Purchased				6.86	9.76	9.91	9.51	9.36	7.99	7.72	6.90	6.62	6.71	6.42	6.33	6.21	6.16	5.94	5.66	5.65				
Unit Cost for Total Supply				7.30	8.59	8.84	8.63	8.42	7.97	7.96	7.53	7.55	7.36	7.27	7.08	7.04	7.06	6.91	6.70	6.67	6.63	6.57	6.44	6.44

Source: PSMP Study Team

AP Table 10-8 Unit Generation Cost for New Gen Plants (Public & Pub/Priv Unclassified) incl. Hydro & Transmission

(Taka Million)

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Fiscal Year Ending at	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Generation Capacity (MW)					0	460	1,132	2,092	3,527	4,187	4,637	5,688	6,287	7,687	7,887	8,687	9,387	10,687	11,887	11,987	13,987	16,287	18,387	21,787	23,387
Net Generation (GWh)					0	3,429	5,518	10,709	18,263	18,723	19,575	21,090	18,700	26,934	27,134	32,039	33,204	38,478	41,762	43,110	53,109	65,776	77,272	93,726	103,073
Less Transmission Loss at end of 132kV @2.5%					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Energy at end of 132kV (GWh)					0	3,429	5,518	10,709	18,263	18,723	19,575	21,090	18,700	26,934	27,134	32,039	33,204	38,478	41,762	43,110	53,109	65,776	77,272	93,726	103,073
Less Transmission Loss at end of 33kV @1.0%					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Energy at end of 33kV (GWh)					0	3,429	5,518	10,709	18,263	18,723	19,575	21,090	18,700	26,934	27,134	32,039	33,204	38,478	41,762	43,110	53,109	65,776	77,272	93,726	103,073
Fixed Cost																									
Depreciation					0	790	4,382	7,336	12,038	14,311	15,783	19,377	19,837	20,296	22,885	28,519	30,053	33,147	36,080	41,134	45,572	43,516	50,837	58,282	65,193
O & M					0	130	281	457	1,364	1,563	2,187	2,746	5,799	11,225	14,553	15,625	18,787	27,055	32,516	34,115	42,625	54,528	61,226	71,868	76,528
Administrative Overhead					0	702	752	920	1,121	1,578	1,625	1,666	1,950	2,397	3,513	4,098	4,194	4,623	5,675	6,569	6,557	8,172	10,018	11,591	14,249
Loan Interest (Donor)					0	619	2,851	5,502	9,472	11,616	13,130	16,612	19,103	23,623	25,995	26,390	28,447	32,363	35,492	34,737	39,891	45,670	50,190	58,624	61,504
Loan Interest (Local)					0	79	460	798	1,303	1,575	1,768	2,210	2,516	3,076	3,369	3,412	3,665	4,154	4,542	4,439	5,084	5,807	6,382	7,450	7,939
Dividend					0	229	1,067	2,055	3,517	4,310	4,872	6,156	7,149	8,943	9,389	10,527	11,623	13,473	15,097	15,454	18,014	20,387	22,773	26,559	28,567
Land Cost																									
Sub-Total					0	2,550	9,792	17,068	28,815	34,953	39,366	48,768	56,354	69,560	79,704	88,572	96,770	114,814	129,402	136,448	157,743	178,081	201,427	234,375	253,981
Variable Cost (Local)																									
Fuel Cost					0	21,966	36,281	62,387	97,895	98,566	103,739	103,823	95,704	123,058	128,804	146,257	156,181	172,818	187,668	197,999	238,286	286,297	331,023	397,159	437,696
Electricity Purchase																									
O & M					0	83	569	1,050	1,752	2,184	2,525	3,345	3,541	4,722	5,454	5,695	6,020	7,137	7,831	7,986	9,675	11,545	13,133	15,721	17,152
Sub-Total					0	22,049	36,850	63,437	99,647	100,750	106,264	107,168	99,245	127,779	134,258	151,952	162,201	179,955	195,499	205,985	247,961	297,842	344,156	412,880	454,848
Salvage Value																									
Land																									
Plant					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,999	564	1,209	0	0
Annual Costs					0	24,598	46,642	80,505	128,462	135,704	145,630	155,936	155,599	197,340	213,962	240,524	258,971	294,769	324,901	342,433	405,704	475,923	545,583	647,254	708,829
Total Fixed Costs					0	2,550	9,792	17,068	28,815	34,953	39,366	48,768	56,354	69,560	79,704	88,572	96,770	114,814	129,402	136,448	157,743	178,081	201,427	234,375	253,981
Total Variable Costs					0	22,049	36,850	63,437	99,647	100,750	106,264	107,168	99,245	127,779	134,258	151,952	162,201	179,955	195,499	205,985	247,961	297,842	344,156	412,880	454,848
Generation Cost																									
Fixed Cost (Tk./kW/month)					0	462	721	680	681	696	707	714	747	754	842	850	859	895	907	949	940	911	913	896	905
Fixed Cost Averaged (Tk/kW/month)	801																								
Variable Cost (Tk./kWh)					0.00	6.43	6.68	5.92	5.46	5.38	5.43	5.08	5.31	4.74	4.95	4.74	4.89	4.68	4.68	4.78	4.67	4.53	4.45	4.41	4.41
Variable Cost Averaged	5.08																								
Generation Cost per Unit																									
Fixed Cost in kWh basis					0.00	0.74	1.77	1.59	1.58	1.87	2.01	2.31	2.73	2.37	2.63	2.51	2.52	2.63	2.61	2.69	2.55	2.37	2.32	2.27	2.26
Average Fixed Cost in kWh Basis	2.43																								
Variable Cost (Tk./kWh)					0.00	6.43	6.68	5.92	5.46	5.38	5.43	5.08	5.31	4.74	4.95	4.74	4.89	4.68	4.68	4.78	4.67	4.53	4.45	4.41	4.41
Fixed & Variable Composite (Tk./kWh)					0.00	7.17	8.45	7.52	7.03	7.25	7.44	7.39	8.32	7.33	7.89	7.51	7.80	7.66	7.78	7.94	7.64	7.24	7.06	6.91	6.88
Average Fixed & Variable Composite (Tk./kWh)	7.51																								
Levelized Fixed & Variable Comp @12% (Tk./kWh)	6.91																								

Source: PSMP Study Team

note:
Capacity includes the capacity of new plants by public and unclassified undertaking including Hydro.
Net generation represents the net generated outputs by new public and unclassified undertaking plants including Hydro.
The decrease of annual output in 2018 from 2017 owes to the decrease of outputs at Chittagong South 600 MW #1, Khulna 600MWs, Chittagong 600 MWs and many other gas fired stations.
Capital cost, investment and loan are the ones for development of new generation plants and related facilities.
The surge in depreciation in 2011is due to commissioning of new gas plants of Sikalbaha, Siddrganj and Fenchganj Power Stations.
Generation cost does not take into consideration of the salvage values.
The cost at the end of transmission with exception of the wheeling charge can be obtained by deducting the transmission loss by 2.5% from the net energy generation for the end of 132kV and the by additional 1% for the end of 33kV.

AP Table 10-9 Unit Generation Cost from Existing Plants (Public) incl. Hydro & Transmission

(Taka Million)

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Fiscal Year Ending at	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Generation Capacity (MW)					3,108	3,108	3,108	3,108	3,104	2,725	2,725	2,474	2,474	2,474	2,384	2,384	2,086	1,779	1,591	1,413	1,135	960	960	785	607
Net Generation (GWh)					16,376	16,336	17,155	13,904	11,942	9,412	8,970	8,444	8,253	8,238	7,957	7,023	6,486	5,496	4,968	4,386	3,548	3,513	2,932	2,268	2,287
Less Transmission Loss at end of 132kV @2.5%					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Energy at end of 132kV (GWh)					16,376	16,336	17,155	13,904	11,942	9,412	8,970	8,444	8,253	8,238	7,957	7,023	6,486	5,496	4,968	4,386	3,548	3,513	2,932	2,268	2,287
Less Transmission Loss at end of 33kV @1.0%					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Energy at end of 33kV (GWh)					16,376	16,336	17,155	13,904	11,942	9,412	8,970	8,444	8,253	8,238	7,957	7,023	6,486	5,496	4,968	4,386	3,548	3,513	2,932	2,268	2,287
Fixed Cost																									
Depreciation					6,206	6,178	6,178	6,178	6,178	5,562	5,562	5,008	5,008	5,008	4,668	4,668	4,132	3,636	3,310	2,952	2,458	2,106	2,106	1,753	1,394
O & M					6,884	6,662	6,651	6,651	6,651	6,085	6,085	5,678	5,678	5,678	5,483	5,483	4,836	4,348	4,014	3,627	3,024	2,644	2,644	2,264	1,877
Administrative Overhead					702	702	701	701	842	769	769	715	715	715	691	691	611	546	502	455	380	333	333	286	239
Loan Interest (Donor)					2,576	2,413	2,250	2,087	1,924	1,730	1,545	1,359	1,184	1,009	793	638	469	318	177	113	85	85	85	85	85
Loan Interest (Local)					339	317	296	274	253	227	202	178	155	132	102	82	60	41	23	15	11	11	11	15	15
Dividend					1,838	1,837	1,837	1,837	1,831	1,664	1,664	1,531	1,531	1,531	1,457	1,457	1,302	1,158	1,066	959	811	705	705	599	491
Land Cost																									
Sub-Total					18,545	18,109	17,912	17,727	17,678	16,037	15,827	14,469	14,271	14,073	13,193	13,019	11,410	10,046	9,092	8,119	6,768	5,883	5,883	5,001	4,101
Variable Cost (Local)																									
Fuel Cost					105,615	107,537	114,868	93,491	79,570	60,639	59,240	54,731	55,646	57,167	55,499	48,143	44,116	37,481	32,880	28,043	20,915	20,595	15,454	9,612	9,866
Electricity Purchase																									
O & M					1,354	1,772	1,770	1,770	1,770	1,602	1,602	1,468	1,468	1,468	1,423	1,423	1,272	1,107	1,009	918	776	687	687	598	508
Sub-Total					106,969	109,309	116,638	95,260	81,339	62,241	60,842	56,199	57,114	58,635	56,922	49,566	45,388	38,589	33,889	28,962	21,691	21,282	16,141	10,210	10,374
Salvage Value																									
Land																									
Plant					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Costs					125,514	127,418	134,550	112,988	99,017	78,278	76,669	70,668	71,385	72,708	70,115	62,585	56,798	48,635	42,981	37,081	28,459	27,165	22,024	15,212	14,474
Total Fixed Costs					18,545	18,109	17,912	17,727	17,678	16,037	15,827	14,469	14,271	14,073	13,193	13,019	11,410	10,046	9,092	8,119	6,768	5,883	5,883	5,001	4,101
Total Variable Costs					106,969	109,309	116,638	95,260	81,339	62,241	60,842	56,199	57,114	58,635	56,922	49,566	45,388	38,589	33,889	28,962	21,691	21,282	16,141	10,210	10,374
Generation Cost																									
Fixed Cost (Tk./kW/month)					497	486	480	475	475	490	484	487	481	474	461	455	456	471	476	479	497	511	511	531	563
Fixed Cost Averaged (Tk/kW/month)			488																						
Variable Cost (Tk./kWh)					6.53	6.69	6.80	6.85	6.81	6.61	6.78	6.66	6.92	7.12	7.15	7.06	7.00	7.02	6.82	6.60	6.11	6.06	5.51	4.50	4.54
Variable Cost Averaged			6.48																						
Generation Cost per Unit																									
Fixed Cost in kWh basis					1.13	1.11	1.04	1.27	1.48	1.70	1.76	1.71	1.73	1.71	1.66	1.85	1.76	1.83	1.83	1.85	1.91	1.67	2.01	2.21	1.79
Average Fixed Cost in kWh Basis			1.67																						
Variable Cost (Tk./kWh)					6.53	6.69	6.80	6.85	6.81	6.61	6.78	6.66	6.92	7.12	7.15	7.06	7.00	7.02	6.82	6.60	6.11	6.06	5.51	4.50	4.54
Fixed & Variable Composite (Tk./kWh)				7.66	7.80	7.84	8.13	8.29	8.32	8.55	8.37	8.65	8.83	8.81	8.91	8.76	8.85	8.65	8.46	8.02	7.73	7.51	6.71	6.33	6.33
Average Fixed & Variable Composite (Tk./kWh)			8.15																						
Levelized Fixed & Variable Comp @12% (Tk./kWh)			8.17																						

Source: PSMP Study Team

note:
Capacity includes the capacity of existing plants by public undertaking including Hydro.
Net generation represents the net generated outputs by existing public undertaking plants including Hydro.
Generation cost does not take into consideration of the salvage values.
The cost at the end of transmission with exception of the wheeling charge can be obtained by deducting the transmission loss by 2.5% from the net energy generation for the end of 132kV and the by additional 1% for the end of 33kV.

AP Table 10-10 Unit Purchase Cost of Electricity from New & Existing Private Plants

(Taka Million)

Fiscal Year	Unit	0 2007	1 2008	2 2009	3 2010	4 2011	5 2012	6 2013	7 2014	8 2015	9 2016	10 2017	11 2018	12 2019	13 2020	14 2021	15 2022	16 2023	17 2024	18 2025	19 2026	20 2027	21 2028	22 2029	23 2030
Generation					2,024	3,601	3,863	4,639	5,146	6,376	7,576	8,233	10,483	10,483	12,233	12,733	13,483	14,483	15,483	16,312	16,261	16,261	15,901	14,686	14,686
Net Generation					11,962	16,078	17,102	18,555	19,750	25,119	31,191	36,053	44,518	44,546	53,670	57,606	64,073	66,747	73,440	82,280	82,158	81,939	80,612	75,684	76,929
Less					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Energy at					11,962	16,078	17,102	18,555	19,750	25,119	31,191	36,053	44,518	44,546	53,670	57,606	64,073	66,747	73,440	82,280	82,158	81,939	80,612	75,684	76,929
Less					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Energy at					11,962	16,078	17,102	18,555	19,750	25,119	31,191	36,053	44,518	44,546	53,670	57,606	64,073	66,747	73,440	82,280	82,158	81,939	80,612	75,684	76,929
Fixed Cost																									
O & M																									
Loan																									
Loan																									
Dividend																									
Land Cost					19,832	62,366	66,304	70,103	74,245	75,264	98,740	99,740	123,953	123,960	147,687	146,608	144,482	141,451	156,327	170,194	166,273	163,387	158,179	143,927	140,814
Sub-Total					19,832	62,366	66,304	70,103	74,245	75,264	98,740	99,740	123,953	123,960	147,687	146,608	144,482	141,451	156,327	170,194	166,273	163,387	158,179	143,927	140,814
Variable Cost																									
Fuel Cost																									
Electricity					62,281	94,572	103,148	106,354	110,620	125,338	142,108	149,098	170,650	174,776	196,624	218,225	253,137	269,998	280,064	295,307	297,719	297,943	293,368	263,966	273,047
O & M																									
Sub-Total					62,281	94,572	103,148	106,354	110,620	125,338	142,108	149,098	170,650	174,776	196,624	218,225	253,137	269,998	280,064	295,307	297,719	297,943	293,368	263,966	273,047
Salvage Value																									
Land																									
Plant					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Costs					82,114	156,938	169,452	176,456	184,864	200,602	240,848	248,838	294,603	298,737	344,311	364,833	397,619	411,449	436,392	465,501	463,992	461,330	451,547	407,893	413,861
Total Fixed					19,832	62,366	66,304	70,103	74,245	75,264	98,740	99,740	123,953	123,960	147,687	146,608	144,482	141,451	156,327	170,194	166,273	163,387	158,179	143,927	140,814
Total					62,281	94,572	103,148	106,354	110,620	125,338	142,108	149,098	170,650	174,776	196,624	218,225	253,137	269,998	280,064	295,307	297,719	297,943	293,368	263,966	273,047
Generation Cost Fixed Cost					817	1,443	1,430	1,259	1,202	984	1,086	1,010	985	985	1,006	960	893	814	841	869	852	837	829	817	799
Fixed Cost			987																						
Variable					5.21	5.88	6.03	5.73	5.60	4.99	4.56	4.14	3.83	3.92	3.66	3.79	3.95	4.05	3.81	3.59	3.62	3.64	3.64	3.49	3.55
Variable			4.32																						
Generation Cost Fixed Cost					1.66	3.88	3.88	3.78	3.76	3.00	3.17	2.77	2.78	2.78	2.75	2.55	2.25	2.12	2.13	2.07	2.02	1.99	1.96	1.90	1.83
Average			2.62																						
Variable					5.21	5.88	6.03	5.73	5.60	4.99	4.56	4.14	3.83	3.92	3.66	3.79	3.95	4.05	3.81	3.59	3.62	3.64	3.64	3.49	3.55
Fixed &					6.86	9.76	9.91	9.51	9.36	7.99	7.72	6.90	6.62	6.71	6.42	6.33	6.21	6.16	5.94	5.66	5.65	5.63	5.60	5.39	5.38
Average			6.94																						
Levelized		7.84																							

Source: PSMP Study Team

note:
Capacity includes the new and existing capacity of private undertaking including IPP and Rentals
Net generation represents the net generated outputs by new and existing private undertaking plants including IPP and Rentals
The cost at the end of transmission with exception of the wheeling charge can be obtained by deducting the transmission loss by 2.5% from the net energy generation for the end of 132kV and the by additional 1% for the end of 33kV.
Generation cost does not take into consideration of the salvage values.
The cost at the end of transmission with exception of the wheeling charge can be obtained by deducting the transmission loss by 2.5% from the net energy generation for the end of 132kV and the by additional 1% for the end of 33kV.

AP Table 10-11 Overall Unit Cost of Electricity incl. New (public & pub/priv unclassified), Related Facilities, Existing Gen Plants and Purchased Electricity (new & existing)

(Taka Million)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Fiscal Year Ending at Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Generation Capacity (MW)				5,132	7,169	8,103	9,839	11,777	13,288	14,938	16,395	19,244	20,644	22,504	23,804	24,956	26,949	28,961	29,712	31,383	33,508	35,248	37,258	38,680
Net Generation (GWh)				28,338	35,843	39,775	43,168	49,955	53,254	59,736	65,587	71,471	79,718	88,761	96,668	103,763	110,721	120,170	129,776	138,815	151,228	160,816	171,678	182,289
Less Transmission Loss at end of 132kV @2.5%				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Energy at end of 132kV (GWh)				28,338	35,843	39,775	43,168	49,955	53,254	59,736	65,587	71,471	79,718	88,761	96,668	103,763	110,721	120,170	129,776	138,815	151,228	160,816	171,678	182,289
Less Transmission Loss at end of 33kV @1.0%				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Energy at end of 33kV (GWh)				28,338	35,843	39,775	43,168	49,955	53,254	59,736	65,587	71,471	79,718	88,761	96,668	103,763	110,721	120,170	129,776	138,815	151,228	160,816	171,678	182,289
Fixed Cost																								
Depreciation				6,206	6,995	10,658	13,731	19,320	21,725	23,478	27,812	27,888	28,516	31,269	36,715	38,404	44,422	46,999	51,940	57,265	58,630	65,715	73,263	79,919
O & M				6,884	7,096	8,626	10,200	13,704	14,236	15,042	17,849	20,211	24,946	27,395	27,957	29,813	36,978	41,633	41,557	48,594	59,601	66,629	77,391	82,331
Administrative Overhead				0	56	265	490	966	1,126	1,330	1,804	2,069	2,668	3,013	3,112	3,415	4,537	5,050	5,111	6,161	7,658	8,534	9,889	10,540
Loan Interest (Donor)				2,576	3,033	5,193	7,792	12,437	14,511	16,681	20,674	23,142	27,631	29,872	30,178	32,077	38,924	41,855	41,033	47,131	56,383	60,781	66,540	71,378
Loan Interest (Local)				339	396	767	1,098	1,687	1,950	2,226	2,732	3,035	3,590	3,869	3,905	4,138	4,998	5,361	5,250	6,013	7,177	7,737	8,470	9,206
Dividend				1,838	2,066	2,938	3,969	5,731	6,404	7,281	8,692	9,745	11,599	12,030	13,222	14,217	17,119	18,701	19,024	21,855	25,472	27,899	31,616	33,551
Land Cost				19,832	62,366	66,304	70,103	74,245	75,264	98,740	99,740	123,953	123,960	147,687	146,608	144,482	141,451	156,327	170,194	166,273	163,387	158,179	143,927	140,814
Sub-Total				37,675	82,009	94,752	107,382	128,091	135,216	164,779	179,303	210,042	222,911	255,134	261,697	266,545	288,429	315,926	334,110	353,292	378,309	395,474	411,095	427,739
Variable Cost (Local)																								
Fuel Cost				105,615	129,502	151,149	155,878	177,465	159,205	162,979	158,555	151,350	180,225	184,302	194,400	200,297	210,300	220,549	226,043	259,201	306,892	346,477	406,771	447,562
Electricity Purchase				62,281	94,572	103,148	106,354	110,620	125,338	142,108	149,098	170,650	174,776	196,624	218,225	253,137	269,998	280,064	295,307	297,719	297,943	293,368	263,966	273,047
O & M				1,354	1,902	2,445	2,982	4,243	4,577	5,809	7,199	7,474	8,734	9,496	9,811	10,054	13,308	13,349	13,563	16,278	19,774	21,503	23,826	24,911
Sub-Total				169,250	225,976	256,742	265,213	292,327	289,120	310,895	314,852	329,475	363,736	390,422	422,436	463,489	493,606	513,962	534,912	573,197	624,609	661,348	694,562	745,520
Salvage Value																								
Land																								
Plant				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,999	564	1,209	0	0
Annual Costs				206,925	307,985	351,493	372,596	420,418	424,336	475,674	494,155	539,517	586,647	645,556	684,133	730,034	782,035	829,888	869,021	926,489	1,002,917	1,056,822	1,105,657	1,173,258
Total Fixed Costs				37,675	82,009	94,752	107,382	128,091	135,216	164,779	179,303	210,042	222,911	255,134	261,697	266,545	288,429	315,926	334,110	353,292	378,309	395,474	411,095	427,739
Total Variable Costs				169,250	225,976	256,742	265,213	292,327	289,120	310,895	314,852	329,475	363,736	390,422	422,436	463,489	493,606	513,962	534,912	573,197	624,609	661,348	694,562	745,520
Generation Cost																								
Fixed Cost (Tk./kW/month)				612	953	974	909	906	848	919	911	910	900	945	916	890	892	909	937	938	941	935	919	922
Fixed Cost Averaged (Tk/kW/month)		904																						
Variable Cost (Tk./kWh)				5.97	6.30	6.45	6.14	5.85	5.43	5.20	4.80	4.61	4.56	4.40	4.37	4.47	4.46	4.28	4.12	4.13	4.13	4.11	4.05	4.09
Variable Cost Averaged		4.85																						
Generation Cost per Unit																								
Fixed Cost in kWh basis				1.33	2.29	2.38	2.49	2.56	2.54	2.76	2.73	2.94	2.80	2.87	2.71	2.57	2.61	2.63	2.57	2.55	2.50	2.46	2.39	2.35
Average Fixed Cost in kWh Basis		2.52																						
Variable Cost (Tk./kWh)				5.97	6.30	6.45	6.14	5.85	5.43	5.20	4.80	4.61	4.56	4.40	4.37	4.47	4.46	4.28	4.12	4.13	4.13	4.11	4.05	4.09
Fixed & Variable Composite (Tk./kWh)				7.30	8.59	8.84	8.63	8.42	7.97	7.96	7.53	7.55	7.36	7.27	7.08	7.04	7.06	6.91	6.70	6.67	6.63	6.57	6.44	6.44
Average Fixed & Variable Composite (Tk./kWh)		7.38																						
Levelized Fixed & Variable Comp @12% (Tk./kWh)		7.83																						

Source: PSMP Study Team

note:

Capacity includes the existing and new capacity of public, private and unclassified undertaking including IPP and Rentals

Net generation represents the net generated outputs of existing and new generation plants by public, private and public undertaking including IPP and Rentals

The decrease of annual output in 2018 from 2017 owes to the decrease of outputs at Chittagong South 600 MW #1, Khulna 600MWs, Chittagong 600 MWs and many other gas fired stat

Capital cost, investment and loan includes the ones for new plants, related facilities and hypothetically constructed for the existing plants.

Generation cost does not take into consideration of the salvage values.

The cost at the end of transmission with exception of the wheeling charge can be obtained by deducting the transmission loss by 2.5% from the net energy generation for the end of 132kV and the by additional 1% for the end of 33kV.

Chapter 12 Selection of Most-prioritized Projects APPENDIX

12.1 APPENDIX –Weighing of Evaluation Items by the AHP Method

(1) Weighting for detail items

The following table shows the result of weighting for detail item by using AHP method.

APTable 12-1 Result of Evaluation by AHP Method for detail items

	Items	1	2	3	4	5	6	7	8	9	10	11	12	13	Geometric Average	Level of Importance	Point Allocation
A Fuel Security																	
1	Fuel Transportation	1	2	-	-	-	-	-	-	-	-	-	-	-	1.4142	0.6667	12.10
2	Port Facilities	1/2	1	-	-	-	-	-	-	-	-	-	-	-	0.7071	0.3333	6.05
B Feasibility Factor for Construction																	
1	Securing the Necessary Amount of Ground Space	1	2	2	1	-	-	-	-	-	-	-	-	-	1.4142	0.3333	3.03
2	Transportation of Facilities	1/2	1	1	1/2	-	-	-	-	-	-	-	-	-	0.7071	0.1667	1.52
3	History of Flood	1/2	1	1	1/2	-	-	-	-	-	-	-	-	-	0.7071	0.1667	1.52
4	Topography / Geology	1	2	2	1	-	-	-	-	-	-	-	-	-	1.4142	0.3333	3.03
C Operational Conditions																	
1	Securement of Cooling Water	1	3	-	-	-	-	-	-	-	-	-	-	-	1.7321	0.75	6.80
2	Ash Treatment	1/3	1	-	-	-	-	-	-	-	-	-	-	-	0.5774	0.25	2.30
D Economic Conditions																	
1	Distance with Existing Power System	1	2	-	-	-	-	-	-	-	-	-	-	-	1.4142	0.6667	6.07
2	Project Cost	1/2	1	-	-	-	-	-	-	-	-	-	-	-	0.7071	0.3333	3.03
E Local Demand − Supply																	
1	Advantage on Power System Viewpoint	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	9.10
F Needs of Bangladesh																	
1	Needs level of Bangladesh	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	18.15
G Donor																	
1	Plan and Priority of WB,ADB Finance	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	9.10
H Environment Influence																	
1	Air Pollution	1	1	2	2	2	2	2	1	1	1	1	2	1	1.3770	0.0998	0.91
2	Water Contamination	1	1	2	2	2	2	2	1	1	1	1	2	1	1.3770	0.0998	0.91
3	Soil Pollution	1/2	1/2	1	1	1	1	1	1/2	1/2	1/2	1/2	1	1/2	0.6885	0.0499	0.45
4	Bottom Sediment	1/2	1/2	1	1	1	1	1	1/2	1/2	1/2	1/2	1	1/2	0.6885	0.0499	0.45
5	Noise and vibration	1/2	1/2	1	1	1	2	1	1/2	1/2	1/2	1/2	1	1/2	0.7262	0.0526	0.48
6	Offensive Odor	1/2	1/2	1	1	1/2	1	1/2	1/2	1/2	1/2	1/2	1	1/2	0.6189	0.0448	0.41
7	Waste	1/2	1/2	1	1	1	2	1	1/2	1/2	1/2	1/2	1	1/2	0.7262	0.0526	0.48
8	Ground subsidence	1	1	2	2	2	2	2	1	2	1	1	2	1	1.4524	0.1053	0.96
9	Geographical feature	1	1	2	2	2	2	2	1/2	1	1/2	1/2	2	1	1.1735	0.0850	0.77
10	Biota and Ecosystem	1	1	2	2	2	2	2	1	2	1	1	2	1	1.4524	0.1053	0.96

	Items	1	2	3	4	5	6	7	8	9	10	11	12	13	Geometric Average	Level of Importance	Point Allocation
11	Water usage	1	1	2	2	2	2	2	1	2	1	1	2	1	1.4524	0.1053	0.96
12	Accidents	1/2	1/2	1	1	1	1	1	1/2	1/2	1/2	1/2	1	1/2	0.6885	0.0499	0.45
13	Global warming	1	1	2	2	2	2	2	1	1	1	1	2	1	1.3770	0.0998	0.91
I Social Issues																	
1	Involuntary resettlement	1	2	1	2	1	2	2	1	2	1	1	1	-	1.3348	0.1081	0.98
2	Local Economy such as employment and livelihood etc.	1/2	1	1	2	2	2	2	1/2	1	1	1/2	1	-	1.0595	0.0858	0.78
3	The poor, indigenous and ethnic people	1	1	1	2	2	2	2	1	1	2	2	1	-	1.4142	0.1146	1.04
4	Misdistribution of benefit and loss	1/2	1/2	0.5	1	1	2	2	1/2	1	1/2	1/2	1	-	0.7937	0.0643	0.59
5	Local conflict of interests	1	1/2	0.5	1	1	1	1	1	1	1/2	1/2	1	-	0.7937	0.0643	0.59
6	Gender	1/2	1/2	1/2	1/2	1	1	1	1	1	1/2	1/2	1	-	0.7071	0.0573	0.52
7	Children's right	1/2	1/2	1/2	1/2	1	1	1	1	1	1/2	1/2	1	-	0.7071	0.0573	0.52
8	Land use and utilization of local resources	1	2	1	2	1	1	1	1	2	1/2	1	1	-	1.1225	0.0909	0.83
9	Social institutions such as social infrastructure and local decision making institutions	1/2	1	1	1	1	1	1	1/2	1	1	1	1	-	0.8909	0.0722	0.65
10	Existing social infrastructures	1	1	1/2	2	2	2	2	2	1	1	1	1	-	1.2599	0.1021	0.93
11	Cultural heritage	1	2	1/2	2	2	2	2	1	1	1	1	1	-	1.2599	0.1021	0.93
12	Infectious diseases such as HIV/AIDS etc	1	1	1	1	1	1	1	1	1	1	1	1	-	1.0000	0.0810	0.74
Total																	100.00

Source: PSMP Study Team

(2) Summary Table of Weighting

The following table shows the weighting that is the point allocation, for major and detail item.

APTable 12-2 Summary Table of Weighting

Evaluation Item		Point Allocation for Screening	
Major Items	Detail Items	1st	2nd
Fuel Security	Fuel Transportation	18.15	12.10
	Port Facilities		6.05
Feasibility Factor for Construction	Securing the Necessary Amount of Ground Space	9.10	3.03
	Transportation of Facilities		1.52
	History of Flood		1.52
	Topography / Geology		3.03
Operational Conditions	Securement of Cooling Water	9.10	6.80
	Ash Treatment		2.30
Economic Conditions	Distance with Existing Power System	9.10	6.07
	Project Cost		3.03
Local Demand-Supply	Advantage on Power System Viewpoint	9.10	9.1
Needs of Bangladesh	Needs Level of Bangladesh	18.15	18.15
Donor	Plan and Priority of WB,ADB Finance	9.10	9.10
Environment Influence	Air Pollution	9.10	0.91
	Water Contamination		0.91
	Soil Pollution		0.45
	Bottom Sediment		0.45
	Noise and Vibration		0.48
	Offensive Odor		0.41
	Waste		0.48
	Ground Subsidence		0.96
	Geographical Feature		0.77
	Biota and Ecosystem		0.96
	Water Usage		0.96
	Accidents		0.45
	Global Warming		0.91
Social Issues	Involuntary resettlement	9.10	0.98
	Local Economy such as employment and livelihood etc.		0.78
	The poor, indigenous and ethnic people		1.04
	Misdistribution of benefit and loss		0.59
	Local conflict of interests		0.59
	Gender		0.52
	Children's right		0.52
	Land use and utilization of local resources		0.83
	Social institutions such as social infrastructure and local decision making institutions		0.65
	Existing social infrastructures		0.93
	Cultural heritage		0.93
	Infectious diseases such as HIV/AIDS etc		0.74
Total		100.00	100.00

Source: PSMP Study Team

(3) Evaluation method of each evaluation item

The evaluation method of each evaluation item is shown on the following table.

APTable 12-3 Concept of Evaluation

Items				View of Evaluation
	Major Items		Minor Items	
A	Fuel Security	1	Fuel Transportation	In general, a coal-fired power station using domestic coal should be located near coal mines in light of fuel transportation costs. In case it is difficult to select a place and a selected location ends up being far in distance from the coal mine, the problem regarding secure stable fuel supply transportation with reduced cost potentially utilizing existing infrastructure and the ingenious application of the new infrastructure should be the focal points to be studied
		2	Port Facility	In the most cases, coal will be imported by coal ships, so the development of coal-fired power plants should include the development of port facilities. In light of this, it is preferable for power stations to be located seaside. Given that coal transportation via big ships does reduce transportation costs, their utilization and related factors such as depth, sea conditions etcetera should be taken into consideration.
B	Feasibility Factor for Construction	1	Securing the Necessary Amount of Ground Space	The ground space for power plant construction should have an enough area for the installed facilities to function normally. For example, in installing two 600MW coal-fired power plant facilities, 140,000 m2 are needed for generation facilities, 15,000 m2 for water treatment facilities, and 100,000 m2 for a coal storage yard should be acquired. Therefore, the securement of such ground space is an absolute candidate site prerequisite.
		2	Transportation of Facilities	In the construction of a power plant, a variety of mechanical facilities will need to be transported to the site. In the majority of cases, large-size facilities will be dismantled into smaller parts prior for transport. However some facilities will contain big parts that will not be able to be broken down any further. For example, in the case of 600MW facilities, the size of a main-transformer is 14m x 13m x 10m and the weight is 320 t; and, the stator of generator is 15m x 7m x 5m and the weight is 400 t. Most of these facilities are imported by ship. So if the site is not at a seaside location (domestic coal power plant), the transportation from the point of unloading to the site should be needed and whether such a route can be secured or not is an essential point that needs to be evaluated.

Items				View of Evaluation
	Major Items		Minor Items	
		3	History of Flood	Bangladesh has many experiences of flood disaster because almost part of the country is morass. The site selected for the power station should not be an area vulnerable to floods. Hence, after investigating the record of past flood disasters, the selection of a site possessing a low probability of flood disaster are imperative.
		4	Topography / Geology	Flat ground should be considered ideal for power plant construction, Even if there are some instances of power plants being constructed on cliffs in Japan, at the least, flat ground should be required for the main facilities. In addition, stable ground is necessary for stable power plant operations. These points are absolute prerequisites in selecting a site.
C	Operational Conditions	1	Securement of Cooling Water	Water is also necessary for the operation of thermal power plants. Water includes plant usage water which is used and consumed by the power generation facility, and cooling water for the condenser and cooler. The flow rate of cooling water is about 30 t/s for 1 x 600MW facility. In case of adoption of the closed cycle type, there is no need for such a large amount of water but 1-2 t/s will be needed for make up and other use. Therefore, the possibility in being able to secure such an amount of water should be one of the conditions.
		2	Ash Treatment	Coal ash is generated by burning coal with the amount of ash generally total 10 to 20% of the coal amount. This amount changes according to the type of coal. The amount of ash generation by a 1 x 600MW coal fired power plant is about 150,000 to 200,000 t/year. The possibility in being able to treat such an amount of ash over a long period of time should be a point of consideration in site selection.
D	Economic Conditions	1	Distance with Existing Power System	In selecting an appropriate site, another important point from an economic point of view is the distance between the power station and the existing grid because there is a direct correlation between this distance and the interconnection cost.
		2	Project Cost	The project cost levels substantially impact the economical analysis.
E	Local Demand-Supply	1	Advantage on Power System Viewpoint	After evaluating not only to shorten the distance of power emission line but also the necessity to reinforce emission line in order to stabilize grid, to evaluate whether there is advantage on power system viewpoint.
F	Needs of Bangladesh	1	Needs Level of Bangladesh	It is important to correspond to the status of the study and pick up on actual needs according to its national plan or policy.

Items				View of Evaluation
	Major Items		Minor Items	
G	Donor	1	Plan and Priority of WB,ADB Finance	At the time of building generation and power system facility in Bangladesh, it is necessary to cooperate with donor such as ADB or WB. So to evaluate the matching with their advantage of development or plan etc.
H	Environment Influence	1	Air Pollution	Evaluation for i) the amount of exhaust gas originating from the use of heavy equipment such as bulldozers, cranes, pile drivers and dump trucks; ii) the amount of dust from land reclamation, development, and road construction etc, and; iii) actual air emissions such as SOx, NOx, and PM by operating existing thermal plants.
		2	Water Contamination	Evaluation for water contamination caused by oil leakage from heavy equipment, dumping of construction wastes and sewages from camp into river/groundwater during construction of power plant / coal-mine / substation, etc.
		3	Soil Pollution	Evaluation for soil pollution caused by oil leakage during construction period and fuel oil leakage during operations, effluence of wastewater including untreated toxic heavy metal.
		4	Bottom Sediment	Evaluation for bottom sediment caused by precipitation of pollutant in wastewater during construction and operation.
		5	Noise and vibration	Evaluation for noise and vibration caused by the operation of construction equipment (especially pile drivers) during construction, and that observed in the boundary area of the power plant site during operation.
		6	Offensive Odor	Evaluation for offensive odor corresponding to the degree of air pollution.
		7	Waste	Evaluation for construction wastes such as coal ash created during operation.
		8	Ground subsidence	Evaluation for distribution pattern of soft clay layer that may cause sink age due to its heavy weight. Draw up recommendations on proper fundamental structure design.
		9	Geographical feature	Evaluation for topographical and/or geological losses of academic and social values.
		10	Biota and Ecosystem	Evaluation for biota and the ecosystem caused by land reclamation and building transmission lines.
		11	Water usage	Evaluation for water usage around the project site and downstream.
		12	Accidents	Evaluation from a safety perspective.
		13	Global warming	Evaluation for greenhouse gas emission.
I	Social Issues	1	Involuntary resettlement	Check if there is any large-scale land acquisition and thus involuntary resettlement anticipated in the proposed site (both permanently and temporarily). Basic principle is to avoid or minimize such adverse impacts. When

Items				View of Evaluation
	Major Items		Minor Items	
				unavoidable, appropriate measures such as compensation should be considered which is deemed appropriate from international and national perspective.
		2	Local Economy such as employment and livelihood etc.	Identify potential loss of agricultural land and that of job opportunities for local people (both permanently and temporarily) caused by the future projects. Identify critical gaps between relevant laws and regulations of Bangladesh and JICA Guidelines for Environmental and Social Considerations to examine suitable livelihood restoration and improvement plan for them including compensation.
		3	The poor, indigenous and ethnic people	Identify appropriate livelihood restoration and improvement plans for vulnerable people such as the destitute, poor, and indigenous people, landless farmers, etc.
		4	Misdistribution of benefit and loss	Identify potential and appropriate ways of equal distribution of project benefits, mitigation measures for damages and losses caused to local people.
		5	Local conflict of interests	Identify appropriate ways of engaging in dialogs and cooperation between relocated communities and host communities when involuntary resettlement is unavoidable.
		6	Gender	Identify women's life styles that are socially vulnerable. Examine possible ways of securing their rights and plans to enhance the quality of life.
		7	Children's right	Minimize adverse impacts on children caused by possible socio-economic changes into their society due to the project implementation, and secure their rights.
		8	Land use and utilization of local resources	Identify relevant laws and regulations in Bangladesh regarding land use and local resources utilization to compare with requirements of JICA Guidelines to examine compensation and other appropriate measures.
		9	Social institutions such as social infrastructure and local decision making institutions	Involve all local stakeholders not only Project Affected People (PAPs), but local governments, universities, NGOs and religious organizations who can influence decision-makings.
		10	Existing social infrastructures	Identify possible losses from present land /infrastructure system (both temporarily and permanently) and examine alternatives.
		11	Cultural heritage	Identify potential effects on and losses of heritages and/or tradition, or landscape blockades at the proposed sites to examine alternatives. Examine potential alternate transmission routes when present ones become

Items				View of Evaluation
	Major Items		Minor Items	
				an obstacle for worshipers and tourists to appreciate the country's cultural heritage.
		12	Infectious diseases such as HIV/AIDS etc	Identify possibility of HIV/AIDS infection among people related to project implementation (such as construction workers). And look into prevention measures.

Source: PSMP Study Team

12.2 APPENDIX – 2 1st Screening

12.2.1 Fuel Security

For Barapukuria, as there is an existing coal mine and power station in operation, it could be a candidate site. Current situation of coal production and usage and the forecast of future development would be the key point for new site.

The other 3 sites (Khalaspir, Dighipara, and Phulbari) hopeful to produce coal in the near future, so the judgment for possibility would be done after investigation about current progress of development.

On the other hand, mining deep mines such as Jamalgonj, Kuchima posed serious technical difficulties resulting in zero developmental progress and a low evaluation result.

About the candidate site of import coal power plant, it is needed for Bheramara site to transport fuel as it located inner area. All of the other sites locate sea side. Chittagong, Mongla, and Matarbari as candidates for Deep Sea Ports are easy to secure imported coal from via the maintenance of port facilities. Meghnaghat, Zajira, Maowa located near the river side so that the establishment of coal transportation routes by internal ships is possible.

Bheramara and Chandpur have been deemed as difficulty to secure coal because the plan for the construction of gas-fired power plant is proceeding.

Based on the above point of view, the result of the evaluation via the AHP method is as follows,

APTable 12-4 Evaluation for Fuel Security (AHP Method)

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1	1/2	1	5	5	5	1/2	1	1/2	1/2	1/2	1/2	1/2	2	1/2	0.9985	0.0516
2	Phulbari	1	1	1/2	1	5	5	5	1/2	1	1/2	1/2	1/2	1/2	1/2	2	1/2	0.9985	0.0516
3	Khalaspir	2	2	1	2	5	5	5	1	2	1	1	1	1	1	3	1	1.7224	0.0890
4	Dighipara	1	1	1/2	1	5	5	5	1/2	1	1/2	1/2	1/2	1/2	1/2	2	1/2	0.9985	0.0516
5	Jamalgonj	1/5	1/5	1/5	1/5	1	1	1	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1/3	1/5	0.2792	0.0144
6	Kuchima	1/5	1/5	1/5	1/5	1	1	1	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1/3	1/5	0.2792	0.0144
7	Bheramara	1/5	1/5	1/5	1/5	1	1	1	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1/3	1/5	0.2792	0.0144
8	Chittagong	2	2	1	2	5	5	5	1	2	1	1	1	1	1	4	1	1.7537	0.0906
9	Cox's Bazar	1	1	1/2	1	5	5	5	1/2	1	1/2	1/2	1/2	1/2	1/2	3	1/2	1.0241	0.0529
10	Mongla	2	2	1	2	5	5	5	1	2	1	1	1	1	1	4	1	1.7537	0.0906
11	Khulna	2	2	1	2	5	5	5	1	2	1	1	1	1	1	4	1	1.7537	0.0906
12	Meghnaghat	2	2	1	2	5	5	5	1	2	1	1	1	1	1	4	1	1.7537	0.0906
13	Zajira	2	2	1	2	5	5	5	1	2	1	1	1	1	1	4	1	1.7537	0.0906
14	Maowa	2	2	1	2	5	5	5	1	2	1	1	1	1	1	4	1	1.7537	0.0906
15	Chandpur	1/2	1/2	1/3	1/2	3	3	3	1/4	1/3	1/4	1/4	1/4	1/4	1/4	1	1/3	0.5221	0.0270
16	Matarbari	2	2	1	2	5	5	5	1	2	1	1	1	1	1	3	1	1.7224	0.0890

Source: PSMP Study Team

12.2.2 Feasibility Factor for Construction

In case of Bheramara and Chandpur, new gas fired power plant is planning to be constructed, so the feasibility for coal fired plant is not so high...

For Barapukuria, Khalaspir, Dighipara, Phulbari at inner area, the study regarding the transportation of equipment is needed.

Based on the above point of view, the results of the evaluation via the AHP method is as follows,

APTable 12-5 Evaluation for Feasibility Factor for Construction (AHP Method)

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1	1	1	1	1	5	2	2	2	2	2	2	2	5	2	1.7294	0.0939
2	Phulbari	1	1	1	1	1	1	5	2	2	2	2	2	2	2	5	2	1.7294	0.0939
3	Khalaspir	1	1	1	1	1	1	5	2	2	2	2	2	2	2	5	2	1.7294	0.0939
4	Dighipara	1	1	1	1	1	1	5	2	2	2	2	2	2	2	5	2	1.7294	0.0939
5	Jamalgonj	1	1	1	1	1	1	5	2	2	2	2	2	2	2	5	2	1.7294	0.0939
6	Kuchima	1	1	1	1	1	1	5	2	2	2	2	2	2	2	5	2	1.7294	0.0939
7	Bheramara	1/5	1/5	1/5	1/5	1/5	1/5	1	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1/5	0.2212	0.0120
8	Chittagong	1/2	1/2	1/2	1/2	1/2	1/2	5	1	1	1	1	1	1	1	5	1	0.9429	0.0512
9	Cox's Bazar	1/2	1/2	1/2	1/2	1/2	1/2	5	1	1	1	1	1	1	1	5	1	0.9429	0.0512
10	Mongla	1/2	1/2	1/2	1/2	1/2	1/2	5	1	1	1	1	1	1	1	5	1	0.9429	0.0512
11	Khulna	1/2	1/2	1/2	1/2	1/2	1/2	5	1	1	1	1	1	1	1	5	1	0.9429	0.0512
12	Meghnaghat	1/2	1/2	1/2	1/2	1/2	1/2	5	1	1	1	1	1	1	1	5	1	0.9429	0.0512
13	Zajira	1/2	1/2	1/2	1/2	1/2	1/2	5	1	1	1	1	1	1	1	5	1	0.9429	0.0512
14	Maowa	1/2	1/2	1/2	1/2	1/2	1/2	5	1	1	1	1	1	1	1	5	1	0.9429	0.0512
15	Chandpur	1/5	1/5	1/5	1/5	1/5	1/5	5	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1	1/5	0.2704	0.0147
16	Matarbari	1/2	1/2	1/2	1/2	1/2	1/2	5	1	1	1	1	1	1	1	5	1	0.9429	0.0512

Source: PSMP Study Team

12.2.3 Operating Conditions

In general, it is difficult to secure water at the inner area and the usage of well water is needed in case there is no river around the site. On the contrary, water inlet from river or sea can be acceptable for secure water.

Regarding ash treatment, all of candidate site has enough area; major problem would not be arising for the time being.

Based on the above point of view, the results of the evaluation via the AHP method is as follows,

APTable 12-6 Evaluation for Operating Conditions (AHP Method)

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1/2	1/2	1/2	1/2	1/2	1	1/3	1/3	1/3	1/3	1/3	1/3	1/3	1/3	1/3	0.4341	0.0250
2	Phulbari	2	1	1	1	1	1	2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	0.7384	0.0425
3	Khalaspir	2	1	1	1	1	1	2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	0.7384	0.0425
4	Dighipara	2	1	1	1	1	1	2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	0.7384	0.0425
5	Jamalgonj	2	1	1	1	1	1	2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	0.7384	0.0425
6	Kuchima	2	1	1	1	1	1	2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	0.7384	0.0425
7	Bheramara	1	1/2	1/2	1/2	1/2	1/2	1	1/3	1/3	1/3	1/3	1/3	1/3	1/3	1/3	1/3	0.4341	0.0250
8	Chittagong	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820
9	Cox's Bazar	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820
10	Mongla	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820
11	Khulna	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820
12	Meghnaghat	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820
13	Zajira	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820
14	Maowa	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820
15	Chandpur	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820
16	Matarbari	3	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1.4247	0.0820

Source: PSMP Study Team

12.2.4 Economic Conditions

Basically all of candidate sites could connect to existing power grid easily. For other points, no material differences have been discerned at the 1st screening. So the result of the AHP method is as follows.

APTable 12-7 Evaluation for Economic Conditions

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
2	Phulbari	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
3	Khalaspir	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
4	Dighipara	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
5	Jamalgonj	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
6	Kuchima	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
7	Bheramara	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
8	Chittagong	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
9	Cox's Bazar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
10	Mongla	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
11	Khulna	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
12	Meghnaghat	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
13	Zajira	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
14	Maowa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
15	Chandpur	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625
16	Matarbari	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0000	0.0625

Source: PSMP Study Team

12.2.5 Local Demand and Supply

In terms of ideal power plant characteristics, it is best for a plant to be located near the point of demand as much as possible. This is because the length of the transmission line from the power plant can be shortened but also the transmission line expansion necessary for stabilizing the power system can be minimized in case of utilization of a long-distance transmission line. It is necessary to study the aforementioned ideal power supply arrangement maintaining the regional imbalances between power supply as much as possible utilizing not only the overall power demand but also regional power demand.

At the first screening, an evaluation was carried out to narrow down the sixteen (16) potential sites nominated from a long list to the mid list as follows, based on the evaluation criteria shown in APTable 12-8. The results of the evaluation are shown as follows.

APTable 12-8 Evaluation Criteria

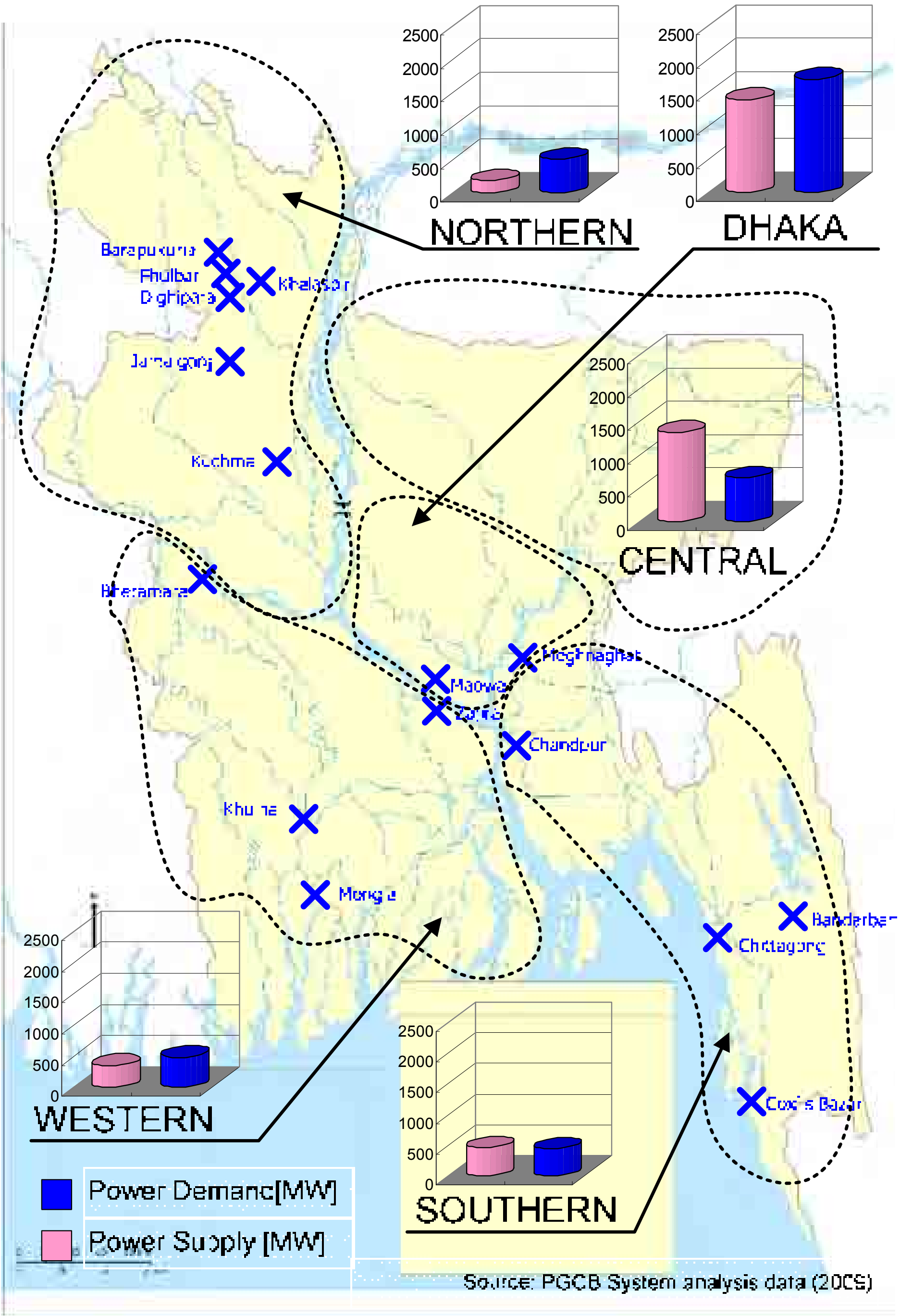
Score	Demand / Supply
5	≥1.5
4	1.2 – 1.49
3	0.75 – 1.19
2	0.5 – 0.74
1	<0.5

APTable 12-9 Result of 1st Screening (Local Demand and Supply) [1]

Region	Power suppl y (MW)	Power dema nd (MW)	Power demand supply	Score	Potential site for coal power development
Souther n	463	440	0.95	3	Chittagong, Cox's Bazar, Chandpur, Bandarban
Dhaka	1393	1700	1.22	4	Meghnaghat, Maowa
Central	1342	659	0.49	1	
Wester n	353	484	1.37	4	Khulna, Zajira, Bheramara, Mongla
Norther n	189	505	2.68	5	Barapukuria, Phulbari, Khalaspir, Dighipara, Jamalgonji, Kuchma

Source: PGCB CENTRAL LOAD DESPATCH CENTER "Daily Report"

[1] The Figs of power supply and power demand including the load shedding are those based on 21:00 data at the end of FY 2009



Source: PGCB CENTRAL LOAD DESPATCH CENTER "Daily Report"

APFig. 12-1 Regional imbalances between power supply & demand and Potential site for coal power development (long list) [1]

[1] The Figs of power supply and power demand including the load shedding are those based on 21:00 data at the end of FY 2009.

For this item, a quantitative evaluation was already conducted. However, AHP method has been used for total evaluation. The results via AHP method was conducted as a matter of convenience as follows,

APTable 12-10 Evaluation for Local Demand and Supply

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1	1	1	1	1	2	3	3	2	2	2	2	2	3	3	1.7067	0.0960
2	Phulbari	1	1	1	1	1	1	2	3	3	2	2	2	2	2	3	3	1.7067	0.0960
3	Khalaspir	1	1	1	1	1	1	2	3	3	2	2	2	2	2	3	3	1.7067	0.0960
4	Dighipara	1	1	1	1	1	1	2	3	3	2	2	2	2	2	3	3	1.7067	0.0960
5	Jamalgonj	1	1	1	1	1	1	2	3	3	2	2	2	2	2	3	3	1.7067	0.0960
6	Kuchima	1	1	1	1	1	1	2	3	3	2	2	2	2	2	3	3	1.7067	0.0960
7	Bheramara	1/2	1/2	1/2	1/2	1/2	1/2	1	2	2	1	1	1	1	1	2	2	0.9170	0.0516
8	Chittagong	1/3	1/3	1/3	1/3	1/3	1/3	1/2	1	1	1/2	1/2	1/2	1/2	1/2	1	1	0.5107	0.0287
9	Cox's Bazar	1/3	1/3	1/3	1/3	1/3	1/3	1/2	1	1	1/2	1/2	1/2	1/2	1/2	1	1	0.5107	0.0287
10	Mongla	1/2	1/2	1/2	1/2	1/2	1/2	1	2	2	1	1	1	1	1	2	2	0.9170	0.0516
11	Khulna	1/2	1/2	1/2	1/2	1/2	1/2	1	2	2	1	1	1	1	1	2	2	0.9170	0.0516
12	Meghnaghat	1/2	1/2	1/2	1/2	1/2	1/2	1	2	2	1	1	1	1	1	2	2	0.9170	0.0516
13	Zajira	1/2	1/2	1/2	1/2	1/2	1/2	1	2	2	1	1	1	1	1	2	2	0.9170	0.0516
14	Maowa	1/2	1/2	1/2	1/2	1/2	1/2	1	2	2	1	1	1	1	1	2	2	0.9170	0.0516
15	Chandpur	1/3	1/3	1/3	1/3	1/3	1/3	1/2	1	1	1/2	1/2	1/2	1/2	1/2	1	1	0.5107	0.0287
16	Matarbari	1/3	1/3	1/3	1/3	1/3	1/3	1/2	1	1	1/2	1/2	1/2	1/2	1/2	1	1	0.5107	0.0287

Source: PSMP Study Team

12.2.6 Needs of Bangladesh

Through discussion with CP until the 1st screening, the priority of coal imports at port such as Chittagong, the possibility of the development of domestic coal and the development of river side sites such as Meghnaghat, Zajira, Maowa are high. Based on this information, the result of the AHP method is as follows,

APTable 12-11 Evaluation for Needs of Bangladesh

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1	1	1	5	5	3	1/2	3	1	1/2	1/2	1	1	5	1	1.3622	0.0696
2	Phulbari	1	1	1	1	5	5	3	1/2	3	1	1/2	1/2	1	1	5	1	1.3622	0.0696
3	Khalaspir	1	1	1	1	5	5	3	1/2	3	1	1/2	1/2	1	1	5	1	1.3622	0.0696
4	Dighipara	1	1	1	1	5	5	3	1/2	3	1	1/2	1/2	1	1	5	1	1.3622	0.0696
5	Jamalgonj	1/5	1/5	1/5	1/5	1	1	1	1/5	1	1/4	1/5	1/5	1/3	1/3	1	1/3	0.3691	0.0188
6	Kuchima	1/5	1/5	1/5	1/5	1	1	1	1/5	1	1/4	1/5	1/5	1/3	1/3	1	1/3	0.3691	0.0188
7	Bheramara	1/3	1/3	1/3	1/3	1	1	1	1/5	1	1/4	1/5	1/5	1/3	1/3	1	1/3	0.4193	0.0214
8	Chittagong	2	2	2	2	5	5	5	1	3	3	1	1	2	2	5	3	2.3828	0.1217
9	Cox's Bazar	1/3	1/3	1/3	1/3	1	1	1	1/3	1	1/3	1/5	1/5	1/3	1/3	2	1/3	0.4603	0.0235
10	Mongla	1	1	1	1	4	4	4	1/3	3	1	1/2	1/2	1	1	3	1	1.2737	0.0650
11	Khulna	2	2	2	2	5	5	5	1	5	2	1	1	2	2	5	4	2.4421	0.1247
12	Meghnaghat	2	2	2	2	5	5	5	1	5	2	1	1	3	3	5	3	2.5232	0.1288
13	Zajira	1	1	1	1	3	3	3	1/2	3	1	1/2	1/3	1	1	3	2	1.2603	0.0643
14	Maowa	1	1	1	1	3	3	3	1/2	3	1	1/2	1/3	1	1	3	2	1.2603	0.0643
15	Chandpur	1/5	1/5	1/5	1/5	1	1	1	1/5	1/2	1/3	1/5	1/5	1/3	1/3	1	1/2	0.3691	0.0188
16	Matarbari	1	1	1	1	3	3	3	1/3	3	1	1/4	1/3	1/2	1/2	2	1	1.0074	0.0514

Source: PSMP Study Team

12.2.7 Donor

According to the presentation held on Sep. 2009 by ADB, Chittagong、Khulna、Meghnaghat and Zajira were mentioned as candidate sites. That means at least ADB, one of the donors, has determined them as prioritized sites. Based on it, the results of the AHP method is as follows,

APTable 12-12 Evaluation for Donor

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
2	Phulbari	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
3	Khalaspir	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
4	Dighipara	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
5	Jamalgonj	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
6	Kuchima	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
7	Bheramara	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
8	Chittagong	3	3	3	3	3	3	3	1	3	3	1	1	1	3	3	3	2.2795	0.1250
9	Cox's Bazar	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
10	Mongla	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
11	Khulna	3	3	3	3	3	3	3	1	3	3	1	1	1	3	3	3	2.2795	0.1250
12	Meghnaghat	3	3	3	3	3	3	3	1	3	3	1	1	1	3	3	3	2.2795	0.1250
13	Zajira	3	3	3	3	3	3	3	1	3	3	1	1	1	3	3	3	2.2795	0.1250
14	Maowa	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
15	Chandpur	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417
16	Matarbari	1	1	1	1	1	1	1	1/3	1	1	1/3	1/3	1/3	1	1	1	0.7598	0.0417

Source: PSMP Study Team

12.2.8 Environment Influence

As for the environment influence side, the potential impact to the neighboring area has been considered. On the stage of the 1st screening, Chittagong is a priority because of existing international ports. Mongla is also an existing international port but there is an environmental protected area so that the point is low. Cox's Bazar is also not good for development because it is a resort area with a long beach.

Based on it, the results of the AHP method is as follows,

APTable 12-13 Evaluation for Environment Influence

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
2	Phulbari	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
3	Khalaspir	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
4	Dighipara	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
5	Jamalgonj	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
6	Kuchima	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
7	Bheramara	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
8	Chittagong	2	2	2	2	2	2	2	1	3	3	2	2	2	2	2	2	2.0148	0.1210
9	Cox's Bazar	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/3	1	1	1/2	1/2	1/2	1/2	1/2	1/2	0.5316	0.0319
10	Mongla	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/3	1	1	1/2	1/2	1/2	1/2	1/2	1/2	0.5316	0.0319
11	Khulna	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
12	Meghnaghat	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
13	Zajira	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
14	Maowa	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
15	Chandpur	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627
16	Matarbari	1	1	1	1	1	1	1	1/2	2	2	1	1	1	1	1	1	1.0443	0.0627

Source: PSMP Study Team

12.2.9 Social Issues

As for the social issues side, the influence of the neighboring society via power plant construction is being considered. On the stage of the 1st screening, Phulbari has a low estimation because the neighborhood is already moving against coal mine development. Jamalgonj and Kuchima also have a low estimation because they have almost no possibility to develop coal mines. Further, the influence for the local industry is a little stronger in the case of Maowa than the other sites.

Based on it, the results of the AHP method are as follows,

APTable 12-14 Evaluation for Social Issues

No.	Site Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Geometric Average	Level of Importance
1	Barapukuria	1	1	1/2	1/2	1	1	1/2	1/5	1/3	1/2	1/3	1/2	1/2	1	1/2	1/2	0.5574	0.0306
2	Phulbari	1	1	1/2	1/2	1	1	1/2	1/5	1/3	1/2	1/3	1/2	1/2	1	1/2	1/2	0.5574	0.0306
3	Khalaspir	2	2	1	1	2	2	1	1/3	1/2	1	1/2	1	1	2	1	1	1.0632	0.0583
4	Dighipara	2	2	1	1	2	2	1	1/3	1/2	1	1/2	1	1	2	1	1	1.0632	0.0583
5	Jamalgonj	1	1	1/2	1/2	1	1	1/2	1/5	1/3	1/2	1/3	1/2	1/2	1	1/2	1/2	0.5574	0.0306
6	Kuchima	1	1	1/2	1/2	1	1	1/2	1/5	1/3	1/2	1/3	1/2	1/2	1	1/2	1/2	0.5574	0.0306
7	Bheramara	2	2	1	1	2	2	1	1/3	1/2	1	1/2	1	1	2	1	1	1.0632	0.0583
8	Chittagong	5	5	3	3	5	5	3	1	2	3	2	3	3	5	3	3	3.1233	0.1713
9	Cox's Bazar	3	3	2	2	3	3	2	1/2	1	2	1	2	2	3	2	2	1.9090	0.1047
10	Mongla	2	2	1	1	2	2	1	1/3	1/2	1	1/2	1	1	2	1	1	1.0632	0.0583
11	Khulna	3	3	2	2	3	3	2	1/2	1	2	1	2	2	3	2	2	1.9090	0.1047
12	Meghnaghat	2	2	1	1	2	2	1	1/3	1/2	1	1/2	1	1	2	1	1	1.0632	0.0583
13	Zajira	2	2	1	1	2	2	1	1/3	1/2	1	1/2	1	1	2	1	1	1.0632	0.0583
14	Maowa	1	1	1/2	1/2	1	1	1/2	1/5	1/3	1/2	1/3	1/2	1/2	1	1/2	1/2	0.5574	0.0306
15	Chandpur	2	2	1	1	2	2	1	1/3	1/2	1	1/2	1	1	2	1	1	1.0632	0.0583
16	Matarbari	2	2	1	1	2	2	1	1/3	1/2	1	1/2	1	1	2	1	1	1.0632	0.0583

Source: PSMP Study Team

12.3 APPENDIX – 3 2nd Screening

12.3.1 Fuel Security

(1) Fuel Transportation

As for domestic coal, Khalaspir, Phulbari and Dighipara are adjacent each other. There is difference to the extent of development, however, it would be reasonable that one single power station is accommodated with then available coal flexibly from fuel security reason. The detail site selection would be proceeded later, for the fuel transportation point of view, because there are no long distance, it has good condition.

With respect to imported coal, Chittagong, Mongla and Khulna are regarded as high priority sites since there already exist port facility currently functioning. Since the depth of the sea is shallow, it will be difficult for large vessel to access to Meghnaghat、Zajira and Maowa, however, it would be relatively easy to build port facility for smaller coastal vessel. Cox's Bazar site is facing shallow beach for a good distance from the shore so that it would be difficult to build port facility. The evaluation was conducted from above mentioned points and the result is shown as follows.

APTable 12-15 Evaluation for Fuel Transportation

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	3	1	1	1	1	1	1	1.1298	0.1200
2	Chittagong	1	1	3	1	1	1	1	1	1	1.1298	0.1200
3	Cox's Bazar	1/3	1/3	1	1/3	1/3	1/3	1/3	1/3	1/3	0.3766	0.0400
4	Mongla	1	1	3	1	1	1	1	1	1	1.1298	0.1200
5	Khulna	1	1	3	1	1	1	1	1	1	1.1298	0.1200
6	Meghnaghat	1	1	3	1	1	1	1	1	1	1.1298	0.1200
7	Zajira	1	1	3	1	1	1	1	1	1	1.1298	0.1200
8	Maowa	1	1	3	1	1	1	1	1	1	1.1298	0.1200
9	Matarbari	1	1	3	1	1	1	1	1	1	1.1298	0.1200

Source: PSMP Study Team

(2) Port Facilities

The site for domestic coal at inner area has no capability to build port facility (the transportation would be done on land), and the concept for import coal site is same as (1).

Based on this concept, the result is shown as follows,

APTable 12-16 Evaluation for Port Facilities

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/5	1/3	1/5	1/5	1/3	1/3	1/3	1/5	0.3001	0.0276
2	Chittagong	5	1	3	1	1	3	3	3	1	1.9486	0.1793
3	Cox's Bazar	3	1/3	1	1/3	1/3	1	1	1	1/3	0.6934	0.0638
4	Mongla	5	1	3	1	1	3	3	3	1	1.9486	0.1793
5	Khulna	5	1	3	1	1	3	3	3	1	1.9486	0.1793
6	Meghnaghat	3	1/3	1	1/3	1/3	1	1	1	1/3	0.6934	0.0638
7	Zajira	3	1/3	1	1/3	1/3	1	1	1	1/3	0.6934	0.0638
8	Maowa	3	1/3	1	1/3	1/3	1	1	1	1/3	0.6934	0.0638
9	Matarbari	5	1	3	1	1	3	3	3	1	1.9486	0.1793

Source: PSMP Study Team

12.3.2 Feasibility Factor for Construction

(1) Securing the Necessary Amount of Ground Space

As for land acquisition, the PSMP Study Team views that Cox's Bazar is located in wide open area, however, it is not suitable to build power station adjacent to long beach. The concrete location of B-K-D-P area is not fixed yet, however, there is plenty of appropriate land which is wide open enough to build power station. With respect to other sites, it seems not so much trouble to acquire the land as some sites already acquire the wide open area by Government or already selected the land for acquisition. Especially, in case of Meghnaghat, not only the land is secured but also some preparation has done, so it is more prioritized than other sites.

Based on above point, the result is shown as follows,

APTable 12-17 Evaluation for Securing the Necessary Amount of Ground Space

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	2	1	1	1/2	1	1	1	1.0000	0.1065
2	Chittagong	1	1	2	1	1	1	1	1	1	1.0801	0.1150
3	Cox's Bazar	1/2	1/2	1	1/2	1/2	1/3	1/2	1/2	1/2	0.5162	0.0550
4	Mongla	1	1	2	1	1	1/2	1	1	1	1.0000	0.1065
5	Khulna	1	1	2	1	1	1/2	1	1	1	1.0000	0.1065
6	Meghnaghat	2	1	3	2	2	1	2	2	2	1.7935	0.1910
7	Zajira	1	1	2	1	1	1/2	1	1	1	1.0000	0.1065
8	Maowa	1	1	2	1	1	1/2	1	1	1	1.0000	0.1065
9	Matarbari	1	1	2	1	1	1/2	1	1	1	1.0000	0.1065

Source: PSMP Study Team

(2) Transportation of Facilities

B-K-D-P area has some disadvantage since it is located far inland so that it is required further investigation as regard to concrete transportation route for heavy and/or bulky facilities. For Cox's Bazar, it faces long beach so that it is not suitable for unloading of large equipment. Other sites would not have significant problem for unloading large equipment since they are located on the coast.

Based on above point, the result is shown as follows,

APTable 12-18 Evaluation for Transportation of Facilities

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/2	1	1/2	1/2	1/2	1/2	1/2	1/2	0.5833	0.0625
2	Chittagong	2	1	2	1	1	1	1	1	1	1.1665	0.1250
3	Cox's Bazar	1	1/2	1	1/2	1/2	1/2	1/2	1/2	1/2	0.5833	0.0625
4	Mongla	2	1	2	1	1	1	1	1	1	1.1665	0.1250
5	Khulna	2	1	2	1	1	1	1	1	1	1.1665	0.1250
6	Meghnaghat	2	1	2	1	1	1	1	1	1	1.1665	0.1250
7	Zajira	2	1	2	1	1	1	1	1	1	1.1665	0.1250
8	Maowa	2	1	2	1	1	1	1	1	1	1.1665	0.1250
9	Matarbari	2	1	2	1	1	1	1	1	1	1.1665	0.1250

Source: PSMP Study Team

(3) History of Flood

Any sites have certain risk to the extent somehow. Especially, Chittagong, Cox's Bazar, Mongla, Khulna and others, there are relatively higher risk caused by cyclone in southern part of Bangladesh.

Based on above point, the result is shown as follows,

APTable 12-19 Evaluation for History of Flood

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	2	2	2	2	1	1	1	2	1.4697	0.1538
2	Chittagong	1/2	1	1	1	1	1/2	1/2	1/2	1	0.7349	0.0769
3	Cox's Bazar	1/2	1	1	1	1	1/2	1/2	1/2	1	0.7349	0.0769
4	Mongla	1/2	1	1	1	1	1/2	1/2	1/2	1	0.7349	0.0769
5	Khulna	1/2	1	1	1	1	1/2	1/2	1/2	1	0.7349	0.0769
6	Meghnaghat	1	2	2	2	2	1	1	1	2	1.4697	0.1538
7	Zajira	1	2	2	2	2	1	1	1	2	1.4697	0.1538
8	Maowa	1	2	2	2	2	1	1	1	2	1.4697	0.1538
9	Matarbari	0.5	1	1	1	1	1/2	1/2	1/2	1	0.7349	0.0769

Source: PSMP Study Team

(4) Topography / Geology

Flooding may impact to ground condition. Most of the sites face such ground risk to some extent, except for Meghnaghat as the land is next to existing IPP power station which has reliable track records as for ground condition.

Based on above point, the result is shown as follows,

APTable 12-20 Evaluation for Topography / Geology

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1/2	1	1	1	0.9259	0.1043
2	Chittagong	1	1	1	1	1	1/2	1	1	1	0.9259	0.1043
3	Cox's Bazar	1	1	1	1	1	1/2	1	1	1	0.9259	0.1043
4	Mongla	1	1	1	1	1	1/2	1	1	1	0.9259	0.1043
5	Khulna	1	1	1	1	1	1/2	1	1	1	0.9259	0.1043
6	Meghnaghat	2	2	2	2	2	1	1	1	1	1.4697	0.1656
7	Zajira	1	1	1	1	1	1/2	1	1	1	0.9259	0.1043
8	Maowa	1	1	1	1	1	1/2	1	1	1	0.9259	0.1043
9	Matarbari	1	1	1	1	1	1/2	1	1	1	0.9259	0.1043

Source: PSMP Study Team

12.3.3 Operational Conditions

(1) Securing of cooling water

For B-K-D-P are, like Barapukuria power station, ground water can be used for cooling, however, it should be considered the impact of land subsidence at the same time. PSMP Study Team will conduct the further investigation for water taking from adjacent rivers.

For sites next to coast such as Cox's Bazar, Zajira and Maowa, there are some possibilities to impact for sea water taking due to shallow water.

Based on above point, the result is shown as follows,

APTable 12-21 Evaluation for Securing of Cooling water

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	0.5400	0.0588
2	Chittagong	2	1	1	1	1	1	1	1	1	1.0801	0.1176
3	Cox's Bazar	2	1	1	1	1	1	1	1	1	1.0801	0.1176
4	Mongla	2	1	1	1	1	1	1	1	1	1.0801	0.1176
5	Khulna	2	1	1	1	1	1	1	1	1	1.0801	0.1176
6	Meghnaghat	2	1	1	1	1	1	1	1	1	1.0801	0.1176
7	Zajira	2	1	1	1	1	1	1	1	1	1.0801	0.1176
8	Maowa	2	1	1	1	1	1	1	1	1	1.0801	0.1176
9	Matarbari	2	1	1	1	1	1	1	1	1	1.0801	0.1176

Source: PSMP Study Team

(2) Ash Treatment

For Mongla, it would be required that coal ash is to be used as recycle material but not for landfill since there is mangrove forest nearby designated as national heritage. It is needed to further study for concrete treatment hereinafter.

As for Khulna, Zajira, Maowa, Meghnaghat and others, there are wide areas, however, not enough land for reclamation by ash.

Based on above point, the result is shown as follows,

APTable 12-22 Evaluation for Ash Treatment

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	2	4	2	3	1	1	1	1.5375	0.1561
2	Chittagong	1	1	2	4	2	3	1	1	1	1.5375	0.1561
3	Cox's Bazar	1/2	1/2	1	2	1/2	1	1/2	1/2	1/2	0.6804	0.0691
4	Mongla	1/4	1/4	1/2	1	1/3	1/2	1/3	1/3	1/3	0.3866	0.0393
5	Khulna	1/2	1/2	2	3	1	2	1	1	1	1.1298	0.1147
6	Meghnaghat	1/3	1/3	1	2	1/2	1	1/2	1/2	1/2	0.6218	0.0631
7	Zajira	1	1	2	3	1	2	1	1	1	1.3180	0.1338
8	Maowa	1	1	2	3	1	2	1	1	1	1.3180	0.1338
9	Matarbari	1	1	2	3	1	2	1	1	1	1.3180	0.1338

Source: PSMP Study Team

12.3.4 Economic Conditions

(1) Distance with Existing Power System

Except for Cox's Bazar and Maowa, there is an existing transmission line near the site.

Based on above point, the result is shown as follows,

APTable 12-23 Evaluation for Distance with Existing Power System

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	2	1	1	1	1	3	2	1.3180	0.1361
2	Chittagong	1	1	2	1	1	1	1	3	2	1.3180	0.1361
3	Cox's Bazar	1/2	1/2	1	1/2	1/2	1/2	1/2	2	1	0.6804	0.0703
4	Mongla	1	1	2	1	1	1	1	3	2	1.3180	0.1361
5	Khulna	1	1	2	1	1	1	1	3	2	1.3180	0.1361
6	Meghnaghat	1	1	2	1	1	1	1	3	2	1.3180	0.1361
7	Zajira	1	1	2	1	1	1	1	3	2	1.3180	0.1361
8	Maowa	1/3	1/3	1/2	1/3	1/3	1/3	1/3	1	1/2	0.4121	0.0426
9	Matarbari	0.5	1/2	1	1/2	1/2	1/2	1/2	2	1	0.6804	0.0703

Source: PSMP Study Team

(2) Project Cost

The project cost of the coal-fired power plant changes according to the type of coal handling facility which depends on how to secure coal.

These candidate sites are categorized into three types according to how to secure coal, utilizing domestic coal on the mine mouth (B-K-D-P), receiving directly imported coal (Chittagong, Cox's Bazar, Mongla, Khulna, Matarbari), internal transportation of imported coal (Meghnaghat, Zajira, Maowa), and the required equipment cost is estimated to substantially increase in this turn.

Based on above point, the result is shown as follows,

APTable 12-24 Evaluation for Project Cost

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	2	2	2	2	3	3	3	2	2.1197	0.2172
2	Chittagong	1/2	1	1	1	1	2	2	2	1	1.1665	0.1195
3	Cox's Bazar	1/2	1	1	1	1	2	2	2	1	1.1665	0.1195
4	Mongla	1/2	1	1	1	1	2	2	2	1	1.1665	0.1195
5	Khulna	1/2	1	1	1	1	2	2	2	1	1.1665	0.1195
6	Meghnaghat	1/3	1/2	1/2	1/2	1/2	1	1	1	1/2	0.6022	0.0617
7	Zajira	1/3	1/2	1/2	1/2	1/2	1	1	1	1/2	0.6022	0.0617
8	Maowa	1/3	1/2	1/2	1/2	1/2	1	1	1	1/2	0.6022	0.0617
9	Matarbari	0.5	1	1	1	1	2	2	2	1	1.1665	0.1195

Source: PSMP Study Team

12.3.5 Local Demand-Supply

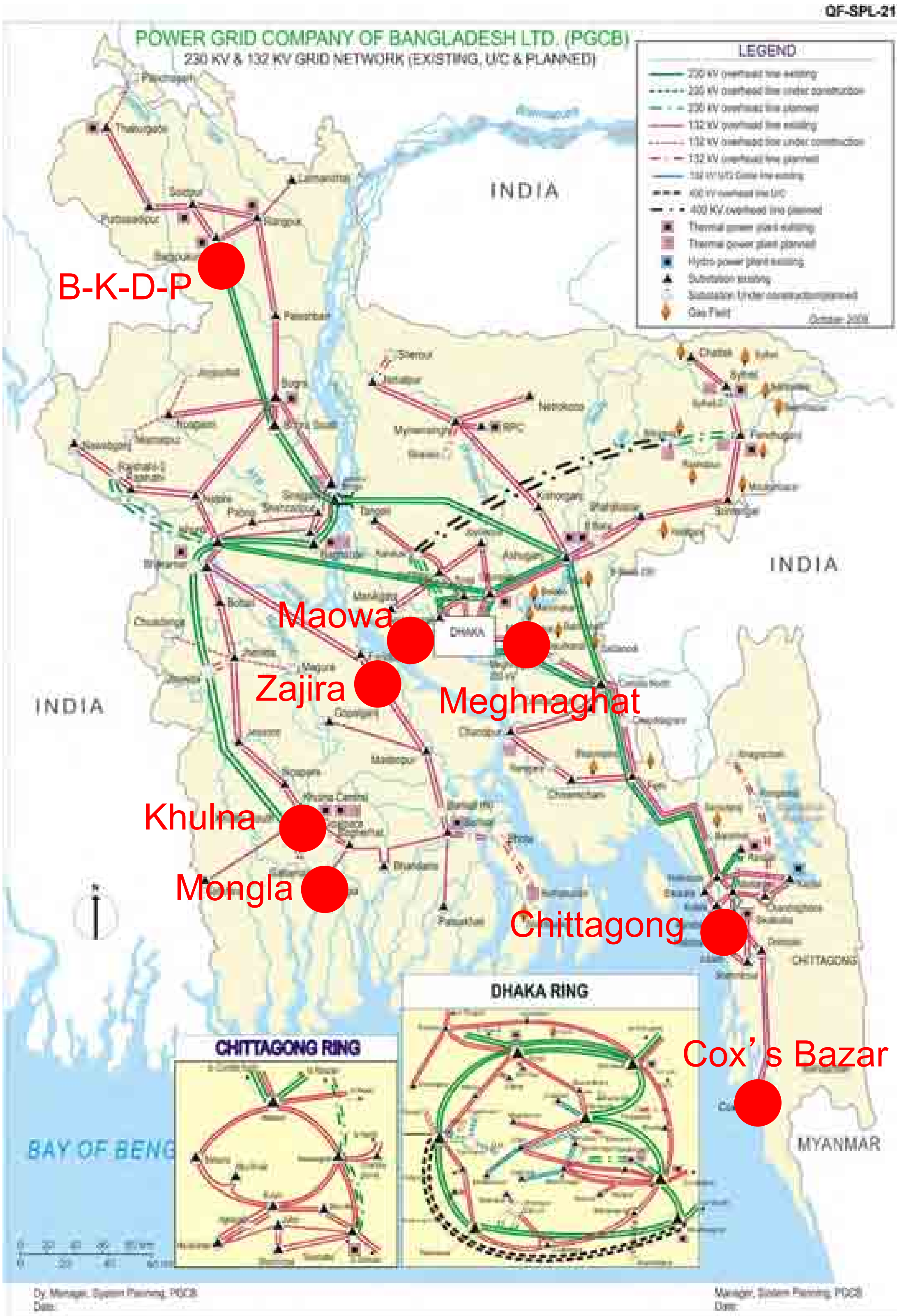
(1) Advantageous sites in the point of network view

At the second screening, an evaluation has been carried out to narrow down the eight (8) potential sites nominated from a mid list to a short list, based on the site reconnaissance from the viewpoint of access to the existing power system. However, as for the potential site where the site reconnaissance has not been carried out, an evaluation has been carried out based on the power system diagram. The results of the evaluation are shown as follows,

APTable 12-25 Result of 2nd screening (Local Demand-Supply)

Potential site for coal power development	Ease of access to the existing power system	Score (on a scale of 1 to 5)
K-P-D	Situated close to the route of 230kV Barapukuria - Bogla South transmission line	4
Chittagong	Situated in the load center of the southern region with developed existing 230kV and 132kV power systems in the surrounding areas	4
Cox's Bazar	Situated approximately 150km south of Chittagong with only a 132kV double circuit transmission line in the surrounding areas	2
Mongla	Situated approximately 40km south of Khulna with only a 132kV single circuit transmission line existing in the surrounding areas	2
Khulna	Situated in the load center of the western region with a developed existing 230kV and 132kV power systems in the surrounding areas	4
Meghnaghat	An already-planned 400kV Meghnaghat – Aminbazar transmission line, and an already-procured 400kV substation site	5
Zajira	Situated approximately 40km northeast of Khulna with only a 132kV single circuit transmission line existing in the surrounding areas, and the possibility of easy access after the completion of Padma Bridge (planned)	3
Maowa	Situated close to the Dhaka region with developed existing 230kV and 132kV power systems in the surrounding areas	4

Source: PSMP Study Team



APFig. 12-2 Existing Power System and Coal Power Development Sites（mid list）

Based on above point, the result is shown as follows,

APTable 12-26 Evaluation for local demand-supply (AHP method)

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	3	3	1	1/2	2	1	1	1.2765	0.1251
2	Chittagong	1	1	3	3	1	1/2	2	1	1	1.2765	0.1251
3	Cox's Bazar	1/3	1/3	1	1	1/3	1/4	1/2	1/3	1/3	0.4311	0.0422
4	Mongla	1/3	1/3	1	1	1/3	1/4	1/2	1/3	1/3	0.4311	0.0422
5	Khulna	1	1	3	3	1	1/2	2	1	1	1.2765	0.1251
6	Meghnaghat	2	2	4	4	2	1	3	2	2	2.2597	0.2214
7	Zajira	1/2	1/2	2	2	1/2	1/3	1	1/2	1/2	0.7025	0.0688
8	Maowa	1	1	3	3	1	1/2	2	1	1	1.2765	0.1251
9	Matarbari	1	1	3	3	1	1/2	2	1	1	1.2765	0.1251

Source: PSMP Study Team

12.3.6 Needs of Bangladesh

(1) Needs level of Bangladesh

In Bangladesh, the original study for coal power development is also proceeding at a very quick pace so that F/S will be able to commence soon. It is important to correspond to the status of the study and pick up on actual needs.

After discussion, the PSMP Study Team has achieved a tentative consensus that the first priority site will be Chittagong, the second Meghnaghat. Further, obtaining consensus for the development of a B-K-D-P site in utilizing domestic coal while developing the basic usage of import coal is a first priority.

Based on above point, the result is shown as follows,

APTable 12-27 Evaluation for Needs level of Bangladesh

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	4	4	1	2	3	3	2	2.0263	0.1898
2	Chittagong	1	1	4	4	1	2	3	3	2	2.0263	0.1898
3	Cox's Bazar	1/4	1/4	1	1	1/4	1/3	1/2	1/2	1/3	0.4230	0.0396
4	Mongla	1/4	1/4	1	1	1/4	1/3	1/2	1/2	1/3	0.4230	0.0396
5	Khulna	1	1	4	4	1	2	3	3	2	2.0263	0.1898
6	Meghnaghat	1/2	1/2	3	3	1/2	1	2	2	1	1.1819	0.1107
7	Zajira	1/3	1/3	2	2	1/3	1/2	1	1	1/2	0.6934	0.0649
8	Maowa	1/3	1/3	2	2	1/3	1/2	1	1	1/2	0.6934	0.0649
9	Matarbari	0.5	1/2	3	3	1/2	1	2	2	1	1.1819	0.1107

Source: PSMP Study Team

12.3.7 Donor

(1) Development priority and plan of Multilateral Development Banks

According to the presentation held on Sep. 2009 by ADB, Chittagong、Khulna、Meghnaghat and Zajira were mentioned as candidate sites.

Based on above point, the result is shown as follows,

APTable 12-28 Evaluation for Development priority and plan of Multilateral Development Banks

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/3	1	1	1/3	1/3	1/3	1	1	0.6137	0.0588
2	Chittagong	3	1	3	3	1	1	1	3	3	1.8411	0.1765
3	Cox's Bazar	1	1/3	1	1	1/3	1/3	1/3	1	1	0.6137	0.0588
4	Mongla	1	1/3	1	1	1/3	1/3	1/3	1	1	0.6137	0.0588
5	Khulna	3	1	3	3	1	1	1	3	3	1.8411	0.1765
6	Meghnaghat	3	1	3	3	1	1	1	3	3	1.8411	0.1765
7	Zajira	3	1	3	3	1	1	1	3	3	1.8411	0.1765
8	Maowa	1	1/3	1	1	1/3	1/3	1/3	1	1	0.6137	0.0588
9	Matarbari	1	1/3	1	1	1/3	1/3	1/3	1	1	0.6137	0.0588

Source: PSMP Study Team

12.3.8 Environment Influence

(1) Air Pollution

Regarding air pollution, sulfur oxide, nitrogen oxide and particle matter will be exhaust from construction machinery or transportation vehicles during construction. During operation, sulfur oxide, nitrogen oxide and particle matter will be exhaust from coal fired power plant. There is coal dust generation in the case of domestic coal mine development. Therefore, environmental impacts due to air pollution are supposed in all sites, no material difference between sites is supposed.

Based on above point, the result is shown as follows,

APTable 12-29 Evaluation for Air Pollution

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(2) Waste Contamination

Regarding water contamination, drainage due to wash the equipment and sewages are drained during construction phase. In operation phase, drainage water from FGD, ash treatment and power generation unit are drained. Therefore, environmental impacts due to water contamination are supposed in all sites, no material difference between sites is supposed.

Based on above point, the result is shown as follows,

APTable 12-30 Evaluation for Waste Contamination

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(3) Soil Pollution

Regarding soil pollution, there is possibility of pollution due to oil leakage during both construction phase and operation phase. So, environmental impacts due to soil pollution are supposed in all sites, no material difference between sites is supposed.

Based on above point, the result is shown as follows,

APTable 12-31 Evaluation for Soil Pollution

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(4) Bottom Sediment

Regarding bottom sediment, there is possibility of pollution due to dredge work during construction phase. Environmental impacts to bottom sediment are supposed in sites where use imported coal power plant with dredge work. Based on above point, the result is shown as follows,

APTable 12-32 Evaluation for Bottom Sediment

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	3	3	3	3	3	3	3	3	2.6553	0.2727
2	Chittagong	1/3	1	1	1	1	1	1	1	1	0.8851	0.0909
3	Cox's Bazar	1/3	1	1	1	1	1	1	1	1	0.8851	0.0909
4	Mongla	1/3	1	1	1	1	1	1	1	1	0.8851	0.0909
5	Khulna	1/3	1	1	1	1	1	1	1	1	0.8851	0.0909
6	Meghnaghat	1/3	1	1	1	1	1	1	1	1	0.8851	0.0909
7	Zajira	1/3	1	1	1	1	1	1	1	1	0.8851	0.0909
8	Maowa	1/3	1	1	1	1	1	1	1	1	0.8851	0.0909
9	Matarbari	1/3	1	1	1	1	1	1	1	1	0.8851	0.0909

Source: PSMP Study Team

(5) Noise and Vibration

Regarding noise and vibration, noise and vibration due to pilling and excavation are supposed during construction phase. In operation phase, noise and vibration caused from operation of each machinery such as fan and pump in power plant, and drilling in coal mine are supposed. In addition that, because there are impacts of the noise and vibration caused by transportation of equipment and material, environmental impacts due to noise and vibration are supposed in all sites, no material difference between sites is supposed.

Based on above point, the result is shown as follows,

APTable 12-33 Evaluation for Noise and Vibration

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(6) Offensive Odor

Regarding offensive odor, though the ammonia which is used for the SCR can become source of odor, it is supposed that there is little impact because the discharge quantity is small.

Based on above point, the result is shown as follows,

APTable 12-34 Evaluation for Offensive Odor

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(7) Waste

Regarding waste, because occurrence of industrial waste is supposed both during construction and operation phase, environmental impacts due to waste are supposed in all sites, no material difference between sites is supposed.

Based on above point, the result is shown as follows,

APTable 12-35 Evaluation for Waste

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(8) Ground subsidence

Regarding ground subsidence, since underground water is pumped with the coal mine and used as power plant service water, environmental impacts due to ground subsidence are supposed in domestic coal fired power plant site. It is supposed that there is little environmental impact due to ground subsidence in imported coal fired power plant which uses river water or sea water as cooling water.

Based on above point, the result is shown as follows,

APTable 12-36 Evaluation for Ground Subsidence

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1/5	0.2392	0.0244
2	Chittagong	5	1	1	1	1	1	1	1	1	1.1958	0.1220
3	Cox's Bazar	5	1	1	1	1	1	1	1	1	1.1958	0.1220
4	Mongla	5	1	1	1	1	1	1	1	1	1.1958	0.1220
5	Khulna	5	1	1	1	1	1	1	1	1	1.1958	0.1220
6	Meghnaghat	5	1	1	1	1	1	1	1	1	1.1958	0.1220
7	Zajira	5	1	1	1	1	1	1	1	1	1.1958	0.1220
8	Maowa	5	1	1	1	1	1	1	1	1	1.1958	0.1220
9	Matarbari	5	1	1	1	1	1	1	1	1	1.1958	0.1220

Source: PSMP Study Team

(9) Geographical feature

Regarding geographical feature, no impact is supposed in all sites because all sites are plain.

Based on above point, the result is shown as follows,

APTable 12-37 Evaluation for Geographical Feature

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(10) Biota and Ecosystem

Regarding biota and ecosystem, it is supposed that there are influence of lumbering trees and shrubs and land alteration by land formation work. So, environmental impacts to biota and ecosystem are supposed in all sites other than Meghnaghat site.

Based on above point, the result is shown as follows,

APTable 12-38 Evaluation for Biota and Ecosystem

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	3	3	1	1	1	1	1	1.2765	0.1304
2	Chittagong	1	1	3	3	1	1	1	1	1	1.2765	0.1304
3	Cox's Bazar	1/3	1/3	1	1	1/3	1/3	1/3	1/3	1/3	0.4255	0.0435
4	Mongla	1/3	1/3	1	1	1/3	1/3	1/3	1/3	1/3	0.4255	0.0435
5	Khulna	1	1	3	3	1	1	1	1	1	1.2765	0.1304
6	Meghnaghat	1	1	3	3	1	1	1	1	1	1.2765	0.1304
7	Zajira	1	1	3	3	1	1	1	1	1	1.2765	0.1304
8	Maowa	1	1	3	3	1	1	1	1	1	1.2765	0.1304
9	Matarbari	1	1	3	3	1	1	1	1	1	1.2765	0.1304

Source: PSMP Study Team

(11) Water usage

Regarding for water usage, there is a possibility of exerting influence on life water for peripheral people.

Based on above point, the result is shown as follows,

APTable 12-39 Evaluation for Water Usage

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1/5	0.2392	0.0244
2	Chittagong	5	1	1	1	1	1	1	1	1	1.1958	0.1220
3	Cox's Bazar	5	1	1	1	1	1	1	1	1	1.1958	0.1220
4	Mongla	5	1	1	1	1	1	1	1	1	1.1958	0.1220
5	Khulna	5	1	1	1	1	1	1	1	1	1.1958	0.1220
6	Meghnaghat	5	1	1	1	1	1	1	1	1	1.1958	0.1220
7	Zajira	5	1	1	1	1	1	1	1	1	1.1958	0.1220
8	Maowa	5	1	1	1	1	1	1	1	1	1.1958	0.1220
9	Matarbari	5	1	1	1	1	1	1	1	1	1.1958	0.1220

Source: PSMP Study Team

(12) Accidents

Regarding accidents, it is supposed that there is no impact because prevention is possible by the introduction of the high quality facility and execution of appropriate health and safety activity.

Based on above point, the result is shown as follows,

APTable 12-40 Evaluation for Accidents

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(13) Global warming

Regarding global warming, since there is carbon dioxide emission during power plant operation, environmental impacts of global warming are supposed in all sites, no material difference between sites is supposed.

Based on above point, the result is shown as follows,

APTable 12-41 Evaluation for Global Warming

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

12.3.9 Social Issues

Based on available secondary data and literature, the present condition of 16 potential sites, future project viability, social change and the social impact potentially caused by such project implementation were examined by checking social scoping items in order to compare and prioritize them.

APTable 12-42 Result of Site Survey (Social Issues)

	Site Name	Impacts predicted at construction stage	Impacts predicted at operation stage
1	B-K-D-P	Information sharing on the development of power plants and local consultation with inhabitants should be thoroughly conducted to obtain a solid understanding and local consensus. Dialog with inhabitants and an active learning process with NGOs such as the GrameenBank, BRAC, and ASA which are already involved in community development in Phulbari are highly recommended.	Land acquisition and resettlement could cause severer social unrest and protests from the local community Environmental protection measures should be thoroughly executed in order to not cause pollution or health hazards; hence, local resistance can be averted.
2	Chittagong	Construction site is already prepared, where inflow of inhabitants without legal status should be avoided Information sharing on development of power plant and local consultation with inhabitants should be thoroughly conducted in order to obtain solid understanding and local consensus. Careful coordination is expected so as not to raise ethnic disputes. Dialogs with inhabitants and active learning processes with NGOs such as BRAC, ASA and PROSHIKA which are already involved in community development in Chittagong are highly recommended	Local consultation and environmental protection measures should be executed so as not to cause pollution or health hazards, so that local resistance can be avoided. Ethnic minorities' rights should be respected and proper management is highly expected not to raise local conflict among them.
3	Cox' s Bazar	Mitigation measures against anticipated impact on forests or the beach should be taken. Information sharing on development of power plant and local consultation with inhabitants should be thoroughly conducted in order to obtain a solid understanding and local consensus. Careful coordination is expected so as to not raise ethnic disputes. Dialogs with inhabitants and active learning process with NGOs such as BRAC, ASA and PROSHIKA which are already involved in community development in Cox's Bazar are highly recommended	Local consultation and environmental protection measures should be executed so as not to cause pollutions or health hazard, so that local resistance can be avoided. Ethnic minorities' rights should be respected and proper management is highly expected so as to not raise local conflict among them.

	Site Name	Impacts predicted at construction stage	Impacts predicted at operation stage
4	Mongla	Mitigation measures for the aquaculture industry, tourism and service industries will be required. Information sharing on development of power plant and local consultation with inhabitants should be thoroughly conducted in order to obtain a solid understanding and local consensus. Dialogs with inhabitants and active learning processes with NGOs such as BRAC and ASA which are already involved in community development in Mongla are highly recommended	Local consultation and environmental protection measures should be executed so as not to cause pollution or health hazards, so that local resistance can be avoided.
5	Khulna	Mitigation measures for aquaculture industry, tourism and service industries will be required. Information sharing on development of power plant and local consultation with inhabitants should be thoroughly conducted in order to obtain a solid understanding and local consensus. Dialogs with inhabitants and active learning processes with NGOs such as BRAC and ASA which are already involved in community development in Khulna are highly recommended	Local consultation and environmental protection measures should be executed so as not to cause pollution or health hazards, so that local resistance can be averted.
6	Meghnaghat	Information sharing on development of power plant and local consultation with inhabitants should be thoroughly conducted in order to obtain a solid understanding and local consensus. Dialogs with inhabitants and active learning processes with NGOs such as BRAC, ASA and PROSHIKA which are already involved in community development in Sonargaon are highly recommended	Local consultation and environmental protection measures should be executed so as not to cause pollution or health hazards, so that local resistance can be averted.
7	Zajira	Information sharing on development of power plant and local consultation with inhabitants should be thoroughly conducted in order to obtain a solid understanding and local consensus. Dialogs with inhabitants and active learning processes with NGOs such as BRAC, ASA and PROSHIKA which are already involved in community development in Shariatpurare highly recommended	Local consultation and environmental protection measures should be executed so as not to cause pollution or health hazards, so that local resistance can be averted.

	Site Name	Impacts predicted at construction stage	Impacts predicted at operation stage
8	Maowa	Impact on local industries can happen because commercial and service industries are popular. Information sharing on development of power plant and local consultation with inhabitants should be thoroughly conducted in order to obtain a solid understanding and local consensus. Dialogs with inhabitants and active learning processes with NGOs such as BRAC, ASA and PROSHIKA which are already involved in community development in Lohajang are highly recommended	Local consultation and environmental protection measures should be executed so as not to cause pollution or health hazards, so that local resistance can be averted.
13	Matarbari	Information sharing on development of power plant and local consultation with inhabitants should be thoroughly conducted in order to obtain a solid understanding and local consensus. Dialogs with inhabitants and active learning processes with NGOs such as BRAC, ASA and PROSHIKA which are already involved in community development in Shariatpurare highly recommended	Local consultation and environmental protection measures should be executed so as not to cause pollution or health hazards, so that local resistance can be averted.

Source: PSMP Study Team

(1) Involuntary resettlement

There is no material difference on necessity between the sites. The result is as follows,

APTable 12-43 Evaluation for Involuntary Resettlement

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(2) Local Economy such as employment and livelihood etc.

Local economics in Chittagong, Cox's Bazar, Mongla, and Khulna are flourishing more than the other sites. The results are as follows,

APTable 12-44 Evaluation for Local Economy such as Employment and Livelihood etc.

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769
2	Chittagong	2	1	1	1	1	2	2	2	2	1.4697	0.1538
3	Cox's Bazar	2	1	1	1	1	2	2	2	2	1.4697	0.1538
4	Mongla	2	1	1	1	1	2	2	2	2	1.4697	0.1538
5	Khulna	2	1	1	1	1	2	2	2	2	1.4697	0.1538
6	Meghnaghat	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769
7	Zajira	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769
8	Maowa	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769
9	Matarbari	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769

Source: PSMP Study Team

(3) The poor, indigenous and ethnic people

The estimation for Chittagong, Cox's Bazar, Mongla, and Khulna are high because of its local economics. The result is as follows,

APTable 12-45　Evaluation for the Poor, Indigenous and Ethnic People

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769
2	Chittagong	2	1	1	1	1	2	2	2	2	1.4697	0.1538
3	Cox's Bazar	2	1	1	1	1	2	2	2	2	1.4697	0.1538
4	Mongla	2	1	1	1	1	2	2	2	2	1.4697	0.1538
5	Khulna	2	1	1	1	1	2	2	2	2	1.4697	0.1538
6	Meghnaghat	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769
7	Zajira	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769
8	Maowa	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769
9	Matarbari	1	1/2	1/2	1/2	1/2	1	1	1	1	0.7349	0.0769

Source:　PSMP Study Team

(4) Misdistribution of benefit and loss

There is no difference between the sites. The results are as follows,

APTable 12-46　Evaluation for Misdistribution of Benefit and Loss

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source:　PSMP Study Team

(5) Local conflict of interests

There is also no difference between the sites.　The results are as follows,

APTable 12-47　Evaluation for Local Conflict to Interests

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source:　PSMP Study Team

(6) Gender

There is also no difference between the sites. The results are also as follows,

APTable 12-48 Evaluation for Gender

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(7) Children's right

The estimation for B-K-D-P is lower than the other sites. The results are as follows,

APTable 12-49 Evaluation for Children's Right

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1/3	1/3	1/3	1/3	1/3	1/3	1/3	1/3	0.3766	0.0400
2	Chittagong	3	1	1	1	1	1	1	1	1	1.1298	0.1200
3	Cox's Bazar	3	1	1	1	1	1	1	1	1	1.1298	0.1200
4	Mongla	3	1	1	1	1	1	1	1	1	1.1298	0.1200
5	Khulna	3	1	1	1	1	1	1	1	1	1.1298	0.1200
6	Meghnaghat	3	1	1	1	1	1	1	1	1	1.1298	0.1200
7	Zajira	3	1	1	1	1	1	1	1	1	1.1298	0.1200
8	Maowa	3	1	1	1	1	1	1	1	1	1.1298	0.1200
9	Matarbari	3	1	1	1	1	1	1	1	1	1.1298	0.1200

Source: PSMP Study Team

(8) Land use and utilization of local resources

The estimation for B-K-D-P is a little higher than the other sites. The results are as follows,

APTable 12-50 Evaluation for Land Use and Utilization of Local Resources

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	2	2	2	2	2	2	2	2	1.8517	0.2000
2	Chittagong	1/2	1	1	1	1	1	1	1	1	0.9259	0.1000
3	Cox's Bazar	1/2	1	1	1	1	1	1	1	1	0.9259	0.1000
4	Mongla	1/2	1	1	1	1	1	1	1	1	0.9259	0.1000
5	Khulna	1/2	1	1	1	1	1	1	1	1	0.9259	0.1000
6	Meghnaghat	1/2	1	1	1	1	1	1	1	1	0.9259	0.1000
7	Zajira	1/2	1	1	1	1	1	1	1	1	0.9259	0.1000
8	Maowa	1/2	1	1	1	1	1	1	1	1	0.9259	0.1000
9	Matarbari	1/2	1	1	1	1	1	1	1	1	0.9259	0.1000

Source: PSMP Study Team

(9) Social institutions such as social infrastructure and local decision making institutions

There are no differences between the sites. The results are as follows,

APTable 12-51 Evaluation for Social institutions such as Social Infrastructure and Local Decision Making Institutions

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(10) Existing social infrastructures

There is no difference between the sites. The results are as follows,

APTable 12-52 Evaluation for Existing Social Infrastructure

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

(11) Cultural heritage

B-K-D-P site has no problem, Mongla has a site of world heritage so that the estimation is low, Khulna has no big problem. Based on this information, the result is as follows,

APTable 12-53 Evaluation for Cultural Heritage

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	3	3	4	2	3	3	3	3	2.6207	0.2603
2	Chittagong	1/3	1	1	2	1/2	1	1	1	1	0.8851	0.0879
3	Cox's Bazar	1/3	1	1	2	1/2	1	1	1	1	0.8851	0.0879
4	Mongla	1/4	1/2	1/2	1	1/3	1/2	1/2	1/2	1/2	0.4780	0.0475
5	Khulna	1/2	2	2	3	1	2	2	2	2	1.6606	0.1649
6	Meghnaghat	1/3	1	1	2	1/2	1	1	1	1	0.8851	0.0879
7	Zajira	1/3	1	1	2	1/2	1	1	1	1	0.8851	0.0879
8	Maowa	1/3	1	1	2	1/2	1	1	1	1	0.8851	0.0879
9	Matarbari	1/3	1	1	2	1/2	1	1	1	1	0.8851	0.0879

Source: PSMP Study Team

(12) Infectious diseases such as HIV/AIDS etc

There is no difference between the sites. The results are as follows,

APTable 12-54 Evaluation for Infectious Diseases such as HIV/AIDS etc

No.	Site Name	1	2	3	4	5	6	7	8	9	Geometric Average	Level of Importance
1	B-K-D-P	1	1	1	1	1	1	1	1	1	1.0000	0.1111
2	Chittagong	1	1	1	1	1	1	1	1	1	1.0000	0.1111
3	Cox's Bazar	1	1	1	1	1	1	1	1	1	1.0000	0.1111
4	Mongla	1	1	1	1	1	1	1	1	1	1.0000	0.1111
5	Khulna	1	1	1	1	1	1	1	1	1	1.0000	0.1111
6	Meghnaghat	1	1	1	1	1	1	1	1	1	1.0000	0.1111
7	Zajira	1	1	1	1	1	1	1	1	1	1.0000	0.1111
8	Maowa	1	1	1	1	1	1	1	1	1	1.0000	0.1111
9	Matarbari	1	1	1	1	1	1	1	1	1	1.0000	0.1111

Source: PSMP Study Team

Chapter 16 Economic and Financial Analysis of the Most Prioritized Projects APPENDEX

16.1 The Model for Economic Analysis of Prioritized Projects

APTable 16-1 ECONOMIC ASSUMPTIONS

Fiscal Year ending at June of	Unit	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018	11 2019	12 2020	13 2021	14 2022	15 2023	16 2024	17 2025	18 2026	19 2027
Inflation																					
Local Inflation (end of June)	% p.a.	10.0%	2.3%	8.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%
Local inflation (average for fiscal year)	% p.a.	9.9%	6.7%	7.3%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%
US inflation (average, calendar yr)	% p.a.	3.8%	-0.4%	1.9%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Inflation in Japan (average, calendar yr)	% p.a.	1.4%	-1.4%	-1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Price index																					
Local prices (average: 1995-96=100)		193.5	206.4	221.5	234.2	247.5	261.6	276.5	292.3	308.9	326.6	345.2	364.8	385.6	407.6	430.9	455.4	481.4	508.8	537.8	568.5
Local prices (end of June: 1996=100)		203.4	208.0	226.1	239.0	252.6	267.0	282.2	298.3	315.3	333.3	352.3	372.4	393.6	416.0	439.8	464.8	491.3	519.3	548.9	580.2
US prices (average: 1982-84=100)		215.3	214.5	218.6	224.0	229.6	235.4	241.3	247.3	253.5	259.8	266.3	273.0	279.8	286.8	294.0	301.3	308.8	316.6	324.5	332.6
Japanese prices (average: 2005=100)		101.7	100.3	99.3	100.3	101.3	102.3	103.3	104.4	105.4	106.5	107.5	108.6	109.7	110.8	111.9	113.0	114.1	115.3	116.4	117.6
Exchange rate																					
Taka/US$ (average)	Taka	68.60	68.80	69.59	68.08	77.14	79.00	80.85	82.71	84.56	86.41	88.27	90.12	91.98	93.83	95.69	97.54	99.40	101.25	103.11	104.96
Change from previous year	% p.a.	-0.62%	0.29%	1.15%	-2.17%	13.31%	2.40%	2.35%	2.29%	2.24%	2.19%	2.15%	2.10%	2.06%	2.02%	1.98%	1.94%	1.90%	1.87%	1.83%	1.80%
Taka/JPY (average)	Taka	0.62	0.70	0.82	0.81	0.84	0.87	0.90	0.94	0.97	1.00	1.04	1.07	1.10	1.14	1.17	1.20	1.24	1.27	1.30	1.34
Change from previous year	% p.a.	6.90%	12.90%	17.14%	-0.73%	2.64%	4.01%	3.86%	3.71%	3.58%	3.46%	3.34%	3.23%	3.13%	3.04%	2.95%	2.86%	2.78%	2.71%	2.64%	2.57%
Electricity Tariff																					
Average Billing Rate of BPDB	Tk/kWh	2.36	2.56	2.75	2.90	3.07	3.24	3.43	3.62	3.83	4.05	4.28	4.52	4.78	5.05	5.34	5.65	5.97	6.31	6.67	7.05
Ave Bulk Wholesale Tariff	Tk/kWh	2.37	2.37	2.37																	
Willingness-to-Pay (generation level)	Tk/kWh		7.32	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85
Fuel price (real)																					
Domestic Coal	US Cents/MM kcal		1.400	1.400	1.467	1.530	1.595	1.655	1.715	1.773	1.830	1.885	1.940	1.992	2.044	2.096	2.147	2.196	2.244	2.293	2.339
	US$/ton		85.38	85.38	89.51	93.36	97.30	100.95	104.61	108.16	111.63	114.99	118.36	121.53	124.70	127.87	130.95	133.93	136.91	139.89	142.68
Imprted Coal	US Cents/MM kcal		1.454	1.454	1.539	1.618	1.698	1.773	1.848	1.921	1.992	2.061	2.130	2.195	2.260	2.325	2.388	2.449	2.510	2.571	2.628
	US$/ton		73.80	73.80	78.10	82.10	86.20	90.00	93.80	97.50	101.10	104.60	108.10	111.40	114.70	118.00	121.20	124.30	127.40	130.50	133.40
Heavy Fuel Oil (Furnace Oil)	US Cents/MM kcal		3.657	4.761	4.843	4.925	5.007	5.089	5.171	5.330	5.489	5.648	5.807	5.966	6.055	6.145	6.234	6.324	6.413	6.503	6.592
High Speed Diesel Oil	US Cents/MM kcal		5.607	7.300	7.425	7.551	7.677	7.802	7.928	8.172	8.416	8.660	8.904	9.148	9.285	9.422	9.559	9.696	9.834	9.971	10.108
Natural Gas (Domestic)																					
Natural Gas (Import)	US Cents/MM kcal		2.428	3.571	3.632	3.693	3.755	3.816	3.878	3.997	4.116	4.236	4.355	4.474	4.541	4.609	4.676	4.743	4.810	4.877	4.944
Fuel price (real)																					
Domestic Coal	Tk/MM kcal		974	974	1.021	1.065	1.110	1.152	1.193	1.234	1.273	1.312	1.350	1.386	1.423	1.459	1.494	1.528	1.562	1.596	1.628
	Taka/Ton		5.941	5.941	6.229	6.497	6.771	7.025	7.280	7.527	7.768	8.002	8.236	8.457	8.678	8.899	9.113	9.320	9.528	9.735	9.929
Imprted Coal	Tk/MM kcal		1.012	1.012	1.071	1.126	1.182	1.234	1.286	1.337	1.386	1.434	1.482	1.527	1.573	1.618	1.662	1.704	1.747	1.789	1.829
	Taka/Ton		5.160	5.160	5.461	5.741	6.027	6.293	6.559	6.818	7.069	7.314	7.559	7.790	8.020	8.251	8.475	8.692	8.908	9.125	9.328
Heavy Fuel Oil (Furnace Oil)	Tk/MM kcal		2.545	3.313	3.370	3.427	3.484	3.541	3.598	3.709	3.820	3.930	4.041	4.152	4.214	4.276	4.338	4.401	4.463	4.525	4.588
	Taka/Litre		24.29	31.63	32.17	32.71	33.26	33.80	34.35	35.40	36.46	37.52	38.57	39.63	40.23	40.82	41.41	42.01	42.60	43.20	43.79
High Speed Diesel Oil	Tk/MM kcal		3.902	5.080	5.167	5.255	5.342	5.430	5.517	5.687	5.857	6.026	6.196	6.366	6.461	6.557	6.652	6.748	6.843	6.939	7.034
	Taka/Litre		34.95	45.50	46.28	47.06	47.85	48.63	49.41	50.93	52.45	53.97	55.49	57.01	57.87	58.72	59.58	60.43	61.29	62.14	63.00
Natural Gas (Domestic)	Tk/MM kcal		309	333																	
	Taka/10^3 cft		73.91	79.82																	
Natural Gas (Import)	Tk/MM kcal		1.689	2.485	2.528	2.570	2.613	2.656	2.699	2.782	2.865	2.948	3.031	3.114	3.160	3.207	3.254	3.301	3.347	3.394	3.441
	Taka/10^3 cft		404	595	605	615	626	636	646	666	686	706	726	745	757	768	779	790	801	813	824

Source: JICA study team

Legend:
- (orange) =Actuals and shall not be changed.
- (pink) =Exchange rate indicated by JICA in March 2010. Actual Record by BB is US$1=Tk 69.185 for FY 2010.
- (lavender) =Estimate based on July-February Performance
- (light cyan) =Fields for input with assumptive data.
- (blue)

Conversion Factor

Coal (Domestic)		1 kg=	6,100	kcal
Coal (Imported)		1 kg=	5,100	kcal
Furnace Oil		1 litre=	9,546	kcal
High Speed Diesel Oil		1 litre=	8,956	kcal
Natural gas (MM kcal/GJ)		1MMkcal=	4.1868	GJ
		1 M cal=	8.454*10^6	cubic meter
Natural gas (GJ/MM BTU)		1MMBTU=	1.0551	GJ
Natural gas (BTU per cubic feet)		1SCF=	1,029	1,000 BTU
		1 cubic feet=	10.3399	mmcfd
	BPDB	1 cubic feet=	239.4000	Kcal
	BPDB	1 cubic feet=	950.0000	BTU

Fiscal Year ending at June of	Unit	20 2028	21 2029	22 2030	23 2031	24 2032	25 2033	26 2034	27 2035	28 2046	29 2037	30 2038	31 2039	32 2040	33 2041	34 2042	35 2043	36 2044	37 2045	38 2046	39 2047	40 2048
Inflation																						
Local Inflation (end of June)	% p.a.	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%
Local inflation (average for fiscal year)	% p.a.	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%	5.7%
US inflation (average, calendar yr)	% p.a.	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Inflation in Japan (average, calendar yr)	% p.a.	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Price index																						
Local prices (average: 1995-96=100)		600.9	635.1	308.9	326.6	345.2	364.8	385.6	407.6	430.9	455.4	481.4	508.8	537.8	568.5	600.9	635.1	430.9	455.4	481.4	508.8	537.8
Local prices (end of June: 1996=100)		613.3	648.3	315.3	333.3	352.3	372.4	393.6	416.0	439.8	464.8	491.3	519.3	548.9	580.2	613.3	648.3	439.8	464.8	491.3	519.3	548.9
US prices (average: 1982-84=100)		340.9	349.4	253.5	259.8	266.3	273.0	279.8	286.8	294.0	301.3	308.8	316.6	324.5	332.6	340.9	349.4	294.0	301.3	308.8	316.6	324.5
Japanese prices (average: 2005=100)		118.8	120.0	105.4	106.5	107.5	108.6	109.7	110.8	111.9	113.0	114.1	115.3	116.4	117.6	118.8	120.0	111.9	113.0	114.1	115.3	116.4
Exchange rate																						
Taka/US$ (average)	Taka	106.82	108.67	110.53	112.38	114.24	116.09	117.94	119.80	140.20	123.51	125.36	127.22	129.07	130.93	132.78	134.64	136.49	138.35	140.20	142.06	143.91
Change from previous year	% p.a.	1.77%	1.74%	33.64%	32.90%	32.19%	31.52%	30.87%	30.25%	49.41%	29.07%	28.52%	27.99%	27.48%	26.98%	26.51%	26.05%	45.46%	44.58%	43.73%	42.92%	42.13%
Taka/JPY (average)	Taka	1.37	1.41	1.44	1.47	1.51	1.54	1.57	1.61	1.97	1.67	1.71	1.74	1.77	1.81	1.84	1.87	1.91	1.94	1.97	2.01	2.04
Change from previous year	% p.a.	2.50%	2.44%	53.69%	51.83%	50.10%	48.48%	46.96%	45.54%	73.66%	42.93%	41.74%	40.61%	39.54%	38.52%	37.56%	36.64%	67.77%	65.83%	64.00%	62.26%	60.62%
Electricity Tariff																						
Average Billing Rate of BPDB	Tk/kWh	7.45	7.88	3.83	4.05	4.28	4.52	4.78	5.05	5.34	5.65	5.97	6.31	6.67	7.05	7.45	7.88	5.34	5.65	5.97	6.31	6.67
Ave Bulk Wholesale Tariff	Tk/kWh																					
Willingness-to-Pay (generation level)	Tk/kWh	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85
Fuel price (real)																						
Domestic Coal	US Cents/MM kcal	2,386	2,432	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478	2,478
	US$/ton	145.57	148.35	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14	151.14
Imprted Coal	US Cents/MM kcal	2,687	2,745	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802	2,802
	US$/ton	136.40	139.30	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20	142.20
Heavy Fuel Oil (Furnace Oil)	US Cents/MM kcal	6,682	6,771	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861	6,861
High Speed Diesel Oil	US Cents/MM kcal	10,245	10,382	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520	10,520
Natural Gas (Domestic)																						
Natural Gas (Import)	US Cents/MM kcal	5,011	5,078	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145	5,145
Fuel price (real)																						
Domestic Coal	Tk/MM kcal	1,661	1,692	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724	1,724
	Taka/Ton	10,130	10,324	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518	10,518
Imprted Coal	Tk/MM kcal	1,870	1,910	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950	1,950
	Taka/Ton	9,538	9,740	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943	9,943
Heavy Fuel Oil (Furnace Oil)	Tk/MM kcal	4,650	4,712	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774
	Taka/Litre	44.39	44.98	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58	45.58
High Speed Diesel Oil	Tk/MM kcal	7,130	7,225	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321	7,321
	Taka/Litre	63.85	64.71	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56	65.56
Natural Gas (Domestic)	Tk/MM kcal																					
	Taka/10^3 cft																					
Natural Gas (Import)	Tk/MM kcal	3,487	3,534	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581	3,581
	Taka/10^3 cft	835	846	857	857	857	857	857	857	857	857	857	857	857	857	857	857	857	857	857	857	857

Source: PSMP Study Team

Legend:

(orange)	=Actuals and shall not be changed.
(pink)	=Exchange rate indicated by JICA in March 2010. Actual Record by BB is US$1=Tk 69.185 for FY 2010.
(lavender)	=Estimate based on July-February Performance
(light cyan)	=Fields for input with assumptive data.
(light blue)	

Conversion Factor

Coal (Domestic)		1 kg=	6,100	kcal
Coal (Imported)		1 kg=	5,100	kcal
Furnace Oil		1 litre=	9,546	kcal
High Speed Diesel Oil		1 litre=	8,956	kcal
Natural gas (MM kcal/GJ)		1MMkcal=	4.1868	GJ
		1 M cal=	8.454*10^6	cubic meter
Natural gas (GJ/MM BTU)		1MMBTU=	1.0551	GJ
Natural gas (BTU per cubic feet)		1SCF=	1,029	1,000 BTU
		1 cubic feet=	10.3399	mmcfd
	BPDB	1 cubic feet=	239.4000	Kcal
	BPDB	1 cubic feet=	950.0000	BTU

APTable 16-2 PROJECT PARAMETERS <2010 Constant Price>

Item	Combined Cycle Gas Turbine		
Capital Investment			
Capacity		1200.0	MW
Plant Factor		85.0%	
Annual Output		8,935.2	GWh
Auxiliary Consumption		5.0%	
Net Units at Busbar		8,488.4	GWh
Net Heat Rate		1,911	kcal/kWh
Project Life		30	years
Construction to Start		July 1, 2014	
Commercial Operation to Start		July 1, 2018	
Land Cost			Tk/m²/yr
Price of Fuel		Refer to Macro Assumption	
Equipment and Infrastructure Cost		Refer to Project Capital Cost	
Depreciation		30	years for total plant
Salvage Value		10.0%	
Physical Contingencies		5.0%	of total EPC Contract
Price Contingencies (Foreign)		2.0%	p.a. of total EPC Contract per
Price Contingency (Local)		5.0%	p.a. of total EPC Contract per
Finance			
Equity	18%	18%	of total investment
Debt	82%	82%	of total investment
Donor Loan	70%	70%	of total investment
Domestic Loan	12%	12%	of total investment
Donor Loan			
Grace Period	5	5	years
Repayment Period	20	20	years
Rate of Interest During Operation Period	4.00%	4.00%	p.a.
Rate of Interest During Construction	4.00%	4.00%	p.a.
Domestic Loan			
Grace Period	5	5	years
Repayment Period	20	20	years
Rate of Interest During Operation Period	3.00%	3.00%	p.a.
Rate of Interest During Construction	3.00%	3.00%	p.a.
Operation & Maintenance			
Normal Maintenance			
Fixed Cost	3,699	3,699	Taka/kW/year (US$53.30/kW)
Variable Cost	208	208	Taka/MWh
Administration Cost			
Overhead Cost	10.00%	10.00%	of O&M cost

(source)

Target Financial Ratio

Debt/equity ratio			(Target set by FRRP=60%)
Return on equity (after tax)		6.0%	
Return on equity (before tax)			
Return on asset			

Source: PSMP Study Team

APTable 16-3 CAPITAL COST (Imported Coal) <2010 Constant Price>

A2. Fuel Gas Brunch Pipeline	Total Cost			Year 1 (Tk million)	Year 2 (Tk million)	Year 3 (Tk million)	Year 4 (Tk million)
	Foreign Cy (US$ million)	Local Cy (Tk.	Total Cost (Tk				
A. Construction Work							
A1.Power Plant Installation & Related Works							
FOB Price of Imported Equipment	1,308	4,410	95,455				
Construction, Erection, Commissioning & I	90	14,632	20,895				
A2. Transmission Line							
Main Transmission Line	39	0	2,693				
A3. Total EPC Contract (Foreign)	1,437	0	100,001	15,000	30,000	35,000	20,000
A4. Total EPC Contract (Local)	0	19,042	19,042	2,856	5,713	6,665	3,808
B. Consulting Services							
Consulting Services (Foreign)	72	0	5,000	750	1,500	1,750	1,000
Consulting Services (Local)	0	952	952	143	286	333	190
C. Contingency							
C1. Physical Contingency (Foreign)	72	0	5,000	750	1,500	1,750	1,000
C2. Physical Contingency (Local)	0	952	952	143	286	333	190
C3. Price Contingency (Foreign)	29	0	1,997	300	599	699	399
C4. Price Contingency (Local)	0	952	952	143	286	333	190
E. Interest During Construction							
E1. Cumulative Total of A-C (Foreign) excl C-3				16,500	49,500	88,001	110,001
E2. Cumulative Total of A-C (Local) excl. C-4				3,142	9,426	16,757	20,946
E3. Interest During Construction (Foreign)				231	924	1,925	2,772
E4. Interest During Construction (Local)				6	23	47	68
Exchange Loss During Construction							
TOTAL PROJECT COST (excl Price Contingency)							
Total (Foreign)				16,731	33,924	40,425	24,772
Total (Local)				3,148	6,306	7,378	4,257
TOTAL				19,879	40,231	47,804	29,029
CUMULATIVE INVESTMENT (excl. Price Contingency)							
Total (Foreign)				16,731	50,655	91,081	115,853
Total (Local)				3,148	10,581	16,832	21,089
TOTAL				19,879	61,236	107,913	136,942
CUMULATIVE BALANCE OF LOAN (excl. Price Contingency)							
Total (Foreign)				13,915	42,865	75,539	95,860
Total (Local)				2,385	7,348	12,950	16,433
TOTAL				16,301	50,214	88,489	112,293
Equity (18%) in Taka million				3,578	11,023	19,424	24,650
Borrowing from GOB (12%) in Taka million				2,385	7,348	12,950	16,433
Borrowing of External Funds (70%) in Taka million				13,915	42,865	75,539	95,860

(Note) Constant price as of June, 2010

Source: PSMP Study Team

APTable 16-4 CAPITAL COST (Minemouth) <2010 Constant Price>

A2. Fuel Gas Brunch Pipeline	Total Cost			Year 1 (Tk million)	Year 2 (Tk million)	Year 3 (Tk million)	Year 4 (Tk million)
	Foreign Cy (US$ million)	Local Cy (Tk. million)	Total Cost (Tk million)				
A. Construction Work							
A1.Power Plant Installation & Related Works							
FOB Price of Imported Equipment	1,237	2,205	88,267				
Construction, Erection, Commissioning & I	90	14,656	20,926				
A2. Transmission Line							
Main Transmission Line	35	0	2,443				
A3. Total EPC Contract (Foreign)	1,362	0	94,775	14,216	28,432	33,171	18,955
A4. Total EPC Contract (Local)	0	16,861	16,861	2,529	5,058	5,901	3,372
B. Consulting Services							
Consulting Services (Foreign)	68	0	4,739	711	1,422	1,659	948
Consulting Services (Local)	0	843	843	126	253	295	169
C. Contingency							
C1. Physical Contingency (Foreign)	68	0	4,739	711	1,422	1,659	948
C2. Physical Contingency (Local)	0	843	843	126	253	295	169
C3. Price Contingency (Foreign)	27	0	1,893	284	568	662	379
C4. Price Contingency (Local)	0	843	843	126	253	295	169
E. Interest During Construction							
E1. Cumulative Total of A-C (Foreign) excl C-3				15,638	46,913	83,402	104,252
E2. Cumulative Total of A-C (Local) excl. C-4				2,782	8,346	14,838	18,547
E3. Interest During Construction (Foreign)				219	876	1,824	2,627
E4. Interest During Construction (Local)				5	20	42	60
Exchange Loss During Construction							
TOTAL PROJECT COST (excl Price Contingency)							
Total (Foreign)				15,857	32,151	38,313	23,478
Total (Local)				2,787	5,584	6,533	3,770
TOTAL				18,644	37,736	44,846	27,247
CUMULATIVE INVESTMENT (excl. Price Contingency)							
Total (Foreign)				15,857	48,008	86,321	109,798
Total (Local)				2,787	8,371	14,904	18,674
TOTAL				18,644	56,379	101,225	128,472
CUMULATIVE BALANCE OF LOAN (excl. Price Contingency & IDC)							
Total (Foreign)				13,051	39,466	70,858	89,931
Total (Local)				2,237	6,766	12,147	15,417
TOTAL				15,288	46,231	83,005	105,347
Equity (18%) in Taka million				3,356	10,148	18,221	23,125
Borrowing from GOB (12%) in Taka million				2,237	6,766	12,147	15,417
Borrowing of External Funds (70%) in Taka million				13,051	39,466	70,858	89,931

(Note) Constant price as of June, 2010

Source: PSMP Study Team

APTable 16-5 CAPITAL & OPERATIONAL COST <EIRR> (Imported Coal)

(Taka Million)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Fiscal Year Ending at	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Gross Annual Energy Output (GWh)						8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935
Net Annual Energy Output (GWh)						8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488
Electricity Sales						66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634
Capital Expenditure (cumulative)		19,879	61,236	107,913	136,942																
Foreign Currency		16,731	50,655	91,081	115,853																
Local Currency		3,148	10,581	16,832	21,089																
Fund Raising (Balance at Year End)																					
Equity (Cumulative Investment)		3,578	11,023	19,424	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650
Loan Balance (foreign)		13,915	42,865	75,539	95,860	95,860	95,860	95,860	95,860	95,860	89,469	83,078	76,688	70,297	63,906	57,516	51,125	44,735	38,344	31,953	25,563
Loan Balance (local)		2,385	7,348	12,950	16,433	16,433	16,433	16,433	16,433	16,433	15,338	14,242	13,146	12,051	10,955	9,860	8,764	7,669	6,573	5,478	4,382
Repayment of Loans																					
Foreign Loan Repayment						0	0	0	0	0	6,391	6,391	6,391	6,391	6,391	6,391	6,391	6,391	6,391	6,391	6,391
Local Loan Repayment						0	0	0	0	0	1,096	1,096	1,096	1,096	1,096	1,096	1,096	1,096	1,096	1,096	1,096
Equity																					
Increase of Equity						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redemption of Equity						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed Cost																					
O & M (Fixed)						4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439
Admin Overhead Expense (Fixed)						444	444	444	444	444	444	444	444	444	444	444	444	444	444	444	444
Depreciation																					
Variable Cost																					
Fuel Cost						25,308	26,080	26,853	27,625	28,374	29,100	29,826	30,552	31,231	31,933	32,612	33,291	33,291	33,291	33,291	33,291
O & M (Variable)						1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859
Admin Overhead Expense (Variable)						186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186
Salvage Value																					
Land																					
Plant																					
Annual Costs						32,235	33,007	33,780	34,552	35,302	36,027	36,753	37,479	38,158	38,860	39,539	40,218	40,218	40,218	40,218	40,218
Total Fixed Costs						4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883
Total Variable Costs						27,352	28,125	28,897	29,670	30,419	31,145	31,870	32,596	33,275	33,977	34,656	35,335	35,335	35,335	35,335	35,335
EIRR under the Logical Willingness-to-Pay																					
Economic Benefit						66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634
Capital Cost		19,879	41,357	46,677	29,029																
Operation Cost						32,235	33,007	33,780	34,552	35,302	36,027	36,753	37,479	38,158	38,860	39,539	40,218	40,218	40,218	40,218	40,218
Economic Benefit - Economic Cost		-19,879	-41,357	-46,677	-29,029	34,400	33,627	32,855	32,082	31,333	30,607	29,881	29,155	28,477	27,774	27,095	26,416	26,416	26,416	26,416	26,416
EIRR		17.69%																			

Source: PSMP Study Team

		21	22	23	24	25	26	27	28	29	30	31	32	33	34
Fiscal Year Ending at	**Unit**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**
Gross Annual Energy Output (GWh)		8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935
Net Annual Energy Output (GWh)		8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488
Electricity Sales		66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634
Capital Expenditure (cumulative)															
Foreign Currency															
Local Currency															
Fund Raising (Balance at Year End)															
Equity (Cumulative Investment)		24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650	24,650
Loan Balance (foreign)		19,172	12,781	6,391	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Loan Balance (local)		3,287	2,191	1,096	0	0	0	0	0	0	0	0	0	0	0
Repayment of Loans															
Foreign Loan Repayment		6,391	6,391	6,391	6,391	0	0	0	0	0	0	0	0	0	0
Local Loan Repayment		1,096	1,096	1,096	1,096	0	0	0	0	0	0	0	0	0	0
Equity															
Increase of Equity		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redemption of Equity		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed Cost															
O & M (Fixed)		4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439
Admin Overhead Expense (Fixed)		444	444	444	444	444	444	444	444	444	444	444	444	444	444
Depreciation															
Variable Cost															
Fuel Cost		33,291	33,291	33,291	33,291	33,291	33,291	33,291	33,291	33,291	33,291	33,291	33,291	33,291	33,291
O & M (Variable)		1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859
Admin Overhead Expense (Variable)		186	186	186	186	186	186	186	186	186	186	186	186	186	186
Salvage Value															
Land															0
Plant															13,694
Annual Costs		40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218
Total Fixed Costs		4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883
Total Variable Costs		35,335	35,335	35,335	35,335	35,335	35,335	35,335	35,335	35,335	35,335	35,335	35,335	35,335	35,335
EIRR under the Logical Willingness-to-Pay															
Economic Benefit		66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	80,328
Capital Cost															
Operation Cost		40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218	40,218
Economic Benefit - Economic Cost		26,416	26,416	26,416	26,416	26,416	26,416	26,416	26,416	26,416	26,416	26,416	26,416	26,416	40,111
EIRR															

Source: PSMP Study Team

APTable 16-6 CAPITAL & OPERATIONAL COST <EIRR> (Minemouth)

(Taka Million)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Fiscal Year Ending at	Unit	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Gross Annual Energy Output (GWh)						8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935
Net Annual Energy Output (GWh)						8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488
Electricity Sales						66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634
Capital Expenditure (cumulative)		18,644	53,592	92,854	113,568																
Foreign Currency		15,857	48,008	86,321	109,798																
Local Currency		2,787	5,584	6,533	3,770																
Fund Raising (Balance at Year End)																					
Equity (Cumulative Investment)		3,356	9,647	16,714	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442
Loan Balance (foreign)		13,051	37,515	64,998	79,497	79,497	79,497	79,497	79,497	79,497	74,198	68,898	63,598	58,298	52,998	47,698	42,399	37,099	31,799	26,499	21,199
Loan Balance (local)		2,237	6,431	11,142	13,628	13,628	13,628	13,628	13,628	13,628	12,720	11,811	10,903	9,994	9,085	8,177	7,268	6,360	5,451	4,543	3,634
Repayment of Loans																					
Foreign Loan Repayment						0	0	0	0	0	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300	5,300
Local Loan Repayment						0	0	0	0	0	909	909	909	909	909	909	909	909	909	909	909
Equity																					
Increase of Equity						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redemption of Equity						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed Cost																					
O & M (Fixed)						4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439
Admin Overhead Expense (Fixed)						444	444	444	444	444	444	444	444	444	444	444	444	444	444	444	444
Depreciation																					
Variable Cost																					
Fuel Cost						23,055	23,673	24,291	24,910	25,509	26,089	26,670	27,251	27,794	28,356	28,899	29,442	29,442	29,442	29,442	29,442
O & M (Variable)						1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859
Admin Overhead Expense (Variable)						186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186
Salvage Value																					
Land																					
Plant																					
Annual Costs						29,982	30,601	31,219	31,837	32,436	33,017	33,597	34,178	34,721	35,283	35,826	36,369	36,369	36,369	36,369	36,369
Total Fixed Costs						4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883
Total Variable Costs						25,100	25,718	26,336	26,954	27,553	28,134	28,714	29,295	29,838	30,400	30,943	31,486	31,486	31,486	31,486	31,486
EIRR under the Logical Willingness-to-Pay																					
Economic Benefit						66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634
Capital Cost		18,644	34,948	39,262	20,714																
Operation Cost						29,982	30,601	31,219	31,837	32,436	33,017	33,597	34,178	34,721	35,283	35,826	36,369	36,369	36,369	36,369	36,369
Economic Benefit - Economic Cost		-18,644	-34,948	-39,262	-20,714	36,652	36,034	35,416	34,798	34,198	33,618	33,037	32,456	31,913	31,351	30,808	30,265	30,265	30,265	30,265	30,265
EIRR		22.10%																			

Source: PSMP Study Team

Fiscal Year Ending at	Unit	21 2035	22 2036	23 2037	24 2038	25 2039	26 2040	27 2041	28 2042	29 2043	30 2044	31 2045	32 2046	33 2047	34 2048
Gross Annual Energy Output (GWh)		8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935	8,935
Net Annual Energy Output (GWh)		8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488	8,488
Electricity Sales		66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634
Capital Expenditure (cumulative)															
Foreign Currency															
Local Currency															
Fund Raising (Balance at Year End)															
Equity (Cumulative Investment)		20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442	20,442
Loan Balance (foreign)		15,899	10,600	5,300	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Loan Balance (local)		2,726	1,817	909	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Repayment of Loans															
Foreign Loan Repayment		5,300	5,300	5,300	5,300	0	0	0	0	0	0	0	0	0	0
Local Loan Repayment		909	909	909	909	0	0	0	0	0	0	0	0	0	0
Equity															
Increase of Equity		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redemption of Equity		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed Cost															
O & M (Fixed)		4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439	4,439
Admin Overhead Expense (Fixed)		444	444	444	444	444	444	444	444	444	444	444	444	444	444
Depreciation															
Variable Cost															
Fuel Cost		29,442	29,442	29,442	29,442	29,442	29,442	29,442	29,442	29,442	29,442	29,442	29,442	29,442	29,442
O & M (Variable)		1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859	1,859
Admin Overhead Expense (Variable)		186	186	186	186	186	186	186	186	186	186	186	186	186	186
Salvage Value															
Land															0
Plant															11,357
Annual Costs		36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369
Total Fixed Costs		4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883	4,883
Total Variable Costs		31,486	31,486	31,486	31,486	31,486	31,486	31,486	31,486	31,486	31,486	31,486	31,486	31,486	31,486
EIRR under the Logical Willingness-to-Pay															
Economic Benefit		66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	66,634	77,991
Capital Cost															
Operation Cost		36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369	36,369
Economic Benefit - Economic Cost		30,265	30,265	30,265	30,265	30,265	30,265	30,265	30,265	30,265	30,265	30,265	30,265	30,265	41,622
EIRR															

Source: PSMP Study Team

APTable 16-7 ECONOMIC INTERNAL RATE OF RETURN (Imported Coal)

(Taka Million)

Fiscal Year	Economic Cost (A)			Economic Benefit (B)	(B) - (A)
	Capital	O&M	Total Cost		
2015	19,879		19,879		-19,879
2016	41,357		41,357		-41,357
2017	46,677		46,677		-46,677
2018	29,029		29,029		-29,029
2019		32,235	32,235	66,634	34,400
2020		33,007	33,007	66,634	33,627
2021		33,780	33,780	66,634	32,855
2022		34,552	34,552	66,634	32,082
2023		35,302	35,302	66,634	31,333
2024		36,027	36,027	66,634	30,607
2025		36,753	36,753	66,634	29,881
2026		37,479	37,479	66,634	29,155
2027		38,158	38,158	66,634	28,477
2028		38,860	38,860	66,634	27,774
2029		39,539	39,539	66,634	27,095
2030		40,218	40,218	66,634	26,416
2031		40,218	40,218	66,634	26,416
2032		40,218	40,218	66,634	26,416
2033		40,218	40,218	66,634	26,416
3034		40,218	40,218	66,634	26,416
3035		40,218	40,218	66,634	26,416
3036		40,218	40,218	66,634	26,416
3037		40,218	40,218	66,634	26,416
2038		40,218	40,218	66,634	26,416
2039		40,218	40,218	66,634	26,416
2040		40,218	40,218	66,634	26,416
2041		40,218	40,218	66,634	26,416
2042		40,218	40,218	66,634	26,416
2043		40,218	40,218	66,634	26,416
2044		40,218	40,218	66,634	26,416
2045		40,218	40,218	66,634	26,416
2046		40,218	40,218	66,634	26,416
2047		40,218	40,218	66,634	26,416
2048		40,218	40,218	80,328	40,111
EIRR	**17.69%**				

Source: PSMP Study Team

APTable 16-8 ECONOMIC INTERNAL RATE OF RETURN (Minemouth)

(Taka Million)

Fiscal Year	Economic Cost (A)			Economic Benefit (B)	(B) - (A)
	Capital	O&M	Total Cost		
2015	18,644		18,644		-18,644
2016	34,948		34,948		-34,948
2017	39,262		39,262		-39,262
2018	20,714		20,714		-20,714
2019		29,982	29,982	66,634	36,652
2020		30,601	30,601	66,634	36,034
2021		31,219	31,219	66,634	35,416
2022		31,837	31,837	66,634	34,798
2023		32,436	32,436	66,634	34,198
2024		33,017	33,017	66,634	33,618
2025		33,597	33,597	66,634	33,037
2026		34,178	34,178	66,634	32,456
2027		34,721	34,721	66,634	31,913
2028		35,283	35,283	66,634	31,351
2029		35,826	35,826	66,634	30,808
2030		36,369	36,369	66,634	30,265
2031		36,369	36,369	66,634	30,265
2032		36,369	36,369	66,634	30,265
2033		36,369	36,369	66,634	30,265
3034		36,369	36,369	66,634	30,265
3035		36,369	36,369	66,634	30,265
3036		36,369	36,369	66,634	30,265
3037		36,369	36,369	66,634	30,265
2038		36,369	36,369	66,634	30,265
2039		36,369	36,369	66,634	30,265
2040		36,369	36,369	66,634	30,265
2041		36,369	36,369	66,634	30,265
2042		36,369	36,369	66,634	30,265
2043		36,369	36,369	66,634	30,265
2044		36,369	36,369	66,634	30,265
2045		36,369	36,369	66,634	30,265
2046		36,369	36,369	66,634	30,265
2047		36,369	36,369	66,634	30,265
2048		36,369	36,369	80,328	43,959
EIRR	22.10%				

Source: PSMP Study Team

Chapter 18 Environmental and Social Examination on Most Prioritized Projects APPENDIX

18.1 Laws and regulation regarding environmental and social consideration

18.1.1 Environmental policy

Strategy, Policy, Law, Rule

Bangladesh has legislated an inclusive policy and law, which is related to all environmental controls after the United Nations Conference on Environment and Development (UNCED), Rio de Janeiro, 3-14 June 1992. The main domestic strategies, policies, laws and rules adopted in Bangladesh related to the environment are shown below.

(1) The National Environmental Policy, 1992
(2) Environmental Action Plan, 1992
(3) The Bangladesh Environmental Conservation Act, 1995
(4) The Environmental Conservation Rules, 1997(ECR)
(5) National Conservation Strategy (NCS), 1992
(6) National Environmental Management Action Plan "NEMAP", 1995
(7) The Environmental Court Act, 2000

The Environmental Policy which was established in 1992 plays the overarching role of outlining the whole of the policy. The objectives of the Environmental Policy are:

- To maintain ecological balance and overall development through protection and improvement of the environment
- To protect the country against natural disasters
- To identify and regulate activities, which pollute and degrade the environment
- To ensure environmentally sound development in all sectors
- To ensure sustainable, long term and environmentally sound use of all national resources
- To actively remain adherent to all international environmental initiatives as much as possible

These objectives include 15 sectors. Environmental policy for industrial areas has been stipulated as follows:

- Adopt corrective measures for industries polluting the environment in phases.
- Undertake Environmental Impact Assessment (EIA) for all new industries both in the public and private sectors.
- Impose a ban on the establishment of industries producing goods which cause environmental pollution; close down such existing industries in phases and discourage the use of such polluting products through the development/introduction of the environmentally sound substitutes.
- Encourage development of environmentally sound and appropriate technology and initiatives with the best of labors and provision of proper wages.
- Prevent wastage of raw materials in industries and ensure their sustainable use.

It also stipulates policy implementation by the National Environment Committee and the legal status of the Department of the Environment (DOE) which implements EIA.

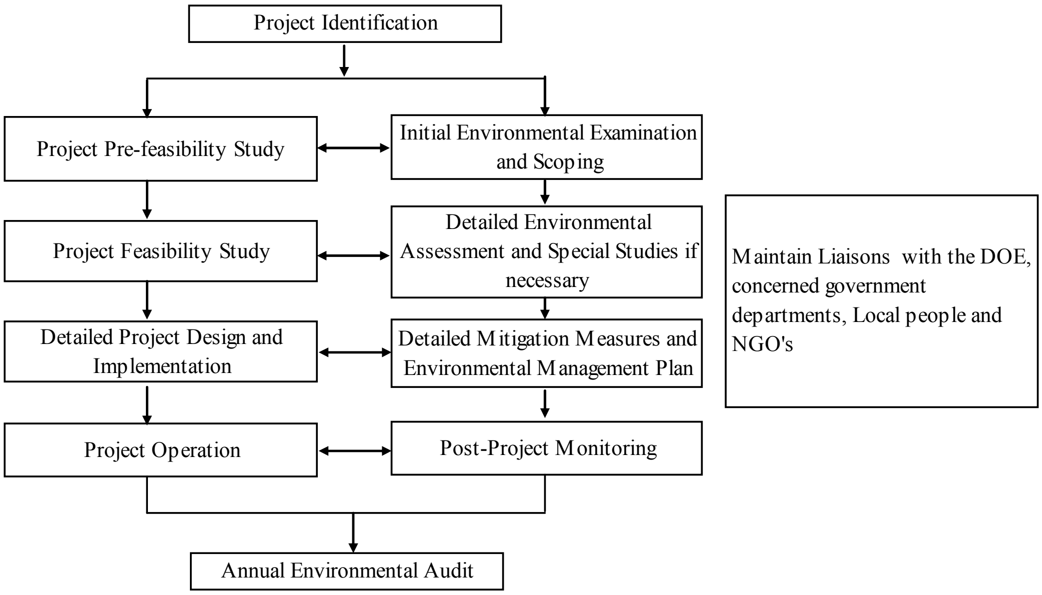
In addition, the Bangladesh State of Environment (SoE) Report, which was prepared in 2001 as a response to the recommendations provided in Agenda 21 at the Earth Summit in 1992, identifies five key environmental issues in Bangladesh (Land degradation, Water Pollution and Scarcity, Air pollution, Biodiversity, Natural disaster), and Bangladesh intends to realize a sustainable environment and development through countermeasures for these five key issues.

18.1.2 Laws and regulations regarding environmental control

(1) Procedures of EIA

The procedures of EIA regarding industrial development in Bangladesh have been stipulated in the Environmental Conservation Rules based on the Environmental Conservation Act. As detailed EIA guidelines regarding procedures, investigation contents and assessment processes, an EIA guideline for Industries was issued by the DOE in 1997. Further, EIA Guidelines for coal mine development were issued in March 2009.

The Environmental Conservation Act has designated projects to be divided into four categories (Green, Amber-A, Amber-B, Red). In the event of a Red Category industrial unit or project, the Initial Environmental Examination (IEE) and a full EIA are required. Subject to a satisfactory review of the environmental assessment, the DOE issues an authorization for the project to proceed.



Source : "EIA Process" EIA Guidelines for Industries, Department of Environment, 1997

APFig. 18-1 Flow chart of EIA process

Coal mine development and Power development are allocated to the Red Category by ECR, and an Initial Environmental Examination (IEE) and a full EIA are required. The IEE procedures are as follows.

- Collection of baseline data in respect of the project and the environmental conditions of the project and its site
- Specify significant items pertaining to IEE
- Suggest mitigation measures, EMP, alternative site or other project improvements
- Terms of Reference (TOR) for EIA

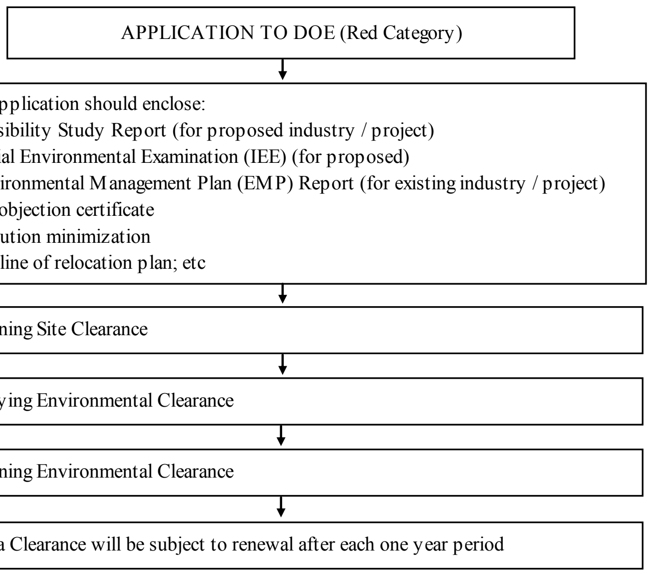
After the completion of an IEE report, the entrepreneur should apply to the DOE in the prescribed format for the application of a Location Clearance Certificate (LCC). The following documents shall be attached with an LCC application.

- Report on the feasibility of the industrial unit or project

- Report on the IEE relating to the industrial unit or project
- No Objection Certificate (NOC) of the local authority
- Emergency plan relating adverse environmental impacts and plans for the mitigation of the effect of pollutions
- Outline of relocation, rehabilitation plan (where applicable)
- Other necessary information (where applicable)

The LCC shall be issued along with DOE's comments on the TOR of the EIA within thirty days of the receipt of the LCC application. The entrepreneur shall submit the EIA report prepared on the basis of a program outlined in the TOR of the EIA to DOE for approval. The EIA report shall be approved within thirty working days. After obtaining approval for the EIA report, an Environmental Clearance Certificate (ECC) shall be granted to the concerned entrepreneur within fifteen working days. The entrepreneur can commence commercial operations after obtaining the ECC[1].
The validity period of Environmental Clearance Certificate shall be one year. At the same time the Environmental Clearance Certificate is validated, the DOE will verify that the environmental standards required by the DOE concerning certification and sound operating conditions are satisfied.
APFig. 18-2 shows the EIA flow chart for procedures in the RED category.

The Environmental Management Plan (EMP) is a key requirement of the EIA, for projects classified in the Red categories. The main objective of the EMP is to enable the entrepreneur to show the DOE how to achieve environmental performance during the construction and operational phases assessed in the EIA which is approved by the DOE. The EMP must describe in detail the organization and management responsibilities, provide details of the mitigation measures identified in the EIA implementation, and explain how the monitoring is implemented. The entrepreneur is also required to comply with environmental regulations.



Source : "EIA Flow Chart" EIA Guidelines for Industries, Department of Environment, 1997

APFig. 18-2 EIA flow chart for procedures on RED category

(2) Environmental regulation

Details of the environmental standards applicable in Bangladesh are described in the Environmental Conservation Rules (ECR). Regulated Areas spread to all industries and regulated

[1] DoE comment, Aug.2010

items are air quality, water quality (surface water, drink water), noise (boundary, source), emissions from motor vehicles or ships, odor, sewage discharge, waste from industrial units and industrial effluents or emissions. Items and standards, which are related to the construction and operation of coal-fired power plants, are listed below. Tables and annotations of environmental regulation are described as textual description of ECR.

(a) Air quality

APTable 18-1 shows the air quality standard in Bangladesh. Air quality standards adhere to WHO guidelines.

APTable 18-1 Standards for air quality in Bangladesh[1]

No.	Pollutant	Density (mg/m^3)		Exposure time
		ECR	WHO guide line	
a)	Carbon Mono-oxide	10	-	8 hours
		40	-	1 hour
b)	Lead (Pb)	0.5	-	Annual
c)	Nitrogen Oxide	0.1	0.04	Annual
d)	Suspended Particulate Matter (SPM)	0.2	-	8 hours
e)	Particulate Matter 10 (PM10)	0.05	0.02	Annual
		0.15	0.05	24 hours
f)	Particulate Matter 2.5 (PM2.5)	0.015	0.01	Annual
		0.065	0.025	24 hours
g)	Ozone	0.235	-	1 hour
		0.157	0.160	8 hours
h)	Sulfur dioxide	0.08	-	Annual
		0.365	0.02	24 hours

Source : Bangladesh Gazette, July 19, 2005 IFC Environmental Health and Safety Guidelines 2007

APTable 18-2 shows gas emission standards for industrial facilities in Bangladesh. APTable 18-3 shows gas emission standards for industrial boiler in Bangladesh.

APTable 18-2 Gas emission standard for industrial facilities[2]

No.	Parameter	Unit	Standard Limit
1	Particulates		
	a) Electric Power Station of 200 Megawatts and above	mg/Nm^3	150
	b) Electric Power Station less than 200 Megawatts	mg/Nm^3	350
2	Chlorine	mg/Nm^3	150
3	Hydrochloric Acid gas & mist	mg/Nm^3	350
4	Total Fluoride (F)	mg/Nm^3	25
5	Sulfuric Acid mist	mg/Nm^3	50
6	Lead particle	mg/Nm^3	10
7	Mercury particle	mg/Nm^3	0.2
8	Sulfur Dioxide		
	a) Sulfuric Acid manufacture (DCDA process)	kg/ton	4
	b) Sulfuric Acid manufacture (SCSA process) Minimum Stack height for Sulfuric Acid emission	kg/ton	10
	Lowest height of stack for dispersion of sulfuric acid a) Coal Fired Electric Power Station		
	i) 500 Megawatts & above	M	275
	ii) 200-500 Megawatts	M	220
	iii) Below 200 Megawatts	M	$14\ (Q)^{0.3(1)}$
	b) Boiler		
	i) For Steam up to 15 tons/hour	M	11

1 Not exceed one time in year

2 (1)Q=SO2 emission in kg/hour

No.	Parameter	Unit	Standard Limit
	ii) For steam above 15 tons/hour	M	$14\ (Q)^{0.3(1)}$
9	Nitrogen Oxides		
	a) Nitric Acid manufacture	kg/ton	3
	b) Gas Fired Electric Power Station		
	i) 500 Megawatts & above	ppm	50
	ii) 200-500 Megawatts	ppm	40
	iii) Less than 200 Megawatts	ppm	30
	c) Metal Treatment Furnace	ppm	200
10	Soot & Dust Particles		
	a) Air Ventilated Furnace	mg/Nm^3	500
	b) Brick-field	mg/Nm^3	1000
	c) Cooking Furnace	mg/Nm^3	500
	d) Limestone Furnace	mg/Nm^3	250

Source : The Environmental Conservation Rules, 1997

APTable 18-3 Gas emission standard for industrial boiler

No.	Parameters	Standards for presence in a unit of mg/Nm3
1	Soot and particulate (fuel based)	
	a) Coal	500
	b) Gas	100
	c) Oil	300
2	Oxides of Nitrogen (fuel based)	
	a) Coal	600
	b) Gas	150
	c) Oil	300

Source : The Environmental Conservation Rules, 1997

A coal fired power plant utilizes coal (main fuel) and oil (auxiliary fuel for startup). Because the planned output of the power plant is 600MW, the emission standard limit of particulates is $150mg/Nm^3$. As for Sulfur Dioxide, if the stack of 275m height is mounted, there are no standard limit of emissions densities and amount limits. The Emission standard limit of Oxides of Nitrogen shown in APTable 18-3 is 600 mg/Nm^3 in the case of coal-firing and 300 mg/Nm^3 in the case of oil firing.

It is common in setting an emission standard to SO2 based on global standards. APTable 18-4 shows a comparison of the flue gas emission standards of Bangladesh with that of World Bank (IFC). A new coal-fired power plant should consider these world standards.

APTable 18-4 Comparison of flue gas emission standard between Bangladesh and IFC[1]

Parameters	ECR	IFC
SO_2	-(1)	$850mg/m^3$ (2)
NOx	600 mg/m^3	510 mg/m^3
Particulate Matter (PM)	$500mg/m^3$	$50mg/m^3$
Dry Gas , Excess O2 Content	-	6%

Source : The Environmental Conservation Rules, 1997 IFC Environmental Health and Safety Guidelines 2008

(b) Water quality

APTable 18-5 shows ambient water quality standard (inland surface water), APTable 18-6 shows environmental water quality standard (drinking water), and APTable 18-7 shows waste water

[1] (1) Lowest height of stack is defined
(2) As high limit in non-degraded airshed

standard parameters in Bangladesh. As for drinking water standard, waste water standard, it is put down in accordance with WHO guidelines.
And World Bank guideline stipulates monitoring of necessary heavy metals according to the character of each thermal power plant.

APTable 18-5 Ambient water quality standard (inland surface water)[1]

No.	Best Practice based classification	pH	BOD mg/1	Dissolved Oxygen (DO), mg/l	Total Coliform Bacteria quantity/ml
a)	Potable Water Source supply after bacteria freeing only	6.5-8.5	2 or less	6 or above	50 or less
b)	Water used for recreation purpose	6.5-8.5	3 or less	5 or above	200 or less
c)	Potable Water Source Supply after conventional processing	6.5-8.5	3 or less	6 or above	5000 or less
d)	Water used for pisciculture	6.5-8.5	6 or less	5 or above	5000 or less
e)	Industrial use water including chilling & other processes	6.5-8.5	10 or less	5 or above	
f)	Water used for irrigation	6.5-8.5	10 or less	5 or above	1000 or less

Source : The Environmental Conservation Rules, 1997

APTable 18-6 Environmental water quality standard (drinking water)

No.	Parameter	Unit	Standard limit	WHO guideline
1	Aluminum	mg/l	0.2	0.2
2	Ammonia (NH_3)	mg/l	0.5	-
3	Arsenic	mg/l	0.05	0.01
4	Barium	mg/l	0.01	0.7
5	Benzene	mg/l	0.01	0.01
6	BOD_5 20^{O}C	mg/l	0.2	-
7	Boron	mg/l	1.0	0.5
8	Cadmium	mg/l	0.005	0.003
9	Calcium	mg/l	75	-
10	Chloride	mg/l	150-600	-
11	Chlorinated Alkanes			-
	Carbon tetrachloride	mg/l	0.01	-
	1.1 Dichloroethylene	mg/l	0.001	-
	1.2 Dichloroethylene	mg/l	0.03	-
	Tetrachloroethylene	mg/l	0.03	-
	Trichloroethylene	mg/l	0.09	-
12	Chlorinated phenols			-
	Pentachlorophenol	mg/l	0.03	-
	2.4.6 Trichlorophenol	mg/l	0.03	-
13	Chlorine (residual)	mg/l	0.2	-
14	Chloroform	mg/l	0.09	0.3
15	Chromium (hexavalent)	mg/l	0.05	-
16	Chromium (total)	mg/l	0.05	0.05
17	COD	mg/l	4	-
18	Coliform (fecal)	n/100 ml	0	-
19	Coliform (total)	n/100 ml	0	-
20	Color	Huyghens unit	15	-
21	Copper	mg/l	1	-
22	Cyanide	mg/l	0.1	-
23	Detergents	mg/l	0.2	-
24	DO	mg/l	6	-
25	Fluoride	mg/l	1	1.5

[1]Textual annotations are as follows.
(1) Maximum amount of ammonia presence in water are 1.2 mg/l (as nitrogen molecule) which is used for pisciculture.
(2) For water used in irrigation Electrical Conductivity-2250 micro mho/cm (at 25oC). Sodium less than 26 mg/l, Boron less than 2 mg/l

No.	Parameter	Unit	Standard limit	WHO guideline
26	Hardness (as $CaCO_3$)	mg/l	200-500	-
27	Iron	mg/l	0.3	-
28	Nitrogen (Total)	mg/l	1	-
29	Lead	mg/l	0.05	0.01
30	Magnesium	mg/l	30-35	-
31	Manganese	mg/l	0.1	0.4
32	Mercury	mg/l	0.001	0.006
33	Nickel	mg/l	0.1	0.07
34	Nitrate	mg/l	10	3
35	Nitrite	mg/l	Less than 1	-
36	Odor		Odorless	-
37	Oil & Grease	mg/l	0.01	-
38	Ph		6.5-8.5	-
39	Phenolic compounds	mg/l	0.002	-
40	Phosphate	mg/l	6	-
41	Phosphorus	mg/l	0	-
42	Potassium	mg/l	12	-
43	Radioactive Materials (gross alpha activity)	Bq/l	0.01	-
44	Radioactive Materials (gross beta activity)	mg/l	0.1	-
45	Selenium	mg/l	0.01	-
46	Silver	mg/l	0.02	-
47	Sodium	mg/l	200	-
48	Suspended particulate matters	mg/l	10	-
49	Sulfide	mg/l	0	-
50	Sulfate	mg/l	400	-
51	Total dissolived solids	mg/l	1000	1000
52	Temperature	℃	20-30	-
53	Tin	mg/l	2	-
54	Turbidity	JTU	10	-
55	Zinc	mg/l	5	-

Source : The Environmental Conservation Rules, 1997 Guidelines for Drinking-water Quality WHO 2008

APTable 18-7 Wastewater discharge standards[1]

No.	Parameter	Unit	Inland Surface Water	Public Sewer at secondary treatment plant	Irrigated Land	IFC (World Bank guideline)
1	Ammoniacal Nitrogen (N molecule)	mg/l	50	75	75	-
2	Ammonia (free ammonia)	mg/l	5	5	15	-
3	Arsenic (As)	mg/l	0.2	0.05	0.2	0.5
4	BOD_5 20°C	mg/l	50	250	100	-
5	Boron	mg/l	2	2	2	-
6	Cadmium (Cd)	mg/l	0.05	0.5	0.5	0.1
7	Chloride	mg/l	600	600	600	-
8	Chromium (total Cr)	mg/l	0.5	1.0	1.0	0.5
9	COD	mg/l	200	400	400	-

[1] Textual annotations are as follows.
(1) These standards shall be applicable to industrial units or projects other than those given under Quality Standards for Classified Industries (Schedule 12).
(2) These quality standards must be ensured at the moment of going into trial production for industrial units and at the moment of going into trial production for industrial units and at the moment of going into operation for other projects.
(3) The value must not exceed the quality standard during spot check at any time ; if required, the quality standards may be more strict to meet the environment terms in certain areas.
(4) Inland Surface Water shall mean drain, pond, tank, water body or water hole, canal, river, spring and estuary.
(5) Public sewer shall mean sewer connected with fully combined processing plant including primary and secondary treatment.
(6) Irrigated land shall mean appropriately irrigated plantation area of specified crops based on quantity and quality of waste water.
(7) Inland Surface Quality Standards (Schedule 13) shall be applicable for any discharge taking place in public sewer or land not defined in Notes 5

No.	Parameter	Unit	Inland Surface Water	Public Sewer at secondary treatment plant	Irrigated Land	IFC (World Bank guideline)
10	Chromium (hexavalent Cr)	mg/l	0.1	1.0	1.0	-
11	Copper (Cu)	mg/l	0.5	3.0	3.0	0.5
12	Dissolved Oxygen (DO)	mg/l	4.5-8	4.5-8	4.5-8	-
13	Electrical Conductivity	micro mho/cm	1200	1200	1200	-
14	Total Dissolved Solids (TDS)	mg/l	2,100	2,100	2,100	-
15	Fluoride (F)	mg/l	7	15	10	-
16	Sulfide (S)	mg/l	1	2	2	-
17	Iron (Fe)	mg/l	2	2	2	1
18	Total Kjeldahl Nitrogen (N)	mg/l	100	100	100	-
19	Lead (Pb)	mg/l	0.1	1.0	0.1	0.5
20	Mangaense (Mn)	mg/l	5	5	5	-
21	Mercury (Hg)	mg/l	0.01	0.01	0.01	0.005
22	Nickel (Ni)	mg/l	1.0	2.0	1.0	-
23	Nitrate (N molecule)	mg/l	10.00	Undetermined	10	-
24	Oil & grease	mg/l	10	20	10	10
25	Phenol compounds(C_6H_5OH)	mg/l	1.0	5	1	-
26	Dissolved Phosphorus (P)	mg/l	8	8	10	-
27	Radioactive Materials.	As determined by Bangladesh Atomic Energy Commission				-
28	PH		6-9	6-9	6-9	6-9
29	Selenium	mg/l	0.05	0.05	0.05	-
30	Zn (Zn)	mg/l	5.0	10.0	10.0	1
31	Total Dissolved solid	mg/l	2,100	2,100	2,100	-
32	Temperature	Centigrade	40	40	40-Summer	-
			45	45	45-Winter	-
33	Total Suspended Solid (TSS)	mg/1	150	500	200	50
34	Cyanide (CN)	mg/1	0.1	2.0	0.2	-

Source : The Environmental Conservation Rules, 1997 IFC Environmental Health and Safety Guidelines 2008

(c) Others

As for noise, the standard limit is set for every category of zone class. APTable 18-8 shows the Noise standard in Bangladesh.

APTable 18-8 Standard for sound[1]

No	Zone Class	Limits in dBa (ECR)		Limits in dBa (IFC)	
		Day	Night	Day	Night
a)	Silent Zone	45	35	55	45
b)	Residential Zone	50	40		
c)	Mixed Zone (this area is used combinedly as residential, commercial and industrial purposes)	60	50	70	70
d)	Commercial Zone	70	60		
e)	Industrial Zone	70	70		

Source : The Environmental Conservation Rules, 1997 IFC Environmental Health and Safety Guidelines 2007

[1]Textual annotations are as follows.
(1) The day time is considered from 6 a.m. to 9 p.m. The night time is considered from 9 p.m. to 6 a.m
(2) From 9 at night to 6 morning is considered night time.
(3) Area within 100 meters of hospital or education institution or educational institution or government designated / to be designated / specific institution / establishment are considered Silent Zones. Use of motor vehicle horn or other signals and loudspeaker are forbidden in Silent Zone.

Ammonia is used in SCR, which is possible to be introduced for the purpose of nitrogen oxide reduction. Including ammonia, APTable 18-9 shows the odor emission standard in Bangladesh.

APTable 18-9 Odor emission standard[1]

Parameter	Unit	Standard Limit
Acetaldehyde	ppm	0.5 – 5
Ammonia	ppm	1 – 5
Hydrogen Sulfide	ppm	0.02 – 0.2
Methyl Disulfide	ppm	0.009 – 0.1
Methyl Sulfide	ppm	0.01 – 0.2
Styrene	ppm	0.4 – 2.0

Source The Environmental Conservation Rules, 1997

18.1.3 Protected area and environmentally controlled area

Classification of Protected areas and environmentally-controlled areas in Bangladesh are shown in APTable 18-10. Those areas are declared as National Park, Wildlife Sanctuary, Game Reserve, Botanical gardens, and Eco-parks under the Wildlife (Preservation) Order, Reserved Forests and Protected Forests under the Forest Act and Ecologically Critical Areas (ECA) notified under the Environmental Conservation Act.

APTable 18-10 Classification of Protected area, Environmentally controlled area

Classification		Competent Authority	Governing law
A	National Park	Department of Forest	Wildlife (Preservation) Order
B	Wildlife Sanctuary		
C	Game Reserve		
D	Botanical Gardens, Eco-parks		
E	Reserved Forests, Protected Forests		Forest Act
F	Ecologically Critical Areas	Department of Environment	Environmental Conservation Act

Source: PSMP Study Team

There are fifteen National parks, thirteen wildlife sanctuaries, five botanical gardens and eco-parks in Bangladesh declared under the Wildlife (Preservation) Order having total area of 2,702.2km^2. List of Protected areas and environmentally-controlled areas are shown as APTable 18-11. There are nine ECA and the total areas is 8063.2 km^2 excluding the Gulshan-Banani-Baridhara Lake.[2] Though industrial development is basically restricted in the ECA, if the project possesses a high development possibility and a high priority as a nation, IEE will be implemented as an exception and the DOE will render a judgment concerning project implementation[3]. APTable 18-12 shows a list of ECA notified under the Environmental Conservation Act. Site selection should be implemented under the condition of not causing environmental impact to protected areas and/or environmentally controlled areas.

[1]Textual annotations are as follows.
(1)Following regulatory limit shall be generally applicable to emission/exhaust outlet pipe of above 5 meter hight:
Q = 0.108 x He2Cm (Where Q = Gas Emission rate Nm3/hour)
He = Hight of exhaust outlet pipe (m)
Cm = Above mentioned limit (ppm)
(2)In cases where a special parameter has been mentioned, the lower limit shall be applicable for warning purpose, and the higher limit shall be applicable for prosecution purpose or punitive measure.

[2] A situation Analysis Report on Environment(MDG7) Bangladesh

[3] Interviewed with DoE

APTable 18-11 List of Protected area, environmentally controlled area

Classification	No.	Name	Place	Area (km^2)
A	1	Bhawal National Park	Gazipur	50.2
	2	Modhupur National Park	Tangail/ Mymensingh	84.4
	3	Ramsagar National Park	Dinajpur	0.3
	4	Himchari National Park	Cox's Bazar	17.3
	5	Lawachara National Park	Moulavibazar	12.5
	6	Kaptai National Park	Chittagong Hill Tracts	54.6
	7	Nijhum Dweep National Park	Noakhali	163.5
	8	Medha Kachhapia National Park	Cox's Bazar	4.0
	9	Satchari National Park	Habigonj	2.4
	10	Khadim Nagar National Park	Sylhet	6.8
	11	Baraiyadhala National Park	Chittagong	29.3
	12	Kuakata National Park	Patuakhali	16.1
	13	Nababgonj National Park	Dinajpur	5.2
	14	Shingra National Park	Dinajpur	3.1
	15	Kadigarh National Park	Mymensingh	3.4
B	1	Rema-Kalenga Wildlife Sanctuary	Hobigonj	18.0
	2	Char Kukri-Mukri Wildlife Sanctuary	Bhola	0.4
	3	Sundarban (East) Wildlife Sanctuary	Bagerhat	312.3
	4	Sundarban (West) Wildlife Sanctuary	Satkhira	715.0
	5	Sundarban (South) Wildlife Sanctuary	Khulna	369.7
	6	Pablakhali Wildlife Sanctuary	Chittagong Hill Tracts	420.9
	7	Chunati Wildlife Sanctuary	Chittagong	77.6
	8	Fashiakhali Wildlife Sanctuary	Cox's Bazar	32.2
	9	Dudh Pukuria-Dhopachari Wildlife Sanctuary	Chittagong	47.2
	10	Hazarikhil Wildlife Sanctuary	Chittagong	29.1
	11	Sangu Wildlife Sanctuary	Bandarban	57.6
	12	Teknaf Wildlife Sanctuary	Cox's Bazar	116.2
	13	Tengragiri Wildlife Sanctuary	Barguna	40.5
D	1	National Botanical Garden	Dhaka	0.8
	2	Baldha Garden	Dhaka	-
	3	Madhabkunda Eco-Park	Moulavibazar	2.7
	4	Sitakunda Botanical Garden and Eco-park	Chittagong	8.1
	5	Dulahazara Safari Parks	Cox's Bazar	6.0

Source: UUhttp://www.bforest.gov.bd/conservation.php (accessed January 2011)

APTable 18-12 List of Environmental Critical Areas

Classification	No.	Name	Place	Area (km^2)
F	1	The Sundarbans	Bagerhat, Khulna, Satkhira	7,620.3
	2	Cox's Bazar (Teknaf, Sea beach)	Cox's Bazar	104.7
	3	St. Martin Island	Cox's Bazar	5.9
	4	Sonadia Island	Cox's Bazar	49.2
	5	Hakaluki Haor	Moulavi Bazar	183.8
	6	Tanguar Haor	Sumamganj	97.3
	7	Marjat Baor	Jhinaidha	2
	8	Gulshan-Banani-Baridhara Lake	Dhaka	-
	9	Rivers (Buriganga, Turag, Sitalakhya and Balu) around Dhaka city	Dhaka	-

Source: Biodiversity National Assessment and Programme of Action 2020) ,DoE Bangladesh, 2010

18.1.4 Land Acquisition and Involuntary Resettlement

(1) Land Acquisition

Land acquisition is implemented in Bangladesh as stipulated in the Acquisition and Requisition of Immovable Property Ordinance of 1982, and land acquisition for power plant and transformer substation is not an exception. The Ordinance stipulates the procedure for land acquisition as the following.

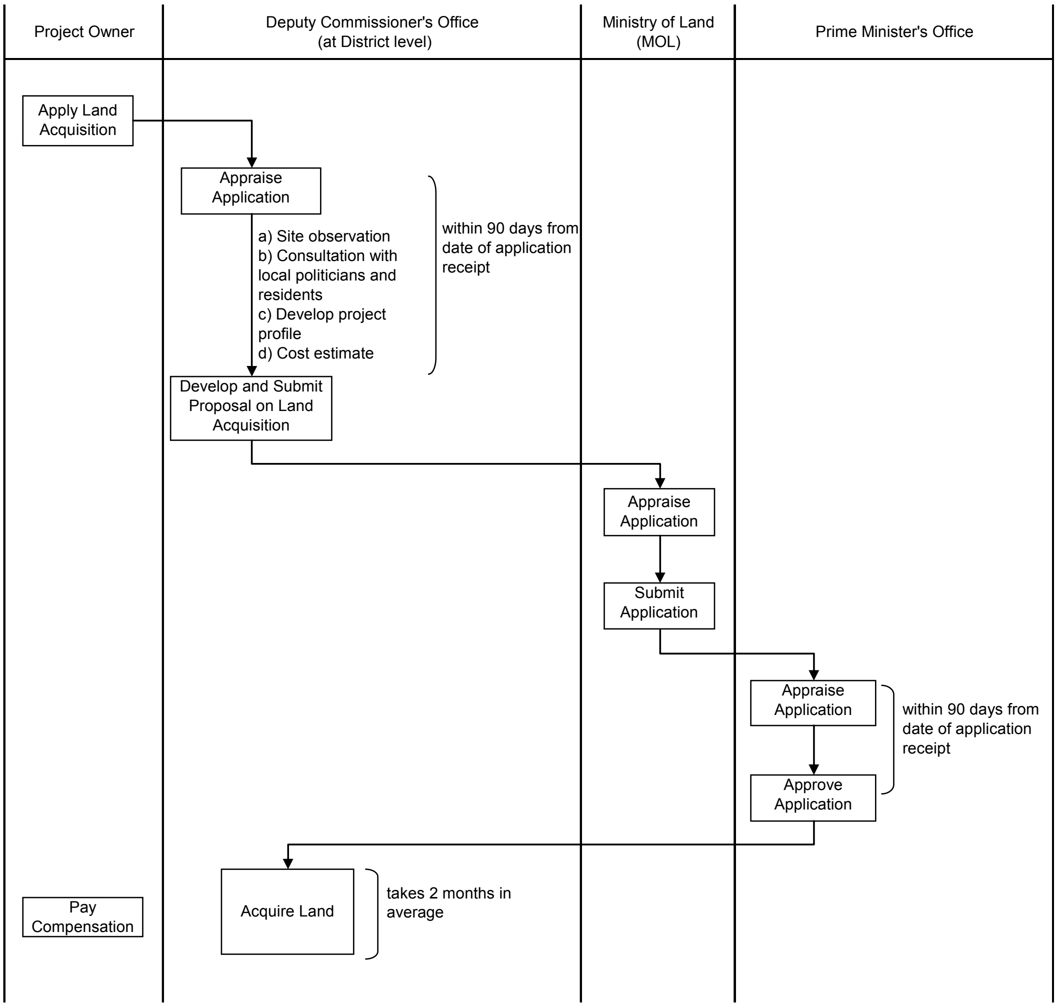
(1) The Project Owner submits an application for land acquisition to the Deputy Commissioner's Office[1]. The Project Owner is responsible to describe the project details in the application.

(2) DC Office appraises the application within 90 days from the submission date. DC Office conducts site visits in which site observation and local consultation with politicians and residents are done, and develops a project profile and cost estimate.

(3) DC Office submits a proposal for land acquisition to the Ministry of Land (MOL).

(4) MOL appraises the proposal and forwards it to the Prime Minister. PM appraises the proposal within 3 months from the submission date.

(5) After getting PM's approval, DC Office takes a course of action for land acquisition. It takes 2 months in average. It is the Project Owner who should pay for compensation.



Source: PSMP Study Team

APFig. 18-3 Official Process for Land Acquisition

[1] Each District is headed by the Deputy Commissioner, and each Division is comprised of several Districts, and headed by the Commissioner.

As for government-funded projects, the project owner also has to submit a Development Project Proposal, DPP, to the Government of Bangladesh. These two applications: one for land acquisition and another for development project proposal, can go spontaneously for getting approval.

The Project Owner does not have to reach MOL for their intervention as long as the size of the acquired land is less than 16.5 acres. DC Office handles all the procedures on behalf. In Metropolitan Area[1], however, MOL is involved in the appraisal process of all applications of land acquisition no matter how big the land size is.
The Ordinance stipulates that land owners are compensated with 1.5 times of the present land price for acquisition of their private-owned lands. No other payment is made even for their resettlement cost including new land purchase and house construction.

As for the land acquisition for the right of way (ROW) of new transmission line extension, the Electricity Act 1910 stipulates that it is not required to acquire land, even the sites for transmission towers. No compensation for land is considered in the Act. Agricultural products, trees and other properties in the ROW are however compensated for their values for the adverse impact during construction period. The owners and users of land and property are entitled to continue their original activities in the operation stage.

(2) Involuntary Resettlement

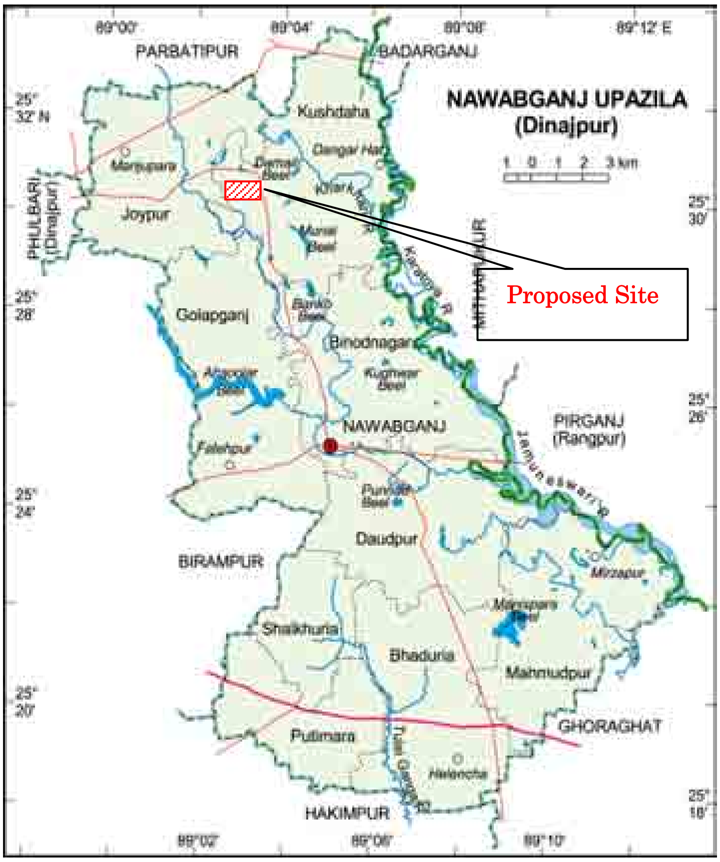
There is no legislation in Bangladesh that stipulates involuntary resettlement and compensation, and it is left to each Project Owner can make a decision. The Project Owners therefore tend to follow established guidelines introduced by investors and donors.

18.2 B-K-D-P Site Information

18.2.1 Site Outlook

The proposed power plant site with domestic coal use is located at the center of Barapukuria, Khalaspir, Dighipara, and Phulbari (B-K-D-P site). The site is within Kushdaha and Binodpur Unions under Nawabganj Upazilla of Dinajpur District. Not far from Nawabganj Town, it is situated in the middle of three domestic coal mines: Barapukuria, Khalashpir, and Dighipara. A map depicting the B-K-D-P site is provided in APFig. 18-4.

[1] Dhaka Mega City, Chittagong City, Barisal City, Khulna City, Rajshahi City and Sylhet City.



Source: http://www.banglapedia.org/httpdocs/HT/H_0143.HTM (accessed May 2010)

APFig. 18-4 Proposed B-K-D-P Site

(1) Health and Sanitation Environment

Local respondents drink water from tube wells. There is no problem with groundwater level which varies from between 25 to 30 feet in the rainy season and from 60 to 80 feet in the dry season. Further, the tube well water is arsenic free.

Local people often suffer from respiratory diseases, diarrhea, fevers, headaches, colds, etc. They do not know the direct causes behind these diseases and simply believe it is normal day-to-day phenomenon. Simple and effective prevention measures have not been fully taken such as the washing of hands after returning home from their outside sojourns or after latrine usage, after caring for their livestock (such as cows and hens) at home, and especially before and after meals that are eaten by hand.

Latrines vary from the *pucca* (concrete) slab one, the *kutcha* (soil-made) one, sanitary (brick-built) one, or just through open spaces use.

The residents in the study area go to the village doctors (*quake*) for simple treatment, and visit the qualified doctors or the government hospital for critical treatment.

(2) Housing Conditions

The house floors are made of clay without any solid foundation. The ceiling is made of tin and the walls are often made out of clay. Some houses are made of bamboo, bricks and tin-shade. Some have a separate kitchen. Their houses are not quake or sound proof. Massive floods can wash them away if heavy rain strikes the area.

(3) Income and Expenditure, and Job Opportunities

According to the Household Income and Expenditure Survey 2005, the average household income in rural areas is Tk. 6,095, expenditures are Tk. 5,165 per month, and Engel's co-efficient applied to rural areas is 58.5 percent of their consumption expenditure.

Most women are housewives; men are businessmen, farmers, van pullers and school teachers, etc. They do not have a wide variety of job opportunities because they are not so well educated or well trained, and thus sources of income generation are also limited. A certain number of residents are associated with the Samity (Association) such as the BRAC and the TMSS, and have taken loans out for business.

(4) Climate condition

The seasons in Bangladesh are roughly divided into the rainy season from April to September, the dry season from October to March. APTable 18-13, APTable 18-14, APTable 18-15, APTable 18-16, APTable 18-17 and APTable 18-18 shows the monthly maximum and minimum air temperature, monthly precipitation, monthly maximum and minimum relative humidity, and monthly average wind speed and the prevailing wind direction at Dinajpur which is located 20 km north west from the proposed site. Colored cell in each table indicates maximum and minimum value.

As for the air temperature, the maximum temperature is over 25°C. The minimum air temperature is under 10 °C in the period from December to January, and the differences between maximum and minimum air temperatures are large, around 20 °C. The monthly maximum temperature is 41.0 °C in May 2007 and monthly minimum temperature is 5.0 °C in January 2003.

The annual precipitation reaches a level of 1,300mm to 3,000mm. The precipitation is primarily concentrated from May to September. Conversely, there is no rainfall in some of the months between November and March. As described above, there is a marked difference in the rainfall between the rainy season and dry season.

As for the humidity level, it is relatively high; the monthly minimum relative humidity exceeds 50% in the period from May to September.

As for the wind speed and wind direction, these elements are largely influenced from the monsoons. It is clear that the wind blows from the west from December to March, and the wind blows from east from April to November. The average wind speed is low, below 2m/s throughout the year.

APTable 18-13 Monthly maximum air temperature at Dinajpur

Unit: °C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	26.5	27	35	37.2	37.5	36.8	35	35.5	35	35	31.8	27.5
2001	26.4	30.5	35.2	38.8	36.4	35.5	36.8	36.5	35.5	34	31.5	27.2
2002	26	31.5	35.4	35.3	36	34.4	35.8	35.5	36	34	32.8	30.5
2003	26.5	28.4	32.5	36.4	36.8	37	37.4	36	35	33	31	27.6
2004	25.6	31.6	37	33.8	40	36.2	34	35.4	34	33.2	31	28.8
2005	26.3	31.4	33.6	35.5	37	40	35	35.5	35.8	33.2	31	27.8
2006	28	33.5	35.8	38.5	36.8	37	36	36.7	35.4	34.2	31	28
2007	28.5	29	35.5	35.7	41	40.7	35	36.5	34.8	35	31.8	27.5
2008	27	29.6	35.2	37	36	35.6	35.2	35.7	35	33.6	32	28.8
2009	26.8	31.2	34.5	38	38	37.5						

Source : BMD, Dhaka

APTable 18-14 Monthly minimum air temperature at Dinajpur

Unit: °C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	7.2	9.6	13.4	17	20.8	23.7	24.3	24.4	22	18	13.3	9
2001	5.7	7	12.4	19	20.8	21.5	25	24.8	24.4	20.4	13	8.5
2002	9	9.5	13.5	16.8	20.4	23	24	24	22.2	16.8	15.4	9
2003	5	11	10.5	18	20	22.4	23.3	25.2	23.3	20.2	11	9.5
2004	7.5	6.2	13.8	18.5	20	22	23.4	25.3	23	18.2	13.3	6.6
2005	7.5	8.4	16.4	17.5	19.5	20.3	23.8	24.8	24	19.5	13.2	9.2
2006	8	11.8	13.5	18.6	20.3	22.2	24.5	25	22.7	18.3	10.5	10.2
2007	6.4	11.5	13	19	19.6	21	24.5	25	23.3	19.7	14	9.5
2008	9.6	7.2	14.5	17.3	20.5	22.5	24.3	23.7	23.7	18.2	13.5	11.2
2009	7.8	9.5	12.8	18.8	20.6	21.8						

Source : BMD, Dhaka

APTable 18-15 Monthly precipitation at Dinajpur

Unit: (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year Total
2000	0	30	1	147	325	399	197	195	196	25	0	0	1515
2001	0	0	0	5	222	573	158	318	462	382	53	0	2173
2002	8	18	13	168	104	658	795	246	481	56	6	0	2553
2003	11	34	53	105	147	337	532	197	230	380	0	31	2057
2004	7	0	12	163	278	517	602	128	253	330	0	3	2293
2005	9	15	37	89	255	474	507	597	222	770	0	0	2975
2006	0	0	1	67	259	222	218	126	340	21	23	8	1285
2007	0	30	2	33	121	474	401	233	234	51	0	0	1579
2008	33	1	19	27	220	363	437	385	242	45	0	0	1772
2009	0	0	10	41	369	457							

Source : BMD, Dhaka

APTable 18-16 Monthly maximum relative humidity at Dinajpur

Unit: %

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	100	100	100	100	100	100	98	98	100	98	100	100
2001	100	100	98	96	100	100	98	98	99	99	99	100
2002	100	100	98	98	98	100	100	100	100	100	98	100
2003	100	100	100	98	98	98	98	100	98	100	100	100
2004	100	100	100	98	98	100	100	98	98	98	98	100
2005	100	98	99	98	98	98	98	98	100	99	100	99
2006	100	99	96	98	98	97	97	98	99	98	99	98
2007	100	99	98	97	98	99	98	98	98	99	99	100
2008	100	100	98	96	97	98	98	98	98	99	98	100
2009	100	97	98	98	98	98	—	—	—	—	—	—

Source : BMD, Dhaka

APTable 18-17　Monthly minimum relative humidity at Dinajpur

Unit: %

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	39	14	19	15	54	58	58	58	57	39	45	35
2001	29	26	12	17	42	58	54	53	57	45	35	33
2002	30	26	21	32	49	55	59	59	54	36	33	38
2003	38	34	22	19	18	52	49	53	55	45	26	37
2004	43	31	17	43	26	59	62	58	57	41	24	33
2005	34	25	24	17	23	15	56	58	48	43	35	35
2006	32	20	15	14	39	49	56	55	56	37	23	37
2007	24	31	18	18	18	22	53	54	49	47	31	26
2008	19	26	22	30	43	57	52	51	54	44	39	43
2009	36	24	13	7	14	46	—	—	—	—	—	—

Source： BMD, Dhaka

APTable 18-18　Monthly average wind speed (m/s) and prevailing wind direction at Dinajpur

Year	Jan		Feb		Mar		Apr		May		Jun	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2000	1.2	W	1.3	W	1.2	W	1.2	E	1.1	E	1	E
2001	1.2	W	1.1	W	1.2	W	1.2	E	1.1	E	1.1	E
2002	1	W	1.1	W	1.4	W	1.1	E	1	E	1	E
2003	1.1	W	1.1	W	1.1	E	1.1	E	1	E	1	E
2004	1.1	W	1.1	W	1.3	W	1.1	E	1	E	1	E
2005	0.9	W	1	W	0.8	E	0.8	E	0.9	E	0.9	E
2006	0.7	W	0.7	E	0.8	W	0.8	E	0.8	E	0.8	E
2007	0.8	W	0.9	E	1.3	W	1.1	E	1.1	E	1.3	E
2008	0.9	W	0.9	W	1	E	1.1	E	1	E	1.1	E
2009	0.7	W	1	W	0.7	E	1	E	1.2	E	0.8	E

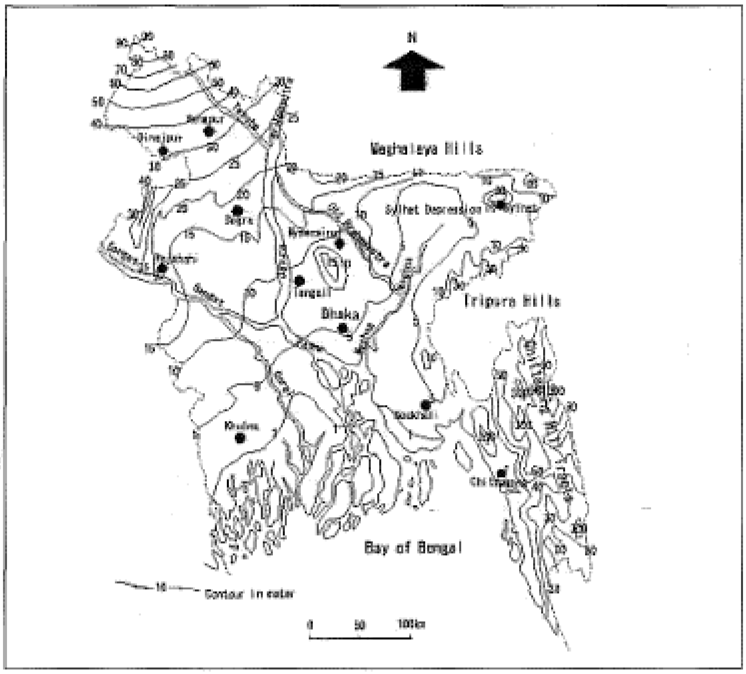
Year	Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2000	1.2	E	1	SE	1.1	E	1.3	E	1	NE	0.8	N
2001	1.1	E	1	E	1	E	1	E	1	E	1.1	W
2002	1	E	1.1	E	1.1	E	1	E	1.3	E	1	W
2003	1.1	E	1	E	1	E	1.1	E	1	W	1	W
2004	1	E	1	E	1	E	1	E	0.9	E	1	E
2005	0.8	E	0.8	E	0.9	E	1	E	0.6	N	0.7	W
2006	0.8	E	1	E	1.6	E	0.9	E	0.9	W	0.8	W
2007	1.2	E	1	E	1	E	0.8	E	0.9	E	0.7	W
2008	0.8	E	0.8	E	1	E	0.8	E	0.8	E	0.7	W
2009	-	-	-	-		-	-	-	-	-		

Source： BMD, Dhaka

(5) Topography and Underground water

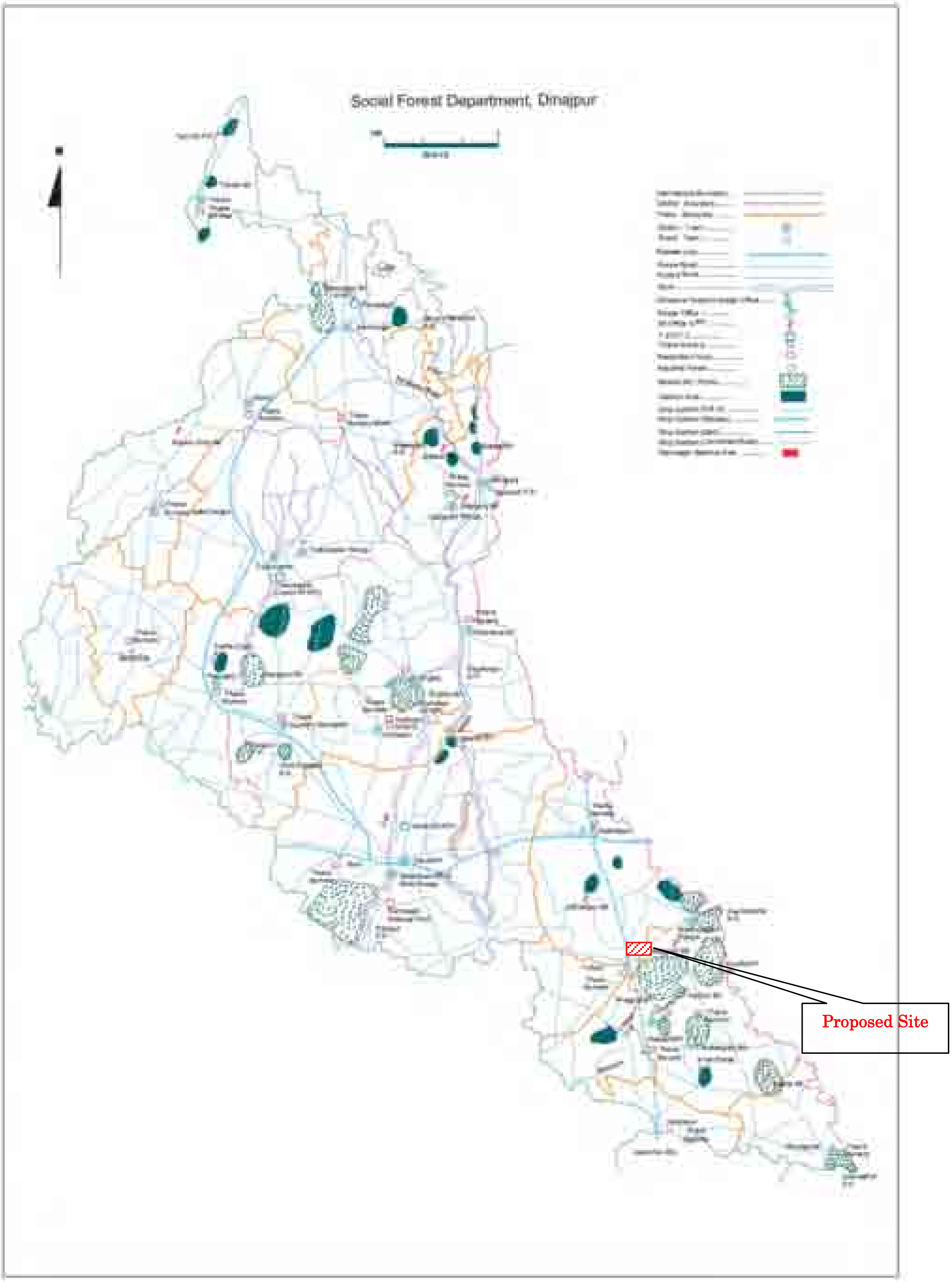
(a) Topography

APFig. 18-5 shows the topographical features of Bangladesh. The general topography of the B-K-D-P site area is mostly plain paddy fields with some residential houses, schools, shops etc.



Source: Taro OKA (2004): Floods and disaster in Bangladesh; Annual Report of Disaster Prevention Research Institute, Kyoto University

APFig. 18-5 Topographical features of Bangladesh



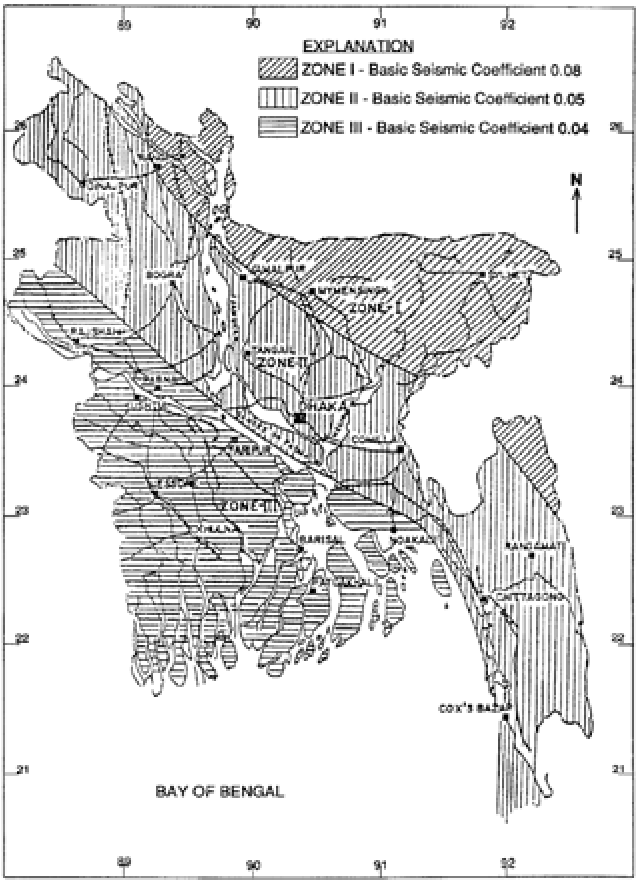
Source： DoF

APFig. 18-6 Distribution of reserved forest in Dinajpur district

(b) Earthquake occurrence situation

APFig. 18-7 shows seismic zoning map in Bangladesh. As shown in APFig. 18-7, the seismic zones in Bangladesh are classified into three zones and the earthquake vibration is estimated to be severe in Zone I, north east of Bangladesh. B-K-D-P site area is located in Zone II.

APTable 18-65 is an earthquake occurrence record in Bangladesh from 1918 to 2008. The maximum magnitude was 8.5, which was occurred in 1997 and 2007.



Source : Bangladesh Meteorological Dept(BMD), 1972

APFig. 18-7 Seismic zoning map in Bangladesh

(c) Soils, water quality and underground water

Geological data is obtained from boring survey results which is conducted at a nearby proposed site by DPHE Territorial Division. The boring survey is conducted in 2002 in the Daldalia village under the Bendighi Union of Phulbari Upazilla, which is very close to the proposed site. The drilling depth was 60.65m. (see APTable 18-19). There are two Aquifers between the depths of 60.65m. As for water quality, out of two measured items, the amount of iron concentration present is over Bangladesh Standard for drinking water, 1.0mg/l. APTable 18-20 shows the measured water quality in the boring survey and the deep well for the existing Barapukuria coal-fired power plant (125MW×2).

Because of underground water pumping in the existing Barapukuria coal mine and the power plant near the B-K-P-D site, Ground water level decreases significantly in B-K-D-P. APFig. 18-8 shows water level variation of deep wells, which is used for the makeup water of the Barapukuria power plant in the period from 2007 to 2009. And

APFig. 18-9 and APFig. 18-10 show yearly change of the deep well water level from 2007 to 2008 and from 2008 to 2009. There was a maximum 2m deep well water level drop at 4UXA from 2007 to 2008. And there was a maximum 1.5m deep well water level drop at 3UXA, it shows the water level lowered totally. On the other hand, there are no signs of decreasing surface level of the little Jamuna River from 2007 to 2008. So, this variation of groundwater level doesn't seem from river water.

APTable 18-19 Boring result in Phulbari in 2002

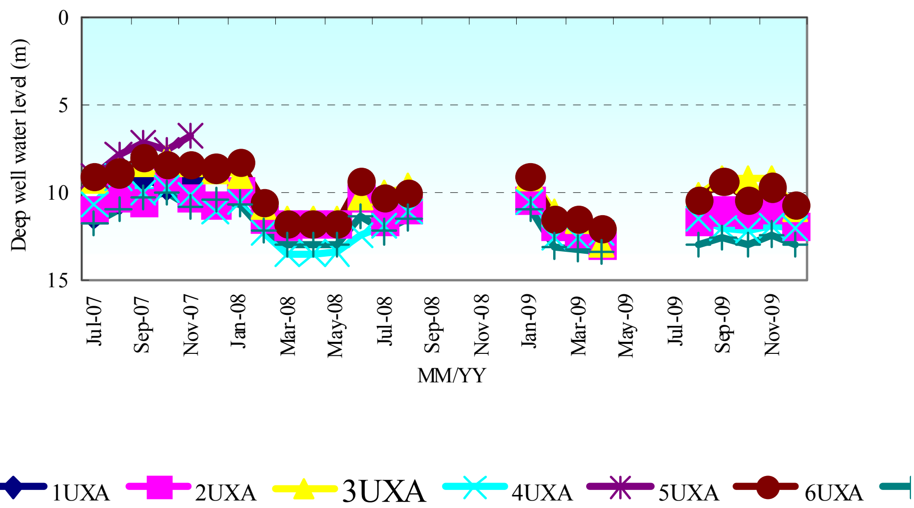
Depth to Top (m)	Depth to Base (m)	Lithologic Description	
0.00	12.00	Silty clay	Aquitard 1
12.00	24.00	Fine sand	Aquifer 1
24.00	42.00	Clay	Aquitard 2
42.00	48.00	Medium sand	Aquifer 2
48.00	60.65	Coarse sand	Aquitard 1

Source: DPHE

APTable 18-20 Water quality of deep well for Barapukuria coal-fired power plant[1]

No.	Parameters	Unit	Concentration Present	Bangladesh Standard for Drinking water
1	Arsenic, As	ppb	0.05 (mg/l)	50
2	Bicarbonate (HCO_3)	mg/L	107 *	—
3	Calcium	mg/L	NA	75
4	Conductivity	µs/cm	187 *	—
5	Chloride	mg/L	3.5	150 – 600
7	Hardness (as Ca CO_3)	mg/L	58.4 *	200 – 500
8	Iron, Fe	mg/L	1.5	0.3 – 1.00
11	pH	—	6.25 *	6.5 – 8.5
12	Total Alkalinity as $CaCO_3$	mg/L	87 *	—
15	Silica (SiO_2)	mg/L	57.2 *	—

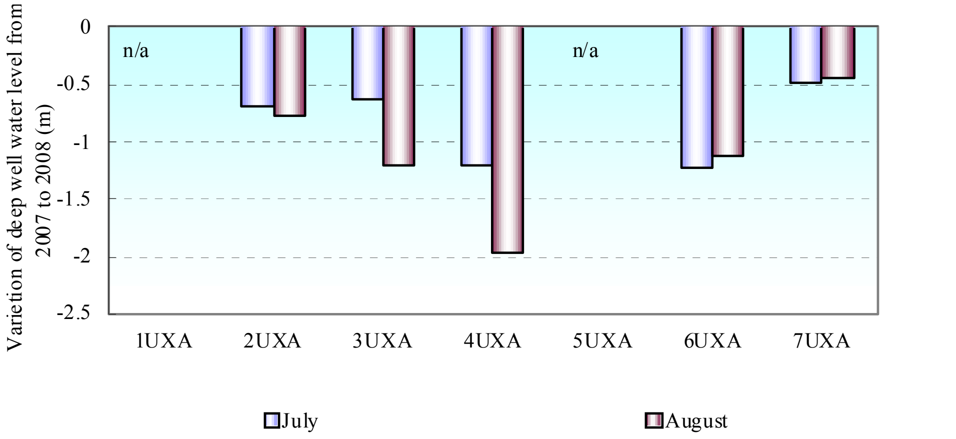
Source: Barapukuria coal-fired power plant



Source : Barapukuria coal-fired power plant

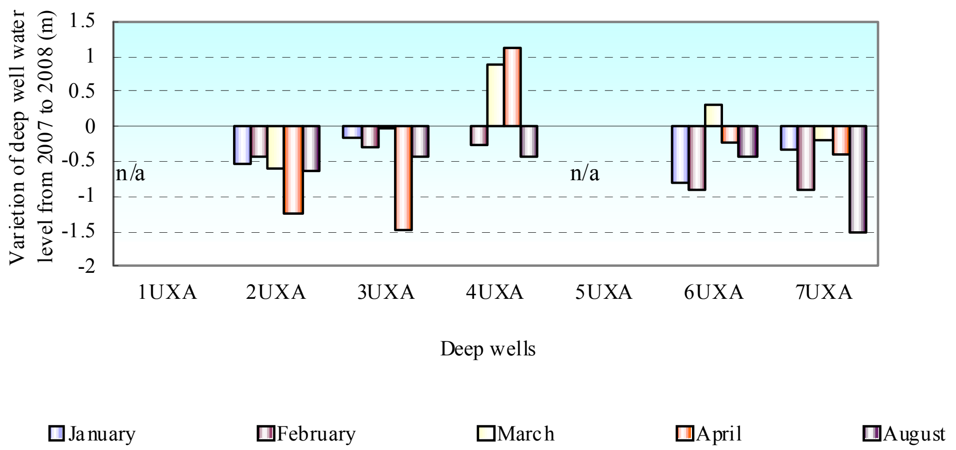
APFig. 18-8 Monthly deep well level variation, Barapukuria power plant[2]

[1] *Data of deep well water(99m) for Barapukuria coal-fired power plant
[2] There are no data from Sep. to Dec. 2008 and May to Jul. 2009 due to defect of water level gauge.



Source: Barapukuria coal-fired power plant

APFig. 18-9 Yearly change of deep well water level from 2007 to 2008



Source : Barapukuria coal-fired power plant

APFig. 18-10 Yearly change of deep well water level from 2008 to 2009

(6) Air quality

Information regarding the air quality condition around the proposed site is not clear. APTable 18-21 shows the estimated maximum ground concentration due to exhaust gas from the Barapukuria power plant which was estimated in the EIA report for the Barapukuria power plant which is near the B-K-D-P. As for NOx, result of the estimation is not satisfying current Bangladesh air quality standard.

APTable 18-21 Estimated maximum ground concentration due to exhaust gas from Barapukuria power plant

(Unit: microgram/m3)

No.	Parameter	Maximum average concentrations	Current Environmental Standard (Bangladesh)
1	Sulfur-dioxide	230	365 (24 hour), 80 (1 year)
2	Oxides Nitrogen	134	100 (1 year)
3	Suspended Particulate Maters(SPM)	7.5	20 (8 hour)

Source : Environmental Impact Assessment (EIA) of Barapukuria Coal Fired Thermal Power Plant, BPDP, Dinajpur

(7) Ecological situation

The ecological situation data has been obtained from the Department of Botany and Zoology of Dhaka University, Respective Upazila offices and local consultant.

(a) Terrestrial Communities

1) Flora

The area is well vegetated with planted trees. The plants found around the site include a total of 74 different species. Out of those plants on the Red List of the International Union for Conservation of Nature (IUCN) there are two species. All of them fall under the category of LC[1]. A list of plants near the proposed site is shown in APTable 18-22.

APTable 18-22 List of plants near B-K-P-D site

No.	Local Name	English Name	Scientific Name	IUCN Global Status
1	Ada	Ginger	*Zingiber officinale*	--
2	Am	Mango	*Mangifera indica L. (Anacard)*	--
3	Arjun		*Terminalia arjuna*	--
4	Ashoke		*Saraca asoca*	--
5	Ashwagondha		*Withania somniferum*	--
6	Babla		*Acacia nilotica*	--
7	Basak		*Adhatoda zeylanica*	--
8	Bash	Bamboo	*Podocarpus neriifolius*	LC
9	Bel	Indian apple	*Aegle marmelos (L).*	--
10	Beli		*Jasmin sambac Ait (Olea)*	--
11	Bet	Cane Tree		--
12	Bokul	Mimusops Elengi	*Mimusops elengi L*	--
13	Boroi	Indian Jujube	*Zizyphus rugosa Lam*	--
14	Bot	Banayan tree	*Ficus benghalensis L. (Mora)*	--
15	Chameli		*Jasminum grandiflorum L. (Oleace)*	--
16	Dalim	Pomegranate	*Punica granatum L.*	--
17	Debdaru	Pine	*Polyalthia longifolia*	--
18	Dhol Kalmi		*Ipomoea fistolosa*	--
19	Dhutra		*Barringtonia acutangula*	--
20	Dumur		*Ficus hispida*	--
21	Gashpul		*Zephyranthes tubispatha Herb. (Amaryllidaceae)*	--
22	Golap	Rose	*Rosa centifolia L. (Rosaceae)*	--

[1] Least Concern

No.	Local Name	English Name	Scientific Name	IUCN Global Status
23	Halencha		*(Altermanthere philoxeroides)*	--
24	Hyacinth		*(Eichhomia crassipes)*	--
25	Ipil Ipil	Ipil Ipil	*Leucaena Latisiliqua*	--
26	Jaba		*Hibiscus rosa sinensis L. (Malvaceae)*	--
27	Jam	Black Berry	*Syzygium cumini skiel. (Myrtaceae)*	--
28	Jambura	Citron	*Citrus grandis*	--
29	Jamrul	Star apple	*Syzygium samraogense (Bl.)*	--
30	Jhau	Poplar	*Thysanolaena maxima*	--
31	Kachu		*Colocasia esculenta (L.)*	--
32	Kadbel	Wood apple	*Feronia limonia (L.)*	--
33	Kalmi		*(lpomoea aquatica)*	--
34	Kalo Dhutra		*Datura metel*	--
35	Kamranga	Carambola	*Averrhoa carambola*	--
36	Kathal	Jack fruts	*Artocarpus heterphyllus Lamk*	--
37	Khejur	Date Palm	*Phoenix sylvestris*	--
38	Kola	Banana	*Musa Paradisica*	--
39	Koroi		*Derris robusta Benth.*	--
40	Kowa nim		*Melia sempervirens*	--
41	Krishnachura	Delonix Regia	*Delonix regia (Boj.) Raf. (Leguminosae)*	--
42	Lebu	Lemon	*Citrus aurantifolia*	--
43	Madar		*Erythriana variegata L. var. orientalis Merr.*	--
44	Mahua		*Madhuca indica gmel*	--
45	Man Kochu		*Alocasia indica*	--
46	Mankata		*Xeromphis spinosa*	--
47	Mehedi		*Lawsonia inermis*	--
48	Mehogoni		*Swietenia mahagoni*	--
49	Methi		*Trigonella foenumgraecum*	--
50	Muktajhuri		*Abroma augusta*	--
51	Narikel	Coconut	*Cocos nucifers L. (Palmae)*	--
52	Nayantara		*Catharanthus roseus*	--
53	Neem		*Azadirachta indica*	--
54	Pakur		*Ficus infectoria*	--
55	Patabahar	Patabahar	*Cdiaeum variegatum*	--
56	Pepe	Papaya	*Carica papaya L (caricaceae)*	--
57	Peyara	Guava	*Psidium Guajava (L) Bat. (Myrtaceae)*	--
58	Pui Shak		*Basella alba L.*	--
59	Radhachura		*Caesalpinia pulcherrima Sw. (Leguminosae)*	--
60	Rain tree		*Samea Samon*	--
61	Rangan		*Ixorarosea will (Rubiceae)*	--
62	Rashun	Garlic	*Allium sativum*	--
63	Sajina		*Moringa Oleifera Lamk. (Moringa)*	--
64	Shal		*Shorea robusta*	LC
65	Shatamuli		*Asparagus racemosus*	--
66	Shimul		*Bombax ceiba L. (Bombacaceae)*	--
67	Shonali Lota			--
68	Sofeda	Sopodilla	*achras Manilkara*	--

No.	Local Name	English Name	Scientific Name	IUCN Global Status
69	Supari	Colloq	*Areca catechu*	--
70	Tal	Palm tree	*Borassus flabellifer L. (Palmae)*	--
71	Tentul	Tamarind	*Tamarindus indica*	--
72	Thankuni		*Centella asiatica*	--
73	Topa pana		*(Pistia stratiotes)*	--
74	Ulatkambal		*Abroma augusta*	--

Source : PSMP Study Team

2) Fauna

The animals found around the site include a total 65 species – 18 species of mammalian animals, 33 species of birds, 12 species of reptiles and 2 species of amphibians. Out of those animals on the Red List of the International Union for Conservation of Nature (IUCN) there are 17 species of LC, 3 species of NT[1], 1 species of EN[2], 1 species of CR[3]. APTable 18-23 shows a list of animals found around the B-K-P-D site. Special attention must be paid to the protection of the Painted Roofed Turtle (CR) and Fishing Cat (ER).

APTable 18-23 List of animals found around the B-K-P-D site

No.	Local Name	English Name	Scientific Name	IUCN Global Status
MAMMALS				
1	Badur/Daini	Greater False Vampire Bat	Megaderma Lyra	LC
2	Bagdash	Large Indian civet	Viverra Zibetha	NT
3	Bara Benji	Indian Gray Mongoose	Herpestes edwardsi	LC
4	Bhera	Sheep	Bovidae: Ovis	--
5	Biral	Cat	Felis: Catus	--
6	Bon Biral/Wab	Jungal Cat/Swamp Cat	Felis chaus	--
7	Indur	Common House Rat	Rattus rattus	--
8	Gadha	Ass	--	--
9	Ghora	Horse	Equus caballus	--
10	Goru	Cow	--	--
11	Kathbirali	Black giant squirrel/Malayan giant squirrel	Ratufa bicolor	NT
12	Khek Shiyal	Bengol Fox/Indian Fox	Vulpes bengalensis	LC
13	Khargosh/Shashak	Rufous-tailed Hare	Lepus nigricollis	--
14	Kukur	Dog	Cannis Familiaris	--
15	Mecho Biral/Mecho Bagh	Fishing cat	Proionailurus viverrinus	EN
16	Mohish	Bafallow	--	--
17	Sagol	Goat	Capra Hircus	--
18	Shojaru	Indian crested Porcupine	Hystrix Indica	LC
BIRDS				
1	Babui-Batan	Small Pratincole	Glareola Lactea	--
2	Bok	Intermediate Egret	Mesophoyx intermedia	--
3	Banspaati	Green Bee-eater	merops orientails	--
4	Baj	Crested Groshawk	Accipiter trivirgatus	--
5	Bulbuli	Red-vented Bulbul	Pycnonotus cafer	LC

[1] Near Threatened
[2] Endangered
[3] Critically endangered

No.	Local Name	English Name	Scientific Name	IUCN Global Status
6	Hutum Pecha	Rock Eagle Owl	Bubo bengalensis	LC
7	Chil	Pariah Kite	Passer domesticus	--
8	Chorui	House Sparrow	Passer Domesticus	--
9	Dahuk	White Breasted water hen	Amaurornis phoenicurus	LC
10	Doyel	White-eyed Buzzard	Butastur teesa	LC
11	Eagal	Bazzard -Eagal	Dicrurus macrocercus	--
12	Fingey	Black Drongo	Dicrurus macrocercus	--
13	Ghughu	Oriental Turtle Dove	Streptopelia orientails	LC
14	Hash	Duck	Anatidae Anseriformes	--
15	Hot-titi	River Lapwing	Vanellus duvaucelii	LC
16	Jalali Kobutor	Rock Pigon	Columba Livia	LC
17	Kak	House Crow	Corvus splendens	--
18	Kana Bok	Indian Pond Heron	Ardeola grayii	--
19	Kat Tokra	Woodpecker	Picoides pubescens	--
20	Kokil	Asian Koel	Eudynamys scolopacea	--
21	Konch Bak.	Pond Heron.	Ardeola grayii	--
22	Machhranga	White Throated Kingfisher	Halcyn smyrensis	--
23	Mohanchura	Hoopoe	Upupa epops	--
24	Moutusi	Purple rumped Sunbird	Nectarinia zeylonica	--
25	Paira	Pigeon	Columba livia domestica	--
26	Pankouri	Great Cormorant	Phalacrocorax carbo	LC
27	Pencha	Spot-bellied Eagle-owl	Bubo nipalensis	LC
28	Rajhans	Bar-headed Goose	Anser indicus	LC
29	Shalik	Indian mynah	--	--
30	Shonkho Chil	Brammoni Kite	Haliastur Indus	--
31	Sipahi Bulbuli	Red –whiskered Bulbul	Pycnonotus jocosus	--
32	Tia	Roseringed parakeet	Psittscula krameri	--
33	Tuntuni	Tailor bird	Orthotomus sutorius	--
REPTILE				
1	Tiktiki	House Lizard	Hemidactylus brokii	--
2	Kasim	Painted Roofed Turtle	Kachuga Kachuga	CR
3	Ajogor	Rock Python	Python molurus	NT
4	Gui Shap	Bengal Monitor	Varanus bengalensis	--
5	Daraj	Green Rat Snake	Coluber nigromarginatus	--
6	Dudhraj	Common Trinket Snake	Elaphe Helena	--
7	Sabuj Dhora	Green Keel back Snake	Macropisthodon plumbicolor	--
8	Laldhora Shap	Red-necked Keelback	Rhabdophis subminiatus	--
9	Kalo Mete Dhora Shap	Dark-Bellied Marsh Snake	Xenochrophis cersogaster	--
10	Shakini Shap	Banded Krait	Bungarus fasciatus	LC
11	Gokhra Shap	Monocellate Cobra	Naja kaouthia	--
12	Raj Gokhra	King Cobra	Ophiophagus Hannah	LC
AMPHIBIA				
1	Beng	Frog	Anura: Ranidae	--
2	Brischik	Scorpion	Archinida1 Scorpionida	--

Source : PSMP Study Team

(b) Aquatic Communities

1) Aquatic Flora

The freshwater dependent plants such as helencha (Altermanthere philoxeroides), kalmi (Ipomoea aquatica), daokalmi (Ipomoea fistulosa), ichadal (Potamo seton) and water hyacinth (Eichhomia crassipes) are common among the ponds, canals and rivers near the B-K-P-D site. The Khuda pana (Lemna minor), topapana, (Pistia stratiotes) and chaicha (Saipus articulatus) are also common.

2) Aquatic Fauna

The crabs inhabit the Little Jamuna and Atrai river, ditches and ponds near the B-K-P-D site. The fresh water snails (Charonia Variegate) and mussels (Mytilus Edilis) are also common. APTable 18-24 shows a list of fishes available near the B-K-D-P site.

APTable 18-24 List of Fishes Available B-K-D-P site

No.	Local Name	English Name	Scientific Name	IUCN Global Status
River fish				
1	Bata	Giantscale Mullet	Lizamelinoptera	--
2	Bele	Scribbled goby	Awaous grammepomus	--
3	Bhagna	--	--	--
4	Bhol/Bol	Indian Trout	Raiamas bola	--
5	Chanda	Elongate glass perchlet	Chanda nama	--
6	Chingri	Shimp	--	--
7	Chitol	Humped Featherback	Nototeruse chitala	--
8	Dhela/ Dipali/ ketti (Cotio)	Cotio	Osteobrama cotio	--
9	Foli	Grey Featherback	Notopterus notopterus	--
10	Gojar/ Gojal	Giant snake head	Channa marulius	--
11	Jhinuk	--	---	--
12	Kajli / Banshpata	Jamua ailia	Ailia punctata	--
13	Kalibaush (kalbasu)	Orange-fin labeo	Labeo calbasu	--
14	Katla	--	Catla Cattla	--
15	Khailsha	Banded gourami	Colisa fasciata	--
16	Meni / Bheda/ Rayan/ Bheduri	Mottled Nandus	Nandus nandus	--
17	Mrigal	Mrigal	Cirrhinus mrigala	--
18	Napit Koi/ Koi Banedi	Dwarf chemeleon fish badis	Badis badis	--
19	Pabda	Pabo Cat fish	Ompak pabo	--
20	Piali	--	---	--
21	Pungash (river)	Yellowtail catfish	Pangasius pagasius	--
22	Puti	Fry	Puntius puntio (Hamilton)	--
23	Rui	Rohu	Labeo rohita	--
24	Sarputi / Swarnaputi	(Olive barb)	Puntias Sarana	--
25	Shal baim/ Baim /Bam(Tire track spiny eel)	Tire trach spinyeel	Mastecembelus armatus	--
26	Shol	Banded Snakehead	Channa striatus	--
27	Sisor / Chenua	Sisor cat fish	Sisor rhabdophorus	--
28	Tara Baim	One Strip spiny eel	Macroganthus aral	--

No.	Local Name	English Name	Scientific Name	IUCN Global Status
29	Tatkini/Bata/Bangla	Reba carp	Cirrhinuss reba	--
30	Telo Taki / Rana Cheng/ Ganchua	Asiatic snake head	Channa Orientalis	--
31	Titpunti	Ticto barb	Puntias Ticto	--

Source : PSMP Study Team

18.2.2 Detailed Information on Meetings with Local Stakeholders

APTable 18-25 Profile of Household Interviewees (B-K-D-P Site)

No	Sex	Age	Village	Distance from Power Plant	Education	Occupation	Household Monthly Income
1	M	47	Rhimapur	500m	Five Pass	Agriculture	4,000
2	M	60	Nundonpur	500m	Nil	Agriculture	3,000
3	F	28	Nundonpur	500m	Seven	Business	4,000
4	F	25	Nundonpur	500m	Nil	Agriculture	4,000
5	M	43	Nundonpur	500m	B A	Teacher	10,000
6	M	45	Nundonpur	500m	Seven	Agriculture	4,000
7	F	30	Rhimapur	500m	Five Pass	Business	10,000
8	M	40	Rhimapur	500m	Nil	Agriculture	3,000
9	F	28	Rhimapur	500m	Nil	Business	4,000
10	F	37	Rhimapur	500m	Nil	Van Puller	4,000
11	F	35	Rhimapur	500m	Nil	Agriculture	5,000
12	M	32	Rhimapur	500m	Nil	Van Puller	4,000
13	F	28	Rhimapur	500m	S.S.C (Pass)	Agriculture	4,000
14	F	45	Rhimapur	500m	Nil	Business	4,000
15	F	30	Rhimapur	500m	Six	Business	7,000

Source: Household interview

APTable 18-26 Profile of FGD Participants (B-K-D-P Site)

No	Age	Education	Occupation	Household Monthly Income
Male Participants				
1	26	S.S.C.	Farmer	4,000
2	37	VIII	Businessman	3,000
3	25	IV	Farmer	1,500
4	34	VI	Farmer	5,000
5	23	VII	Farmer	5,000
6	24	VI	Farmer	5,000
7	26	Signature Only	Van Driver	2,000
8	35	X	Farmer	5,000
9	42	S.S.C.	Farmer	5,000
10	42	V	Farmer	3,000

11	43	V	Farmer	3,000
12	26	S.S.C.	Farmer	3,000
1	50	None	Housewife	4,000
2	50	None	Housewife	5,000
3	30	Signature Only	Housewife	3,000
4	32	V	Housewife	4,000
5	32	Signature Only	Housewife	8,000
6	23	VI	Housewife	4,000
7	27	Signature Only	Housewife	4,000
8	55	Signature Only	Housewife	5,000

Source: Focus group discussions

APTable 18-27 Participants Profile of Local Stakeholder Meeting (B-K-D-P Site)

No.	Designation and Organization
Participants from B-K-D-P site	
1	Chairman, No.7, Daudpur Union Porishad, Nowabgonj, Dinajpur.
2	Member, No.7 Daudpur UP, Nawabgonj, Dinajpur,
3	Professor, Nowabgonj, Dinajpur
4	Professor, Daudpur Technical College, Dinajpur
5	Agriculture & business, Nowabgonj, Dinajpur
6	Imam, Nowabgonj, Dinajpur
7	Teacher, Nowabgonj, Dinajpur
8	Businessman, Nowabgonj, Dinajpur
9	Businessman, Nowabgonj, Dinajpur
The Government of Bangladesh	
1	Joint Chief, Power Division,
2	Asst. Chief, Power Division
PSMP Study Team and Local Consultant	
1	PSMP Study Team
2	EAL, Executive Director
3	EAL, Engineer
4	EAL, Social Specialist
5	EAL
6	EAL
7	EAL

Source: PSMP Study Team

18.2.3 Problem Analysis and Problem Solution

Problem analysis on environmental pollution and natural environment is as found in AP Table 18-28.

AP Table 18-28 Problem Analysis: Assessment Results on Environmental Impact (B-K-D-P)

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
1	Air Pollution	Air pollution can be caused by exhausted gas from transportation vehicles and construction machinery. And dust particles may be scattered near the construction site and construction vehicle road.	B	Planned coal-fired power plant burns domestic coal which is mined from the adjacent coal mine as the main fuel. And it burns light oil as auxiliary fuel (fuel for starting up). NO_X, SO_X and soot will be generated due to the combustion of these fuels. And coal transportation may generate coal dust.	A
2	Water Contamination	Drainage caused by rainfall, equipment washing drainage, and sewage will be generated during the work. And if waste management isn't appropriately conducted, effluents from waste may be generated.	B	Thermal discharge will be produced when using river water as cooling water. If cooling tower is used, condensed cooling water effluent will be generated. Plant effluent and domestic waste water will be generated through plant operation. In case waste management methods aren't appropriately conducted, effluents from waste may be generated.	A
3	Soil pollution	Soil pollution can occur due to lubrication oil or fuel oil spillage from transportation vehicles and construction machinery.	B	Soil pollution can occur due to lubrication oil or fuel oil spillage for unit operations. When an ash pond is used, it is necessary to pay attention to the contaminations from the pond.	B
4	Bottom Sediment	As the proposed site is located inland, there is no possibility of bottom sediment.	C	As the proposed site is located inland, there is no possibility of bottom sediment.	C
5	Noise and vibration	Noise and vibration arise due to vibrations from transportation vehicles and construction machinery. AP Table 18-61 shows the list of the general noise level of transportation vehicles and construction machinery. Steam blowing during commissioning will also generate significant noise.	A	Noise and vibration will be generated through the operation of power facilities. If a cooling tower is used, there is significant noise and vibration from the cooling fan of the tower. For periodic inspections, noise and vibration may arise due to vibration from transportation vehicles and construction machinery. When using vehicles for coal transportation, noise and vibration may occur.	A
6	Offensive Odor	If the domestic waste management isn't applicable at worker stations, offensive odor may be generated due to waste decomposition.	B	If ammonia which is used at SCR leaks, may be a source of offensive odor. If the domestic waste management isn't applicable at worker stations for maintenance work etc., offensive odor may be generated due to waste decomposition.	B

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
7	Waste	Construction work will generate metal chips, waste plastic, wood shavings, waste glass and waste oil. Domestic wastes such as cans, bottles and food residue will be generated by construction workers at their work stations.	B	By-products generated through the operation of coal-fired power plant are coal ash, gypsum (if limestone-gypsum FGD is used), sludge from waste water treatment facility, and cooling water canal fouling (if the river water or sea water is used for the cooling water). These by-products will be wasted if they are discarded without recycling. Maintenance work will generate metal chips, waste plastic, wood shavings, waste glass and waste oil. And domestic waste such as cans, bottles, and food residue will be generated at the workers' stations.	A
8	Ground Subsidence	If the underground water level decreases due to water being used for construction work, there is a possibility of ground subsidence occurring. However, water usage during construction work stays minimum, and such possibility is small.	C	There is a large possibility of ground subsidence occurring if ground water is used as cooling water.	A
9	Geographical Feature	There is little impact since the proposed site is plain and doesn't have any outstanding geographical features.	C	There is little impact since the proposed site is plain and doesn't have any outstanding geographical features.	C
10	Biota and Ecosystem	There is a possibility of Painted Roofed Turtle existing in the site which is categorized CR in IUCN Red list. Site location and transmission line route should be carefully examined in order to avoid the reserved forests in Dinajpur District (see AP Fig.18-6) not to bring adverse impact to the natural environment.	B	There is a possibility of Painted Roofed Turtle existing which is categorized CR in IUCN Red list. Site location and transmission line route should be carefully examined in order to avoid the reserved forests in Dinajpur District (see AP Fig.18-6) not to bring adverse impact to the natural environment.	B
11	Water Usage	People in the surrounding areas of the proposed site use tube well water for their daily life needs. If the underground water level decreases due to water used during construction work, there is a possibility of adverse impact to life water usage. Because water usage for construction work is not so large, the impact of underground water level reduction on water usage will be small.	C	People in the surrounding area of the proposed site uses tube well water for daily life. If underground water is used for cooling water, it will have a large impact on water usage by decreasing underground water level.	A

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
12	Accident	Construction accidents may be caused due to the defects of health and safety management of construction work. It is necessary to pay attention especially to high altitude areas where accidents from falling may occur as well as construction vehicle road accidents and electricity accident.	A	There is possibility of accidents occurring such as fires due to oil spillage or instantaneous combustion of coal, accidents due to leakage or spillage of chemicals like caustic soda and sulfuric acid, accidents or incidents involving maintenance work.	B
13	Global Warming	Transportation vehicles and construction machinery will emit CO_2.	C	It is estimated that approximately 3.54 million tons of CO_2 will be emitted from per 600MW unit per year through operation of coal-fired power plant. Domestic coal is classified bituminous coal which exhausts less amount of CO_2 compared with sub-bituminous coal and brown coal.	B

Source： PSMP Study Team

Problem analysis on social impact is as found in AP Table 18-29.

AP Table 18-29 Problem Analysis: Assessment Results on Social Impact (B-K-D-P)

No	Item	Impact during Construction Stage		Impact during Operation Stage	
1	Involuntary Resettlement	Land acquisition is anticipated for 200 acres that require approximately 1,250 households to be relocated.	A	Damage to houses and health hazards can be caused by smoke extraction, noise pollution, water pollution and land subsidence when the resettlement action plan is not appropriately planned and implemented. Political intervention and/or local movement against the operation of the power station can occur when adverse impacts on local residents' lives and livelihoods are severe.	B
2	Local Economy such as Employment and Livelihood etc.	Loss of employment and livelihoods can be caused by temporary loss of agricultural lands during the construction period. The Bangladesh regulation stipulates that displaced persons are entitled to compensation for loss of land, property and standing crops in monetary terms at the fixed rates. It however does not compensate for loss of employment or livelihoods.	B	Permanent loss of employment and livelihoods can be caused by land acquisition due to power station construction and surrounding areas. The Bangladesh regulation stipulates that displaced persons are entitled to compensation for loss of land, property and standing crops in monetary terms at the fixed rates. It however does not for loss of employment or livelihoods. The destitute, poor and landless farmers as agricultural laborers and wage laborers can become further distressed when job opportunities or at least skill training opportunities for them are not secured.	B
3	The Poor, Indigenous and	There are no ethnic minorities living on site grounds.	B	There are no ethnic minorities living on site grounds.	B

No	Item	Impact during Construction Stage		Impact during Operation Stage	
	Ethnic People	The destitute, poor and landless farmers can lose their jobs when agricultural land is lost due to the construction of power station.		The destitute, poor and landless farmers can become further distressed when job opportunities or at least skill training opportunities for them are not secured.	
4	Misdistribution of Benefit and Loss	Disparity between the land owners and the rest (landless farmers, wage laborers etc.) can be widened.	B	Landless farmers and wage laborers can become further distressed and the disparity between the land owners and them can be widened when job opportunities and skill training opportunities are not given to them.	B
		In case an ample number of job opportunities and skill training opportunities are not provided to meet the demand, the disparity between those with such opportunities and those without may widen.		Local livelihoods can be affected and health hazards can be caused by land subsidence, smoke extraction, noise pollution, water pollution and water shortage in case the environmental management plan is not appropriately planned and implemented.	
5	Local Conflict of Interests	Local conflict can occur between the relocated people and the host community.	B	Local conflict can become constant between the relocated people and the host community.	B
		Excessive interventions by various stakeholders can trigger local conflict among residents, and the disruption of the local community.		-	
6	Gender	Appropriate information and knowledge may not be properly disseminated to the illiterate, particularly women.	B	Appropriate information and knowledge may not be properly disseminated to the illiterate, particularly women.	B
		Gender gaps can occur in job opportunities.			
7	Children's Rights	Child labor may occur due to their parents' loss of job.	C	Child labor may occur due to their parents' loss of job.	C
		Children may lose education opportunities.		Children may lose education opportunities.	
		Playgrounds for children may be lost.		Playgrounds for children may be lost.	
		Children may catch infectious diseases triggered by outsiders' entry into the community.		Children may catch infectious diseases triggered by outsiders' entry into the community.	
8	Land Use and Utilization of Local Resources	The present potential site that has been selected is away from the city center, residential areas, local markets, and protected forests. Land use and utilization of local resources however may be affected by the selected location and transmission line route.	C	The present potential site that has been selected is away from the city center, residential areas, local markets, and protected forests. Land use and utilization of local resources however may be affected by the selected location and transmission line route.	C
		Temporary loss of present land use pattern and/or economic infrastructure may occur.		Permanent loss of present land use pattern and/or economic infrastructure may occur.	

No	Item	Impact during Construction Stage		Impact during Operation Stage	
9	Social Institutions such as Social Infrastructure and Local Decision Making Institutions	Disruption of local community can be caused via a conflict of interests among politicians, government offices, and residents. It might cause a delay in procedures of land acquisition and resettlement.	B	-	C
10	Existing Social Infrastructure	Temporary loss of existing social infrastructure can occur due to the construction works.	C	Traffic to/from power station may become heavier. Social services may become insufficient.	C
11	Cultural Heritage	There is no cultural heritage existing in the site. A careful consideration however should be given to Seeta Kuthuri located near the site.	C	A careful consideration however should be given to Seeta Kuthuri located near the site.	C
		Landscape may be lost.		-	
12	Infectious Diseases such as HIV/AIDS	Infectious diseases may be spread via the construction workers into the community.	C	Infectious diseases may be spread via the operation workers into the community.	C

Source: PSMP Study Team

Mitigation measures on environmental pollution and natural environment are as found in AP Table 18-30.

AP Table 18-30 Mitigation Measures for Environmental Impact (B-K-D-P)

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
1	Air pollution	Countermeasures for air pollution by exhaust gas from transportation vehicles and construction machinery, and dust scattering from construction traffic are studied as in AP Table 18-67 and AP Table 18-68. As for the reduction of exhaust gas from transportation vehicles and construction machinery, idling stops and keeping proper exhaust condition by routine inspection of vehicles are judged to be applied. As for countermeasures for dust scattering, load cover, periodical vehicle washing and periodic peripheral road cleaning are judged to be applied.	AP table 18-62 shows countermeasures for NO_X, AP Table 18-63 shows countermeasures for SO_X, AP Table 18-64 shows countermeasures for Soot, and AP Table 18-66 shows countermeasures for coal dust. Besides conducting flue gas treatment by system including FGD, SCR, and ESP etc., mitigation of coal dust scattering is paid attention to. It is desirable to apply covered conveyer to prevent coal dust with coal transfer.
2	Water contamination	Countermeasures for water contamination due to excavation waste soil outflow are suitable via a fence installation utilizing sandbags etc. As for the effluent due to equipment washing, it is suitable to install a temporary precipitation tank and to drain the supernatant water. As for sewage, it is suitable to put up a septic tank. In addition, as for waste, water contamination can be prevented if waste treatment is conducted promptly and the waste is not left for long time.	There will be no warm effluent water generation since cooling tower or air cooled condenser will be adopted as cooling system. Plant effluent and sewage according to plant operations are discharged after waste water treatment including coagulating sedimentation, neutralization, and oil separation. Appropriate waste water facility capacity design is needed especially if air cooling tower is adopted as condensed cooling water blow effluent is a large amount.

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
3	Soil pollution	AP Table 18-69 shows the study result of countermeasures for soil pollution due to oil spillage from transportation vehicles and construction machinery. As a result, periodic maintenance implementation and conducting pre-operational machinery checks of machinery is judged important to be applied.	Oil and grease treatment procedures make it clear to prevent the spillage of lubrication oil or fuel oil. In addition, the management organization has been established to implement works according to designated procedures. And action procedures should be prepared in order to not to spread the adverse impact in case of an oil spillage occurrence. An oil dike has been set around the oil storage tank. It is necessary to dump ash properties in dumping site with water proof seat to prevent bottom sediment leakage out of the ash pond.
4	Noise and vibration	AP Table 18-70shows the study result of countermeasures for noise and vibration due to vibrations from transportation vehicles and construction machinery. As a result, leveling the construction process, using low-noise machinery, and lowering vehicle speed in residential areas are judged to be proper countermeasures. As for countermeasures for noise due to steam blowing during commissioning, the establishment of a work schedule without the blowing of steam during the night time is judged to be applied.	Developing the green belt along the site border is a costless and effective way to mitigate noise and vibrational impact. To avoid noise and vibration due to coal transportation, covered conveyor is desirable to use. If the boundary noise simulated in the detail EIA exceeds the noise regulations which is decided on each category (AP Table 18-8), the introduction of a green belt, sound insulating material and a sound insulating wall will be examined. B-K-D-P site is categorized in Residential Zone[1].
5	Offensive odor	Offensive odor caused by domestic waste decomposition from workers camps can be prevented by the separate collection and periodic disposal of waste.	NOx mitigation without SCR which uses ammonia is effective measure against offensive odor. When using ammonia, storage tanks, pipes, and valves must be inspected periodically. In addition to preventing operational mishaps, operations of the ammonia facility are to be managed by the person in charge. With regards to garbage treatment, it is suitable to dump it periodically and not have it in storage for a long time.
6	Waste	Reduction of waste amount can be conducted by establishing a waste management program including reduction, reuse and recycling. Implementation of a separate collection of waste, especially for paint sludge and batteries will be required. These items should be collected separately and disposed in designated areas.	Reduction of waste amount can be conducted by establishing a waste management program including reduction, reuse, and recycling. Because by-products due to plant operations are large amount, they should be recycled as much as possible. AP Table 18-71 shows examples of by-products recycling.
7	Ground subsidence	-	Ground subsidence should be prevented by adopting a cooling tower or air cooled condenser as a cooling system.

[1] Information source is DoE.

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
8	Biota and Ecosystem	Painted Roofed Turtle's nest building should be investigated in detail EIA. The nest relocation should be conducted when detected. Existence of Painted Roofed Turtle should be carefully paid attention to during construction stage and necessary protection actions should be conducted if detected. The site location and transmission line route should avoid protected forests.	Painted Roofed Turtle nest building should be investigated in detail EIA. The nest relocation should be conducted when detected. Existence of Painted Roofed Turtle should be carefully paid attention to during operation stage, and necessary protection actions should be conducted when detected
9	Water Usage	-	Air cooled condenser or cooling tower will be adopted as cooling system. Underground water drawdown for power plant operation should be prevented by using river water even if adopting the cooling tower. It is difficult to avoid a groundwater drawdown due to coal mine development. At the timing of pilot mining, mitigation measures should be confirmed of ground water drawdown by reinjection of drainage.
10	Accidents	A suitable OHS organization (policy, manual, announcement of policy, safety training and safety patrol) should be established to prevent accidents. It is also important to conduct quality control in construction work to prevent accidents during commissioning and operation period.	A suitable OHS organization (policy, manual, announcement of the policy and manuals, safety training, safety patrols) should be established for accident prevention. It is also important to conduct quality control in maintenance work in order to prevent accidents.
11	Global warming	-	It is estimated that approximately 3.54 million ton of CO_2 will be emitted from per 600MW unit per year through the operation of a coal-fired power plant. An ultra-super critical boiler with high thermal efficiency is being planned to be introduced into this master plan. Due to the introduction of a high efficiency unit, 1.07 million tons of CO_2 can be reduced per 600MW unit per year compared with the case of the Barapukuria class unit introduction. These figures are calculated based on designed value. It is important to keep designed output and efficiency from adequate O&M.

source： PSMP Study Team

18.3 Chittagong Site Information

18.3.1 Site Overview

The proposed Chittagong site (Chittagong South) is expected to be located on land covering several mauzas of Banskhali Upazilla under Chittagong District, on the southern mouth of the Sangu River pouring into the Bay of Bengal. It is 15 km away from Chittagong town in the south-eastern direction. A map showing the site has been given in APFig. 18-11.

Source : http://www.banglapedia.org/httpdocs/HT/B_0273.HTM (Accessed May 2010)

APFig. 18-11 Chittagong Site

(1) Health and Sanitation Environment

Local residents usually go to the village doctor for treatment. They also go to M.B.B.S. doctor and visit government hospitals and private hospitals for complicated health and medical treatment. They used to drink water from tube well, which is arsenic-free. They have slab latrines, brick-built latrines.

(2) Housing Condition

They have tin-made house ceilings. Some have walls constructed out of brick, tin, clay, bamboo and wood. Some of them have clay floors and brick-built floors. Some of them have separate kitchens.

(3) Income and Expenditure, and Job Opportunity

People are involved in businesses, farming, pulling rickshaws, daily labor and are also self-employed. Some households are associated with some Samity and five have already taken loans from samity for business purposes.

(4) Climate condition

APTable 18-31, APTable 18-32, APTable 18-33, APTable 18-34, APTable 18-35 and APTable 18-36 show the monthly maximum and minimum air temperature, monthly precipitation, monthly maximum and minimum relative humidity, and monthly average wind speed and prevailing wind direction at Chittagong (Patenga) station from 2000 to 2002 and from 2008 to 2009. Colored cell in each table indicates maximum and minimum value.

As for the air temperature, it is as hot as the maximum air temperature is over 28°C throughout the year. The minimum air temperature is under 20°C from November to March. The monthly maximum temperature is 39.5°C in May 2001 and the monthly minimum temperature is 9.0 °C in January 2001.

The annual precipitation reaches a level of 2,100mm to 3,500mm. The precipitation is at its most concentrated in the months from May to September. Conversely, there is no rainfall in some of the months from November to March. As described above, there is a marked difference in the rainfall between the rainy season and the dry season.

As for the humidity, it is relatively high, the monthly minimum relative humidity exceeds 50% in the period from May to October

As for the wind speed and wind direction, there are large influences from monsoons. It is clear that the wind blows from north from November to January, and the wind blows from south or southeast from April to September. The wind direction fluctuated between February and March. The average wind speed is not high, below 5m/s throughout a year. However, the Chittagong port experienced 12 times as many major cyclonic storms in the past 50 years. The maximum wind speed of the major cyclonic storm in 1991 was 62.5m/s.

APTable 18-66 shows a past record of the Major Cyclonic storms in Bangladesh.

APTable 18-31 Monthly maximum air temperature at Chittagong

Unit: °C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	30.2	30.6	36	34.9	35	35.5	35	35	34.4	35.8	34	29.6
2001	30	32.4	36.7	38.5	39.5	33	33.3	34.5	36	36	34	30.8
2002	31.2	35.2	37.2	34.5	35.4	33.5	33	33.5	35.2	35.4	35	30.6
2008	28	29.5	33.6	34	34.3	34.2	32.4	33.3	33.5	34	31.7	30.5
2009	29.5	31	34	34.3	35	34.2	34.5	—	—	—	—	—

Source : BMD, Dhaka

APTable 18-32 Monthly minimum air temperature at Chittagong

Unit: °C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	12	13	17	19.4	19.8	21.4	21.5	22.3	22	21.5	15.6	13
2001	9	11.6	14	22.5	21.2	22.8	25.5	24.5	22.8	22.8	16.5	14.2
2002	12.5	12.5	17.2	17.3	21	23	24	24	22.5	20.5	17.5	12.2
2008	12.6	11.8	17.6	20.5	22.1	24.2	24	24.2	23.4	20.6	17	14.5
2009	12.8	14	18.2	18.8	21.4	22.2	24	—	—	—	—	—

Source: BMD, Dhaka

APTable 18-33 Monthly precipitation at Chittagong (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year Total
2000	17	0	16	108	748	643	713	689	138	416	15	0	3503
2001	0	12	1	41	423	—	385	238	224	242	81	0	—
2002	1	0	70	67	453	366	920	456	145	129	128	10	2745
2008	64	7	6	1	244	538	963	757	250	171	31	0	3032
2009	0	2	3	114	373	434	1244	—	—	—	—	—	—

Source : BMD, Dhaka

APTable 18-34 Monthly maximum relative humidity at Chittagong (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	100	98	98	98	98	100	100	100	100	100	100	100
2001	100	100	100	93	94	98	96	96	100	100	100	100
2002	91	100	93	98	97	97	95	96	96	95	93	—
2008	100	100	100	98	96	98	100	100	100	100	98	100
2009	100	100	98	97	98	97	100	—	—	—	—	—

Source : BMD, Dhaka

APTable 18-35 Monthly minimum relative humidity at Chittagong (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	23	26	28	48	45	59	64	57	60	61	41	38
2001	31	22	16	34	46	54	62	60	56	59	33	29
2002	29	32	23	34	54	55	57	63	58	43	45	36
2008	31	20	31	26	40	60	67	69	52	48	41	44
2009	20	25	16	47	43	59	60	—	—	—	—	—

Source : BMD, Dhaka

APTable 18-36 Monthly average wind speed (m/s) and prevailing wind direction at Chittagong

Year	Jan		Feb		Mar		Apr		May		Jun	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2000	1.7	N	2.1	N	3.8	S	4.9	S	2.7	SE	4.0	S
2001	1.4	N	4.2	S	2.5	W	4.3	S	2.7	SE	4.2	SE
2002	2.2	NE	3.3	W	3.2	W	4.4	S	5.2	S	3.6	SE
2008	2.7	N	2.9	N	2.9	WSW	2.7	S	3.7	SSE	4.4	SSE
2009	3.2	WSW	3.9	WSW	3.2	WSW	4.4	SSE	3.7	SSE	3.3	E
Year	Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2000	4.1	SSE	2.7	SE	3	S	2.3	W	1.7	NNE	1.7	N
2001	5.3	S	3.4	SE	3.1	SE	2.7	W	2.6	NNE	2.1	NE
2002	4.3	S	4.5	S	2.7	SE	2.7	WNW	2.2	NE	2.1	NE
2008	4.4	SE	4.3	ESE	3.1	E	2.5	NNW	2.6	NNW	2.5	NNW
2009	4.5	E	-	-	-	-	-	-	-	-	-	-

Source : BMD, Dhaka

(5) Topography and Underground water

Bangladesh's topography and earthquake situation of Bangladesh is shown in APFig. 18-5 and APTable 18-65. The land form around the proposed site is almost a flat land with some high spots. The Chittagong site area is located in Zone II as seismic zones.

(a) Geology and water quality

Geological data has been obtained from boring survey results conducted at our near proposed site by the DPHE Territorial Division. The boring survey conducted in 2008 in the Deotala village under the Paraikora Union of Anowara Upazilla, which is close to the proposed site. APTable 18-37 and APTable 18-38 shows the result of the boring survey. The drilling depth was 208.23m. The results indicate that there is an Aquifer under 150m in depth. In addition, as for water quality, the iron concentration present exceeds the Bangladeshi Standard for drinking water, 1.0mg/l out of 3 measured items.

APTable 18-37 Boring result in Anowara (1)

Depth to Top (m)	Depth to Base (m)	Lithologic Description	
0.00	20.00	Silty clay	Aquitard 1
20.00	60.00	Silty	
60.00	100.00	Silty clay	
100.00	150.00	Silty	
150.00	180.00	Fine to Medium Sand	Aquifer 1
180.00	200.00	Medium to Coarse Sand	
200.00	208.23	Coarse Sand with gravel	

Source: DPHE

APTable 18-38 Boring result in Anowara (2)

Sl. No.	Parameters	Unit	Concentration Present	Bangladesh Standard for Drinking water
1	Iron, Fe	mg/L	3.0	0.3 – 1.00
2	Arsenic, As	ppb	0.0 (mg/l)	50
3	Chloride	mg/L	200	150 – 600

Source: DPHE

(6) Ecological situation

Data on the ecological situation has been obtained from the Department of Botany and Zoology of Dhaka University, Respective Upazila offices and local consultant.

(a) Terrestrial Communities

1) Flora

The area is well vegetated with planted trees. 75 species of the plants were found around the site. According to the Red List of the International Union for Conservation of Nature (IUCN), 2 species of them are identified as Least Concern (LC). A list of plants near the proposed site is provided in APTable 18-39.

APTable 18-39 List of animals found around Chittagong site

No.	Local Name	English Name	Scientific Name	IUCN status
1	Ada	Ginger	*Zingiber officinale*	--
2	Am	Mango	*Mangifera indica L.* (Anacard)	--
3	Arjun		*Terminalia arjuna*	--
4	Ashoke		*Saraca asoca*	--

No.	Local Name	English Name	Scientific Name	IUCN status
5	Ashwagondha		*Withania somniferum*	--
6	Babla		*Acacia nilotica*	--
7	Bansh pata		*Podocarpus nerifolia*	--
8	Basak		*Adhatoda zeylanica*	--
9	Bash	Bamboo	*Podocarpus nebifolia*	LC
10	Beet	Can Tree	*Beta vulgaris*	--
11	Bel	Indian apple	*Aegle marmelos (L).*	--
12	Beli		*Jasmin sambac* Ait (Olea)	--
13	Bokul	(Mimusops Elengi)	*Mimusops elengi L*	--
14	Boroi	Indian Jujube	*Zizyphus rugosa Lam*	--
15	Bot	Banayan tree	*Ficus benghalensis L.* (Mora)	--
16	Chameli		*Jasminum grandiflorum L.* (Oleace)	--
17	Chandan	Sandal	*Santalum album L.* (Santalaceae)	--
18	Dalim	Pomegranate	*Punica granatum L.*	--
19	Debdaru	Pine	*Polyalthia longifolia*	--
20	Dhol Kalmi		*Ipomoea fistolosa*	--
21	Dhutra	Thorn Apple	*Barringtonia acutangula*	--
22	Dumur		*Ficus hispida*	--
23	Gashpul		*Zephyranthes tubispatha Herb.* (Amaryllidaceae)	--
24	Golap	Rose	*Rosa centifolia L.* (Rosaceae)	--
25	Halencha		*(Altermanthere philoxeroides)*	--
26	Hyacinth		*(Eichhomia crassipes)*	--
27	Ipil Ipil	Ipil Ipil	*Leucaena Latisiliqua*	--
28	Jaba		*Hibiscus rosa sinensis L.* (Malvaceae)	--
29	Jam	Black Berry	*Syzygium cumini skiel.* (Myrtaceae)	--
30	Jambura	Citron	*Citrus grandis*	--
31	Jamrul	Star apple	*Syzygium samraogense (Bl.)*	--
32	Jhau	Poplar	*Thysanolaena maxima*	--
33	Kachu		*Colocasia esculenta (L.)*	--
34	Kadbel	Wood Apple	*Feronia limonia (L.)*	--
35	Kalmi		*(lpomoea aquatica)*	--
36	Kalo Dhutra		*Datura metel*	--
37	Kamranga	Carambola	*Averrhoa carambola*	--
38	Kathal	Jack Fruit	*Artocarpus heterphyllus Lamk*	--
39	Khejur	Date Plam	*Phoenix sylvestris*	--
40	Kola	Banana	*Musa Paradisica*	--
41	Koroi		*Derris robusta Benth.*	--
42	Kowa nim		*Melia sempervirens*	--
43	Krishnachura	Delonix regia	*Delonix regia (Boj.) Raf.* (Leguminosae)	--
44	Lazzaboti		*M. pudica L*	--
45	Lebo	Lemon	*Citrus aurantifolia*	--
46	Madar		*Erythriana variegata L.* var. *orientalis Merr.*	--
47	Man Kochu		*Alocasia indica*	--
48	Mankata		*Xeromphis spinosa*	--
49	Mehedi		*Lawsonia inermis*	--
50	Mehogoni		*Swietenia mahagoni*	--
51	Methi		*Trigonella foenum-graecum*	--
52	Muktajhuri		*Abroma augusta*	--

No.	Local Name	English Name	Scientific Name	IUCN status
53	Narikel	Coconut	*Cocos nucifers L.* (Palmae)	--
54	Neem		*Azadirachta indica*	--
55	Pakur		*Ficus Infectoria*	--
56	Patabahar	Patabahar	*Codiaeum Variegateum*	--
57	Pepe	Papaya	*Carica papaya L* (caricaceae)	--
58	Peyara	Guava	*Psidium Guajava (L)* Bat. (Myrtaceae)	--
59	Pui Shak		*Basella alba L.*	--
60	Radhachura		*Caesalpinia pulcherrima* Sw. (Leguminosae)	--
61	Rain tree		*Samea Samon*	--
62	Rangan		*Ixora rosea Will* (Rubiceae)	--
63	Rashun	Garlic	*Allium sativum*	--
64	Sajina		*Moringa Oleifera Lamk.* (Moringa)	--
65	Shal		*Shorea robusta*	LC
66	Shatamuli		*Asparagus racemosus*	--
67	Shimul		*Bombax ceiba L.* (Bombacaceae)	--
68	Shonali Lota			--
69	Sofeda	Sapodilla	*Achras Manilkara*	--
70	Supari	Colloq		--
71	Tal	Palm Tree	*Borassus flabellifer L.* (Palmae)	--
72	Tentul	Tamarind	*Tamarindus indica*	--
73	Thankuni		*Centella asiatica*	--
74	Topa pana		*(Pistia stratiotes)*	--
75	Ulatkambal		*Abroma augusta*	--

Source : PSMP Study Team

2) Fauna

The animals found around the site include a total of 73 species - 24 species of mammalian animals, 39 species of birds, 8 species of reptiles and 2 species of amphibians. Out of those animals on the Red List of the International Union for Conservation of Nature (IUCN) there are 8 species of LC, 1 species NT, 1 species of VU[1], 3 species of EN, 1 species of CR. Special care is needed for the protection of the Panited Roofed Turtle (CR) and Fishing Cat, Ganges River dolphin, Blue Whale (ER). APTable 18-40 shows a list of all the animals found around the Chittagong site.

APTable 18-40 List of animals found around Chittagong site

No.	Local Name	English Name	Scientific Name	IUCN Global Status
MAMMALS				
1	Badur/Daini	False Vampire	*Megaderma Lyra*	--
2	Bagdash	Large Indian civet	*Viverra Zibetha*	--
3	Bara Benji	Common Mongoose	*Herpestes edwardsi*	--
4	Bhera	Sheep	*Bovidae : Ovis*	--
5	Biral	Cat	*Felis : Catus*	--
6	Bon Biral/Wab	Jungal Cat/Swamp Cat	*Felis chaus*	--
7	Indur	Common House Rat	*Rattus rattus*	--
8	Gadha	Ass	--	--
9	Gecho Chucho	Common Tree shrew	*Tupaiaglis*	--
10	Ghora	Horse	*Equus caballus*	--

[1] Vulnerable

No.	Local Name	English Name	Scientific Name	IUCN Global Status
11	Goru	Cow	--	--
12	Kathbirali	Malayan Giant Squirrel	*Ratufa bicolor*	--
13	Khek Shiyal	Bengol Fox/Indian Fox	*Vulpes bengalensis*	--
14	Khargosh/Shashak	Rufous-tailed Hare	*Lepus nigricollis*	--
15	Kukur	Dog	*Cannis Familiaris*	--
16	Mecho Biral/Mecho Bagh	Fishing cat	*Prionailurus viverrinus*	EN
17	Mohish	Bafallow	--	--
18	Sagol	Goat	*Capra Hircus*	--
19	Shojaru	Indian crested Porcupine	*Hystrix Indica*	LC
20	Shesu	Ganges River dolphin	*Platanista gangetica gangetica*	EN
21	Shial	Jackal	*Canis Aureus Linnaeus*	--
22	Shukor	Pig	--	--
23	Timi	Blue Whale	*Balaenoptera musculus*	EN
24	Uod Biral	Oriental Small-clawed Otter	*Aonyx cinerea*	VU
BIRDS				
1	Babui-Batan	Small Pratincole	*Glareola Lactea*	--
2	Bali Hash	--	--	--
3	Banspaati	Green Bee-eater	*merops orientalis*	--
4	Baj	Crested Groshawk	*Accipiter trivirgatus*	--
5	Bok	Intermediate Egret	*Mesophoyx intermedia*	--
6	Bulbuli	Red-vented Bulbul	*Pycnonotus cafer*	--
7	Hutum Pecha	Rock Eagle Owl	*Bubo bengalensis*	--
8	Chil	Pariah Kite	*Passer domesticus*	--
9	Chorai	House Sparrow	*Passer Domesticus*	--
10	Dahuk	White Breasted water hen	*Amaurornis phoenicurus*	LC
11	Doyel	Magpie Robin	*Butastur teesa*	--
12	Eagal	Bazzard -Eagal	*Butastur teesa*	LC
13	Fingey	Black Drongo	*Dicrurus macrocercus*	LC
14	Gang Shalik	Bank Myna	*Acridotheres ginginianus*	--
15	Ghughu	Oriental Turtle Dove	*Streptopelia orientails*	--
16	Gung Chil	Whiskered Tern	*Chlidonias hybridus*	--
17	Hash	Duck	*Anatidae Anseriformes*	--
18	Hot-titi	River Lapwing	*Vanellus duvaucelii*	--
19	Jalali Kobutor	Rock Pigon	*Columba Livia*	LC
20	Kak	House Crow	*Corvus splendens*	--
21	Kana Bok	Indian Pond Heron	*Ardeola grayii*	--
22	Kat Tokra	Woodpecker	*Picoides pubescens*	--
23	Kokil	Asian Koel	*Eudynamys scolopacea*	--
24	Konch Bak.	Pond Heron.	*Ardeola grayii*	--
25	Machhranga	White Throated	*Halcyn smyrensis*	--

No.	Local Name	English Name	Scientific Name	IUCN Global Status
		Kingfisher		
26	Mohanchura	Hoopoe	*Upupa epops*	--
27	Moutusi	Purple rumped Sunbird	*Nectarinia zeylonica*	--
28	Paira	Pigeon	*Columba livia domestica*	--
29	Pankouri	Great Cormorant	*Phalacrocorax carbo*	--
30	Pencha	Sport-bellied Owl	*Bubo nipalensis*	--
31	Rajhans	Bar-headed Goose	*Anser indicus*	LC
32	Shalik	Indian mynah	--	--
33	Shamuk Bhanga, Shamuk Khol.	Open Bill Stork	*Anastomus oscitans*	--
34	Shonkho Chil	Brammoni Kite	*Haliastur Indus*	--
35	Sipahi Bulbuli	Red –whiskered Bulbul	*Pycnonotus jocosus*	--
36	Baro Tia	Large Indian Parakeet	*Psittacula eupatria*	--
37	Kalim	Purple Moorhen	*Porphyrio porphyrio*	--
38	Tuntuni	Tailor bird	*Orthotomus sutorius*	--
REPTILE				
1	Tiktiki	HouseLizard	*Hemidactylus bowringii*	--
2	Ajogor	Rock Python	*Pyhon molurus*	NT
3	Kasim	Painted Roofed Turtle	*Kachuga Kachuga*	CR
4	Gui Shap	Bengal Monitor/ Grey Monitor Lizard	*Varanus bengalensis*	--
5	Sabuj Dhora	Green Keel back Snake	*Macropisthodon plumbicolor*	--
6	Kalo Mete Dhora Shap	Dark-Bellied Marsh Snake	*Xenochrophis cersogaster*	--
7	Gokhra Shap	Monocellate Cobra	*Naja kaouthia*	--
8	Raj Gokhra	King Cobra	*Ophiophagus hannah*	--
AMPHIBIAN				
1	Beng	Frog	*Anura : Ranidae*	--
2	Geso Beng	Canyon treefrog	*Hyla arenicolor Cope*	--

Source : PSMP Study Team

(b) Aquatic Communities

1) Aquatic Flora

The freshwater dependent plants such as helencha (Altermanthere philoxeroides), kalmi (Ipomoea aquatica), daokalmi (Ipomoea fistulosa), ichadal (Potamo seton) and water hyacinth (Eichhomia crassipes) are common among the ponds, canals and rivers near the Chittagong site. The Khuda pana (Lemna minor), topapana, (Pistia stratiotes) and chaicha (Saipus articulatus) are also common.

2) Aquatic Fauna

The fishes found around the site include a total of 56 species of river dwellers and 15 species of sea dwellers. Out of those animals on the Red List of the International Union for Conservation of Nature (IUCN) contain 1 species of NT. APTable 18-41 shows confirmed species of fishes.

APTable 18-41 List of Fishes Available Chittagong site.

No.	Local Name	English Name	Scientific Name	IUCN Global Status
RIVER FISH				
1	Ayer	Long Whiskered cat fish	*Aorichthys aor*	--
2	Bacha	(Batchwa Bacha)	*Eutropicchthys vhacha*	--
3	Baghair	Gangetic goonch	*Bagarius Yarrellii sykes*	--
4	Bamos / Baobaim	(Indian Long Fin Eel)	*Anguilla bengalensis*	--
5	Banshpata	Sind danio	*Devario devario*	--
6	Bata	Giantscale Mullet	*Lizamelinoptera*	--
7	Bele	Scribbled goby	*Awaous grammepomus*	--
8	Bhagna	--	--	--
9	Bhangon Bata/Bata	(Bata labeo)	*Labeo Bata*	--
10	Bhol/Bol	Indian Trout	*Raiamas bola*	--
11	Chanda	Elongate glass perchlet	*Chanda nama*	--
12	Cheka / Chega (Indian Chaca)	Indian Chaca	*Chaca chaca*	--
13	Chitol	Humped Featherback	*Nototeruse chitala*	--
14	Darkina	Flying barb	*Esomus Danricus*	--
15	Dhela/ Dipali/ ketti(Cotio)	Cotio	*Osteobrama cotio*	--
16	Ek Thota	Wrestling halfbeak	*Dermogenys pusillus*	--
17	Elong/Sefatia	(Bengal barb)	*Bengala Elanga*	--
18	Foli	Grey Featherback	*Notopterus notopterus*	--
19	Ghaura	(Gaura Bacha)	*Clapisoma gaura*	--
20	Ghonia/Gonainya	(Kuria baleo)	*Labeo gonius*	--
21	Gojar/ Gojal	Great snake head	*Channa marulius*	--
22	Golsa/ Golsa Tengra	Gangetic Mystus	*Mystus cavasius*	--
23	Guijja Air	Giant River Cat Fish	*Aorichthys (Mystus) seenghala*	--
24	Ilish	Hilsa	*Tenualosa ilisha*	--
25	Kajli / Banshpata	Jamua ailia	*Ailia punctata*	--
26	Kala Bata	(Gan Getic latia)	*Crossocheilus latius*	--
27	Kalibaush (kalbasu)	Orange-fin labeo	*Labeo calbasu*	--
28	Kani Pabda / Boali Pabda	(Indian Butter cat fish)	*Ompak bimaculatus*	--
29	Kash Khaira	(Indian Glass barb)	*Chela laubuca*	--
30	Katla	Catla	*Catla Cattla*	--
31	Khailsha	Banded gourami	*Colisa fasciata*	--
32	Khorshola		*Labeo dero*	--
33	Kucha / Kuchia	Gangetic Mudeel Cuchia	*Monopterus cuchia*	--
34	Meni / Bheda/ Rayan/ Bheduri	Mottled nandus, mud perch	*Nandus nandus*	--
35	Mrigal	Mrigal	*Cirrhinus mrigala*	--
36	Nandina / Nandil	(Nandi Labeo)	*Labeo nondina*	--

No.	Local Name	English Name	Scientific Name	IUCN Global Status
37	Napit Koi/ Koi Banedi	Dwarf chemel confish Badis	*Badis badis*	--
38	Neftani	Indian Paradise Fish	*Clenops nobolis*	--
39	Pabda	Pabo Cat fish	*Ompok pabo*	--
40	Pungash (River)	Yellowtail catfish	*Pangasius pangasius*	--
41	Puti	Fry	*Puntius puntio (Hamilton)*	--
42	Raikh bata	---	*Rhinomugil corsula*	--
43	Ranga Chanda / Lal Chanda	(Indian Glassy Fish)	*Pseudembassis ranga*	--
44	Rani / Beti	(Necktie Loach)	*Batia Dario*	--
45	Rani/ Putul /Beti	(Y-Loach)	*Botia Iohachata Chaudhuri*	--
46	Rui	Rohu	*Labeo rohita*	--
47	Sarputi / Swarnaputi	(Olive barb)	*Puntius sarana*	--
48	Shal baim/ Baim Bam	Tire trach spinyeel	*Mastecembelus armatus*	--
49	Shillong	Silondia V acha	*Silonla Silondia*	--
50	Shol	Banded Snakehead	*Channa striatus*	--
51	Sisor / Chenua	Sisor cat fish	*Sisor rhabdophorus*	--
52	Tara Baim	One Strip spiny eel	*Macroganthus aral*	--
53	Tatkini/Bata/Bangla	Reba carp	*Cirrhinuss reba*	--
54	Telo Taki / Rana Cheng/ Ganchua	Asiatic snake head	*Channa Orientalis*	--
55	Tengra	Assamese Batasio	*Batasio Tengana*	--
56	Titputi	(Ticto barb)	*Puntias Ticto*	--
Sea Fish				
1	Bagair	Gangetic Goonch	*Bagarius yarrelli*	--
2	Chingri	Shimp	--	--
3	Choto Shark	Small Shark Fish	--	--
4	Fasha	Fasha Fish	--	--
5	Hangar	Whitetip reef shark	*Triaenodon obesus (Ruppell)*	NT
6	Ilish	Hilsa shad	*Hilsa ilisha*	--
7	Jhinuk	--	--	--
8	Kakra	Crabs	--	--
9	Korat	Karat Fish	--	--
10	Nuna Bailla	Bumblebee Goby	*Brachygobius nunus*	--
11	Nuna Tangra	Long whiskers catfish	*Mystus gulio*	--
12	Poa	Pama croaker	*Otolithoides pama*	--
13	Potka	Green pufferfish	*Tetraodon fluviatilis*	--
14	Rita	Rita	*Rita Rita*	--
15	Rup Chanda	Elongate glass perchlet	*Chanda nama*	--

Source : PSMP Study Team

18.3.2 Detailed Information on Meetings with Local Stakeholders

APTable 18-42 Profile of Household Interviewees (near Chittagong Site)

No	Sex	Age	Village	Distance from Power Plant	Education	Occupation	Household Monthly Income
1	F	35	Gobadiya	400m	Nil	Agriculture	7,500
2	F	30	Dud Kumra	250m	Nil	Business	4,000
3	M	27	Dud Kumra	300m	S.S.C	Business	8,000
4	F	35	Gobadiya	500m	Nil	Riksha Puller	3,000
5	F	30	Gobadiya	500m	Nil	Riksha Puller	4,000
6	F	20	Dud Kumra	300m	Class V	Business	4,000
7	M	30	Dud Kumra	300m	S.S.C	Business	10,000
8	F	27	Dud Kumra	300m	Nil	Day labor	4,000
9	F	30	Dud Kumra	300m	Class V	Day labor	5,000
10	M	55	Dud Kumra	200m	Class V	Agriculture	4,000
11	M	38	Dud Kumra	250m	H.S.C	Service	70000
12	M		Gobadiya	300m	Class VIII	Service	6,000
13	M		Gobadiya	350m	Class IV	Business	6,000
14	M	23	Gobadiya	400m	Class VII	Business	6,000
15	M	35	Gobadiya	450m	S.S.C	Business	6,000

Source: Household interview

APTable 18-43 Profile of FGD Participants (near Chittagong Site)

No	Age	Education	Occupation	Household Monthly Income
Male Participants				
1	75	Nil	Rickshaw Puller	3,000
2	54	VI	Job	8,000
3	61	VIII	Unemployed	10,000
4	28	Only Signature	Business	3,000
5	32	VI	Business	6,000
6	37	V	Electrician	5,000
7	36	Only Signature	Rickshaw Puller	4,000
8	57	VIII	Business	8,000
Female Participants				
1	26	V	Housewife	4,000
2	60	None	Housewife	4,000

No	Age	Education	Occupation	Household Monthly Income
3	50	None	Housewife	10,000
4	18	IX	Student	5,000
5	25	None	Housewife	5,000
6	27	S.S.C.	Housewife	6,000

* 'business' describes shop running, tea store etc.

Source: Focus group discussions

APTable 18-44 Participants Profile Local Stakeholder Meeting (Chittagong Site)

No.	Designation and Organization
Participants from Chittagong Site	
1	Chairman, Banskhali Upazila
2	Banskhali (Villager)
3	Banskhali (Villager)
4	Banskhali (Villager)
5	UNO, Banskhali
6	Principal, Banskhali
7	Banskhali (Villager)
8	UAO, Banskhali
9	SUFO (DOF), Banskhali
10	Chairman, 3No. Khankhanabad
GOB	
1	Additional Secretary
2	Asst. Chief, Power Division
3	EGCB Ltd.
4	Assistant Engineer, Design & Inspection-I, BPDB
PSMP Study Team and Local Consultant	
1	PSMP Study Team
2	PSMP Study Team
3	EAL, Executive Director
4	EAL, Engineer
5	EAL, Social Specialist
6	EAL
7	EAL

Source: PSMP Study Team

18.3.3 Problem Analysis and Problem Solution

Problem analysis on environmental pollution and natural environment is as found in APTable 18-48.

AP Table 18-45 Problem Analysis: Assessment Results on Environmental Impact (Chittagong)

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
1	Air Pollution	The occurrence of air pollution is possible due to exhausted gas from transportation vehicles and construction machinery. And dust particles may be scattered near the construction site and construction vehicle road.	B	Planned coal-fired power plant burns domestic coal which is mined from the adjacent coal mine as main fuel. And it burns light oil as auxiliary fuel (fuel for starting up). NO_X, SO_X and soot will be generated due to the combustion of these fuels. And coal transportation may generate coal dust.	A

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
2	Water Contamination	Rainfall drainage equipment washing drainage and sewage will be generated during the construction work. If waste management isn't appropriate, effluent from waste may be generated.	B	Thermal discharge will be produced when using river water as cooling water. Plant effluent and domestic waste water will be generated through plant operations. If a cooling tower is used, a large amount of condensed cooling water effluent will be generated. If waste management isn't appropriate, effluents from waste may be generated.	A
3	Soil pollution	Soil pollution can occur due to lubrication oil or fuel oil spillage generated by transportation vehicles and construction machinery.	B	Soil pollution can occur due to lubrication oil or fuel oil spillage for unit operations.	B
4	Bottom Sediment	There is a possibility of bottom sediment if effluent due to construction work flow out to the Bay of Bengal or the Sangu River.	B	There is a possibility of bottom sediment if the plant effluent and domestic waste water discharge after inadequate treatment. If an ash pond is used, it is necessary to pay attention to the bottom sediment of the pond.	B
5	Noise and vibration	Noise and vibration arise due to the vibration of transportation vehicles and construction machinery (see AP Table 18-61). And steam blowing during commissioning will generate significant noise.	A	Noise and vibration will be generated through the operation of the power facilities. If a cooling tower is used, there is significant noise and vibration from the cooling fan of the tower. During periodic inspections, the noise and vibration arise due to the vibration of the transportation vehicle and construction machinery.	A
6	Offensive Odor	If domestic waste management isn't applicable to workers' stations, offensive odors may be generated due to waste decomposition.	B	Ammonia, which is used at SCR leaks, may be the source of offensive odor. If the domestic waste management isn't applicable to the workers' stations for maintenance work etc., offensive odor may be generated due to waste decomposition.	B
7	Waste	Construction work will generate metal chips, waste plastic, wood shavings, waste glass and waste oil. And domestic waste such as cans, bottles, and food residue will be generated from construction workers' stations.	B	By-products through the operation of coal-fired power plant are coal ash, gypsum (if limestone-gypsum FGD is used), sludge from waste water treatment facility, and cooling water canal fouling (if the river water or sea water is used for the cooling water). These by-products will be wasted if they are discarded without recycling. Maintenance work will generate metal chips, waste plastic, wood shavings, waste glass and waste oil. And domestic waste such as cans, bottles, and food residue will be generated from workers' stations.	A
8	Ground Subsidence	Ground subsidence will not occur since water will be taken from the Sangu River to use for construction works, not from the underground water.	C	Ground subsidence will not occur since cooling water and makeup water will be taken from the Sangu River, not from the underground water.	C

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
9	Geographical Feature	There is little impact since the proposed site is plain and doesn't possess any outstanding geographical features.	C	There is little impact since the proposed site is plain and doesn't have any outstanding geographical features.	C
10	Biota and Ecosystem	Though the proposed site and its surrounding area have already been converted into the agricultural land, there is a possibility of Painted Roofed Turtle which is categorized CR in IUCN Red List and Fishing Cat which is categorized EN in IUCN Red List existing around the site. Around sea area, Ganges River Dolphin and Blue Whale which are categorized EN in IUCN Red List may Exist.	B	Though the proposed site and its surrounding area have already been converted into the agricultural land, there is a possibility of Painted Roofed Turtle which is categorized CR in IUCN Red List and Fishing Cat which is categorized EN in IUCN Red List existing around the site. Around sea area, Ganges River Dolphin and Blue Whale which are categorized EN in IUCN Red List may exist.	B
11	Water Usage	There is no impact to water usage as the Sangu River water is available as water for construction work.	C	There is no impact to water usage as the Sangu River water is available as cooling water and makeup water of power plant.	C
12	Accident	Construction accidents can occur due to the oversights of health and safety management during construction work. It is necessary to pay attention especially to falling accidents from high altitude locations, road accidents of construction vehicles and electrical accidents.	A	Fires due to oil spillage or instantaneous combustion of coal, accidents due to leakage or spillage of chemicals like caustic soda and sulfuric acid, and accidents or incidents involving maintenance work can occur.	B
13	Global Warming	Transportation vehicles and construction machinery will exhaust CO_2.	C	It is estimated that approximately 3.79 million ton of CO_2 will be exhausted from per 600MW unit per year through the operations of coal-fired power plant. In light of its cost-effectiveness, brown coal will be imported. Brown coal emits more CO_2 than domestic coal which has been classified as bituminous coal.	B

Source： PSMP Study Team

Social impact assessment results can be found in AP Table 18-46

AP Table 18-46 Problem Analysis: Assessment Results on Social Impact (Chittagong Site)

No	Item	Impact during Construction Stage		Impact during Operation Stage	
1	Involuntary Resettlement	Land acquisition is anticipated for 1,000 acres that require approximately 1,000 households to be relocated.	A	Damage to houses and health hazards can be caused by smoke extraction, noise pollution, water pollution and land subsidence when the resettlement action plan is not appropriately planned and implemented. Political intervention and/or local movement against the operation of power stations can occur when adverse impacts on local residents' lives and livelihoods are severe.	B

No	Item	Impact during Construction Stage	Rating	Impact during Operation Stage	Rating
2	Local Economy such as Employment and Livelihood etc.	Residents around the site are mainly involved in the secondary and the tertiary industries. There are much more seaport workers than there are agricultural laborers. The temporary loss of agricultural lands can cause loss of employment and livelihoods, particularly among agricultural laborers during the construction period.	C	Land acquisition for power station operations and surrounding areas can cause permanent loss of employment and livelihoods, particularly among agricultural laborers. In case water treatment is not properly conducted, adverse impacts may occur to local fishing industry.	C
		The Bangladesh regulation stipulates that displaced persons are entitled to compensation for loss of land, property and standing crops in monetary terms at the fixed rates. It however does not compensate for the loss of employment or livelihoods.		The Bangladesh regulation stipulates that displaced persons are entitled to compensation for loss of land, property and standing crops in monetary terms at the fixed rates. It however does not compensate for the loss of employment or livelihoods. The destitute and poor, particularly landless farmers can become further distressed when job opportunities or at the least, skill training opportunities for them are not secured.	
3	The Poor, Indigenous and Ethnic People	There are no ethnic people living in the site.	C	There are no ethnic people living in the site.	C
		The destitute, poor and landless farmers can lose their jobs when agricultural land is lost due to the construction of power station.		The destitute, poor and landless farmers can become further distressed when job opportunities or at the least skill training opportunities for them are not secured.	
4	Misdistribution of Benefit and Loss	Disparity between land owners and the rest (landless farmers, wage laborers etc.) may widen.	C	Landless farmers and wage laborers can become further distressed and the disparity between land owners and them can be widened when job opportunities and skill training opportunities are not provided.	C
		In case an ample number of job opportunities and skill training opportunities are not provided to meet the demand, the disparity between those with such opportunities and those without can be widened.		Local livelihoods can be affected and health hazards can be caused by land subsidence, smoke extraction, noise pollution, water pollution and water shortages when the environmental management plan is not appropriately planned and implemented.	
5	Local Conflict of Interests	Local conflict can occur between the relocated people and the host community.	C	Local conflict can become constant between the relocated people and the host community.	C
		Excessive interventions by various stakeholders can trigger local conflict among residents, and the disruption of the local community.			
6	Gender	Appropriate information and knowledge may not be properly communicated to the illiterate, particularly women.	C	Appropriate information and knowledge may not be properly communicated to the illiterate, particularly women.	C
		Gender gaps can occur in terms of job opportunities.			

No	Item	Impact during Construction Stage		Impact during Operation Stage	
7	Children's Rights	Child labor may occur due to their parents' loss of job.	C	Child labor may occur due to their parents' loss of job.	C
		Children may lose education opportunities.		Children may lose education opportunities.	
		Playgrounds for children may be lost.		Playgrounds for children may be lost.	
		Children may catch infectious diseases triggered by outsiders' entry into the community.		Children may catch infectious diseases triggered by outsiders' entry into the community.	
8	Land Use and Utilization of Local Resources	The present potential site that has been selected is away from the city center, residential area, local market, and the protected forest.	C	The present potential site that has been selected is away from the city center, residential area, local market, and the protected forest.	C
		Temporary loss of present land use patterns and/or economic infrastructure may occur.		Permanent loss of present land use patterns and/or economic infrastructure may occur.	
9	Social Institutions such as Social Infrastructure and Local Decision Making Institutions	Disruption of local community may be caused by a conflict of interests among politicians, government offices, and residents. It might cause a delay in procedures of land acquisition and resettlement.	C	-	C
10	Existing Social Infrastructure	Temporary loss of existing social infrastructure may occur due to the construction works.	C	Traffic to/from power station may become heavier. Social services may become insufficient.	C
11	Cultural Heritage	There is no cultural heritage existing on the site. Careful consideration however should be given to Mazan of Peer Mohsin Aulia located near the site.	C	Careful consideration however should be given to Mazan of Peer Mohsin Aulia located near the site.	C
		Landscapes may be lost.		-	
12	Infectious Diseases such as HIV/AIDS	Infectious diseases may spread via the construction workers into the community.	C	Infectious diseases may spread via the operation workers into the community.	C

Source: PSMP Study Team

Mitigation measures are examined for environmental pollution and natural environmental impacts are as found in APTable 18-47 .

APTable 18-47 Mitigation Measures for Environmental Impact (Chittagong)

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
1	Air pollution	Countermeasures for air pollution due to exhaust gas from transportation vehicles and construction machinery and dust scattering due to construction traffic are studied as in AP Table 18-67 and AP Table 18-68. As for the reduction of exhaust gas from transportation vehicles and construction machinery, idling stops and keeping proper exhaust condition by routine inspection of vehicles are judged to be applied. As for countermeasures for dust scattering, load cover, periodical vehicle washing, and periodic peripheral road cleaning are judged to be applied.	AP Table 18-62 shows countermeasures for NO_X, AP Table 18-63 shows countermeasures for SO_X, AP Table 18-64 shows countermeasures for Soot, and AP Table 18-66 shows countermeasures for coal dust. Besides conducting flue gas treatment by system including FGD, SCR and ESP etc., mitigation of coal dust scattering should be paid attention to.
2	Water contamination	Countermeasures for water contamination due to excavation waste soil outflow are suitable via a fence installation utilizing sandbags etc. As for the effluent due to equipment washing, it is suitable to install a temporary precipitation tank and to drain the supernatant water. As for sewage, it is suitable to put up a septic tank. In addition, as for waste, water contamination can be prevented if waste treatment is conducted promptly and the waste is not left for long time.	There is no warm effluent water generation since cooling tower or air cooled condenser will be adopted as a cooling system from consideration to impact of warm effluent water and local fishery. Plant effluent and sewage according to plant operations are discharged after waste water treatment including coagulating sedimentation, neutralization, and oil separation. Appropriate waste water facility capacity design is needed especially because condensed cooling water blow effluent is a large amount.
3	Soil pollution	AP Table 18-69 shows the study result of countermeasures for soil pollution by oil spillage from transportation vehicles and construction machinery. As a result, periodic maintenance implementation and conducting pre-operational machinery checks of machinery is judged important to be applied.	Oil and grease treatment procedures make it clear to prevent the spillage of lubrication oil or fuel oil. The management organization should be established to implement works according to designated procedures. And action procedures should be prepared in order not to spread the adverse impact in case of an oil spillage occurrence. An oil dike should be set around the oil storage tank.
4	Bottom sediment	Implement measures described in 2)Water contamination.	It is necessary to dump ash properties in dumping site with water proof seat to prevent bottom sediment leakage out of the ash pond.

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
5	Noise and vibration	AP Table 18-70 shows the study result of countermeasures for noise and vibration due to vibrations from transportation vehicles and construction machinery. As a result, leveling the construction process, using low-noise machinery, and lowering vehicle speed in residential areas are judged to be proper countermeasures. As for countermeasures for noise due to steam blowing during commissioning, the establishment of a work schedule without the blowing of steam during the nighttime is judged to be applied.	Developing the green belt along the site border is a costless and effective way to mitigate noise and vibrational impact. If the boundary noise simulated in the detail EIA exceeds the noise regulations which is decided on each category (AP table 18-8), the introduction of a green belt, sound insulating material and a sound insulating wall will be examined. Chittagong site is categorized in Mixed Zone[1]
6	Offensive Odor	Offensive odor caused by domestic waste decomposition from workers camps can be prevented by separate collection and periodic disposal of waste.	NOx mitigation without SCR which uses ammonia is an effective measure against offensive odor. In the case of use ammonia, storage tanks, pipes, and valves must surely be inspected periodically. In addition to preventing operational mishaps, operations of the ammonia facility are to be strictly managed by the person in charge. With regards to garbage treatment, it is suitable to dump periodically and not keep in storage for a long time.
7	Waste	Reduction of waste amount can be conducted by establishing a waste management program including reduction, reuse, and recycling (3R). Implementation of a thorough separate collection of the waste is needed, especially for paint sludge and batteries. These items should be collected separately and disposed in designated areas.	Reduction of waste amount can be conducted by establishing a waste management program including reduction, reuse, and recycling (3R). Because by-products through plant operations are large amount, they should be recycled as much as possible. APTable 18-71 shows examples of by-products recycling
8	Biota and Ecosystem	Nest building of Painted Roofed Turtle, Fishing Cat, Ganges River Dolphin, and Blue Whale should be examined in detail EIA. The nest relocation should be conducted if there are any. Existence of each endangered species should be carefully paid attention to during construction stage, and necessary protection action should be conducted if there are any.	Nest building of Painted Roofed Turtle, Fishing Cat, Ganges River Dolphin, and Blue Whale is examined in detail EIA. The nest relocation should be conducted if there are any. Existence of each endangered species should be carefully paid attention to during operation stage and necessary protection action should be conducted if there are any
9	Accident	A suitable OHS organization (policy, manual, announcement of policy, safety training and safety patrol) should be established to prevent accidents. It is also important to conduct quality control in construction work to prevent accidents during commissioning and operation period.	A suitable OHS organization (policy, manual, announcement of the policy and manuals, safety training, safety patrols) should be established for accident prevention. It is also important to conduct quality control in maintenance work to prevent accident.

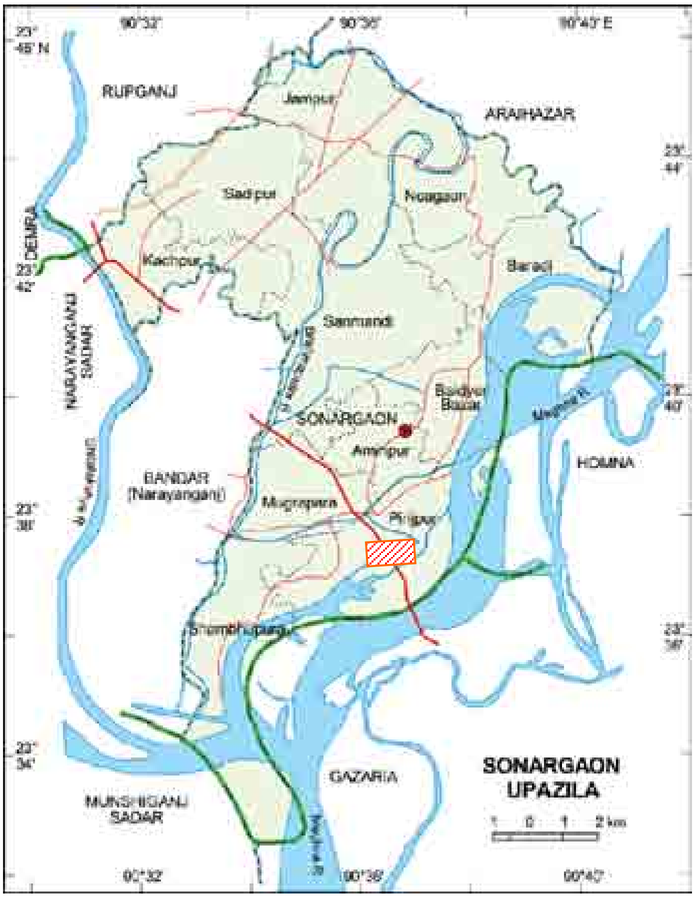
No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
10	Global warming	-	It is estimated that approximately 3.54 million ton of CO_2 will be emitted from per 600MW unit per year through the operation of a coal-fired power plant. An ultra-super critical boiler with high thermal efficiency is being planned to be introduced into this master plan. The introduction of a high efficiency unit can reduce 1.07 million tons of CO_2 per 600MW unit per year compared with the case of the Barapukuria class unit introduction. These figures are calculated based on designed value. It is important to keep designed output and efficiency from adequate O&M.

Source: PSMP Study Team

18.4 Meghnaghat Site Information

18.4.1 Site Overview

The proposed Meghnaghat power plant is close to Dhaka City, located on the bank of the Meghna River, to the south of Sonargaon Upazilla center. It is expected to be located at Islampur and Ganganagar villages in Pirojpur Union under Sonargaon Upazilla of Narayanganj District. A map showing Meghhaghat is given in APFig. 18-12



Source: http://www.banglapedia.org/httpdocs/HT/N_0057.HTM (accessed May 2010)

APFig. 18-12 Proposed Meghnaghat Site

(1) Health and Sanitation Environment

Local people suffer from diseases like colds, asthma, headaches, fevers, etc. They consult with local pharmacists, medical doctors or go to public hospital. For more serious problems, they go to Dhaka or visit the Sheba Clinic as there's no hospital in town.

They used to drink arsenic free water from the tube-well which is also used for cooking and use the river water for bathing and washing clothes. The present layer of water is 100 feet below, although it was around a depth of 60 feet in the past. All respondents have hygienic slab latrines in their houses.

(2) Housing Condition and Surrounding Area

The floors of houses are made out of brick and clay. The walls of houses are brick-made and the ceilings are tin-made. Electricity is distributed for 24 hours a day except during irrigation periods and they are very conscious about the proper consumption of electricity.

(3) Income, Expenditure and Job Opportunities

They do business, are self-employed, and work in other professions. Some of them are associated with samity (Association) and have taken out loans from samity to start their own businesses.

(4) Climate condition

The Dhaka station is the nearest station of the Bangladesh Meteorological Department (BMD) from Meghnaghat. APTable 18-48, APTable 18-49, APTable 18-50, APTable 18-51, APTable 18-52 and APTable 18-53 show the monthly maximum and minimum air temperature, monthly precipitation, monthly maximum and minimum relative humidity, and monthly average wind speed and prevailing wind direction at the Dhaka station from 2000 to 2009. Colored cell in each table indicates maximum and minimum value.

As for the air temperature, it is as hot as the maximum air temperature is over 27°C throughout the year. The minimum air temperature is under 10°C from November to March, so the difference between maximum and minimum temperature is large. The monthly maximum temperature is 39.6°C as of April 2009 and the monthly minimum temperature is 8.1 °C in January 2003.

The annual precipitation reaches a level of 1,700mm to 2,900mm. The precipitation is at its most concentrated between May and September. Conversely, there is no rainfall during some of the months from November to March. As described above, there is a marked difference in the rainfall between the rainy season and the dry season.

As for the humidity, it is relatively high; the monthly minimum relative humidity exceeds 50% during the period between May and September.

As for the wind speed and wind direction, there are large influences from the monsoon. It is clear that the wind blows from the north or northeast between November and February, and the wind blows from the south to the southeast between March and September. The average wind speed is not that high, below 3m/s throughout a year.

APTable 18-48 Monthly maximum temperature of Dhaka station (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	28.7	28.2	34	35.1	36.6	35.2	35.2	35	34.4	34.9	32.5	27.3
2001	28	31.4	35.8	37.5	35	33.8	34	34	34.2	34.8	32	28.4
2002	28.2	33.5	35.5	34.3	35.4	34.4	35.2	34.1	35	34.2	32	29.5
2003	27.5	31.6	34	36.2	36.3	36.7	35.3	35.1	34.2	34	32.1	29.2
2004	27.5	32.8	35.7	35.2	38.1	35.2	34.5	34.6	34	34.5	31.1	29.4
2005	28.5	32.1	35.6	37	36.4	36.6	33.7	34	35.1	34.6	31.4	29
2006	28.2	35.9	38.5	37.1	36.8	35	35.6	35.2	35.7	34.7	32.6	30.1
2007	28.8	30.8	36.7	35.9	37.5	35.9	34.8	35.9	34.9	35.6	31.8	28.2
2008	29	30.6	34.6	36.9	36.7	35.4	34	36	34.8	34.8	32.3	29
2009	28.1	33.9	36	39.6	37.8	36.5	35.7	34.3	—	—	—	—

Source : BMD, Dhaka

APTable 18-49 Monthly minimum temperature of Dhaka station (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	10	13.2	15.4	18	19.5	23.8	24	23.6	23	19.3	16.8	13.4
2001	9.8	12.4	16.6	20.9	19.9	24	24	22.5	21.5	19.7	15.5	12.6
2002	11.2	11.5	15.8	16.6	19.4	22	22.8	23.3	22	18.3	17.5	11.7
2003	8.1	14.2	13.5	17.8	19.6	22.5	23.4	24.2	23.5	23	14	13.2
2004	10.7	10.4	16.3	18.5	20.2	22.4	21.5	24.8	22.7	21.5	15.8	11.5
2005	11.4	11.5	19	19.6	19.7	22.5	24	24.3	23.8	20.8	16	12.2
2006	10.4	15.4	16.3	20.2	20.4	22.3	24.6	22.7	23.8	21.8	13.3	12.6
2007	9.6	12.6	15	18.1	22.5	22	23.4	24.2	24.5	19.5	16.8	11.3
2008	10.5	10.8	16.5	19.6	20.3	22.5	24.6	23.6	24.4	18	16.3	13
2009	11.1	12.2	15.8	20.4	21.6	22.6	24.4	24.3	—	—	—	—

Source : BMD, Dhaka

APTable 18-50 Monthly precipitation of Dhaka station (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year Total
2000	13	44	172	189	491	165	197	359	216	278	0	0	2124
2001	0	1	33	46	402	386	202	205	209	177	18	0	1679
2002	22	4	51	111	272	373	446	272	156	52	116	0	1875
2003	0	25	96	123	140	473	191	202	264	134	0	45	1693
2004	0	0	9	167	162	476	295	191	839	208	0	0	2347
2005	1	3	155	91	291	259	542	361	514	417	3	0	2637
2006	0	0	0	181	185	326	331	167	663	61	5	0	1919
2007	0	30	11	163	185	628	753	505	179	320	111	0	2885
2008	23	56	45	91	205	577	563	319	279	227	0	0	2385
2009	1	1	43	14	168	170	676	482	—	—	—	—	—

Source : BMD, Dhaka

APTable 18-51 Monthly maximum relative humidity of Dhaka station (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	99	97	98	97	99	98	98	100	98	98	98	99
2001	99	99	96	96	98	99	98	98	98	99	99	99
2002	98	94	94	98	98	98	98	99	98	97	99	99
2003	100	99	98	98	98	98	98	99	98	98	96	98
2004	100	97	98	98	98	99	99	98	98	98	98	98
2005	97	97	98	94	98	98	99	97	98	98	98	98
2006	100	98	96	96	98	99	98	95	99	98	95	97
2007	100	100	96	95	98	98	99	98	98	98	99	98
2008	98	96	95	94	96	98	98	97	98	98	97	99
2009	99	98	97	95	95	95	98	98	—	—	—	—

Source : BMD, Dhaka

APTable 18-52 Monthly minimum relative humidity of Dhaka station (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	24	14	11	39	43	49	45	52	51	47	28	28
2001	20	22	13	16	51	55	54	59	51	38	36	30
2002	26	18	16	35	47	49	55	52	45	32	28	33
2003	28	26	13	28	31	45	56	52	51	47	21	28
2004	25	17	16	40	15	50	54	52	58	32	27	27
2005	28	17	18	27	44	46	57	55	52	34	32	24
2006	21	15	6	28	40	57	55	52	51	38	26	29
2007	20	23	14	32	33	52	55	50	42	31	35	28
2008	25	13	28	23	37	51	61	57	53	32	29	33
2009	24	9	10	21	39	36	45	56	—	—	—	—

Source : BMD, Dhaka

APTable 18-53 Monthly average wind speed (m/s) and prevailing wind direction at Dhaka

Year	Jan		Feb		Mar		Apr		May		Jun	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2000	0.8	N	1	N	1.2	S	1.7	S	1.3	S	1.3	S
2001	1.1	NW	0.9	NE	1.9	S	2.1	S	1.7	S	1.6	S
2002	1.3	N	1.3	NW	2	S	2.1	S	1.8	S	1.4	S
2003	1.6	NW	1.8	N	2	S	2.6	S	2.5	S	2.1	SE
2004	1.8	W	2	W	2.9	S	3	S	2.8	S	1.9	S
2005	2.1	NNW	2.2	W	2.4	S	2.3	S	2.3	S	2.3	SE
2006	1.5	N	1.9	S	2.6	NNW	2	S	2	S	1.1	S
2007	1.5	NW	1.6	NW	2.2	NW	2	S	1.8	S	1.6	S
2008	1.9	N	1.6	N	2	S	1.7	S	1.7	S	1.7	S
2009	1.7	W	2.1	W	2.1	W	2.1	S	2	S	1.6	S
Year	Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2000	1.2	S	1.2	S	1.1	S	1.7	NE	0.8	N	0.8	N
2001	2	S	1.3	S	1.5	S	1.3	S	0.9	N	1	N
2002	1.4	S	1.4	S	1.5	SE	1	N	3.3	NE	1.2	N
2003	2.1	S	2.2	SE	2.2	SE	1.7	NE	1.4	N	1.6	W
2004	2.2	SE	2.1	SE	3.2	E	2.2	SE	1.6	W	1.7	NNW
2005	2.4	SE	1.8	S	2.4	SE	2.5	SE	1.7	NW	1.9	NNW
2006	1.1	SE	2.3	SE	2.8	SE	1.2	N	1.1	NW	1.2	NW
2007	1.6	S	1.6	S	1.6	S	2.1	NE	2.8	NE	1.5	NW
2008	1.7	S	1.4	S	1.4	S	4.9	NE	1.3	NE	1.7	W
2009	2.2	SE	1.4	S	-	-	-	-	-	-	-	-

Source : BMD, Dhaka

(5) Topography and Underground water

The Topography and Earthquake situation in Bangladesh is shown in APFig. 18-5 and APTable 18-65. The Land form around the proposed site is almost a flat land with some high spots. The Meghnaghat site area is located in Zone II as seismic zones.

The geological data has been obtained from boring survey results which have been conducted at a nearby proposed site under the DPHE R&D Division. The boring survey conducted in 1997 in Uchitpur village under Uchitpur union, Araihazar Upazilla, Narayanganji which is close to the proposed site. The drilling depth was 182.87m., APTable 18-54 shows the result of boring investigation. The drilling depth was 182.87m. The result indicates there are three Aquiferes between the depths to 121.91m.

APTable 18-54 Boring result of near Meghnaghat site

Depth to Top (m)	Depth to Base (m)	Lithologic Description	
0.00	6.10	Silty clay	Aquitard 1
6.10	12.19	Very Fine sand	Aquifer 1
12.19	18.29	Medium sand	
18.29	42.67	Fine sand	
42.67	48.77	Fine to Medium Sand	
48.77	54.86	Silty Clay	Aquitard 2
54.86	60.96	Clay	
60.96	73.15	Silty Clay	
73.15	79.24	Medium sand	Aquifer 2
79.24	82.29	Clay	Aquitard 3
82.29	85.34	Silty Clay	

Depth to Top (m)	Depth to Base (m)	Lithologic Description	
85.34	97.53	Fine to medium sand	Aquifer 3
97.53	106.67	Fine Sand	
106.67	121.91	Fine to medium sand	
121.91	128.01	Silty Clay	Aquitard 4
128.01	137.15	Very Fine sand	
137.15	167.63	Silty Clay	
167.63	182.87	Clay	

Source: DPHE

(6) Surface water

APTable 18-55 shows the water quality of the Meghna River which is measured in the Meghnaghat combined cycle power plant EIA in 1999.
Chromium (total), COD, BOD_5 20^OC do not satisfy the standard of drinking water of Bangladesh.

APTable 18-55 Water quality of Meghna River upstream of Meghnaghat site (1999)

No.	Parameter	Unit	Concentration	Bangladesh Standard for drinking water
1	Arsenic	mg/l	<0.001	0.05
2	BOD_5 20^OC	mg/l	7.2	0.2
3	Chromium (total)	mg/l	0.071	0.05
4	Chlorine (residual)	mg/l	—	0.2
5	COD	mg/l	15.2	4
6	Copper	mg/l	0.224	1
7	DO	mg/l	3.31	6
8	Hardness (as $CaCO_3$)	mg/l	40.0	200-500
9	Lead	mg/l	0.19	0.05
10	Mercury	mg/l	—	0.001
11	Nickel	mg/l	0.025	0.1
12	Oil & Grease	mg/l	—	0.01
13	pH		7.2	6.5-8.5
14	Suspended particulate matters	mg/l	2.0	10
15	Total dissolved solids	mg/l	79.0	1000
16	Turbidity	NTU	18.4	10(JTU)
17	Zinc	mg/l	0.479	5

Source : Meghnaghat Power Project Final Environmental Impact Assessment, AES Meghnaghat Limited

(7) Ecological situation

Data of the ecological situation has been obtained from the Department of Botany and Zoology of Dhaka University, Respective Upazila offices and local consultants. According to the EIA examination of the Meghnaghat gas combined power station in 2000, there is the possibility of existence of 6 species of NT, 2 species of VU, 2 species of EN, and 1 species of CR. However, the report states that the power station has no impact on these species and their respective habitats.

(a) Terrestrial Communities

1) Flora

There seems to be 53 species of land plants around the proposed site. Out of them, there is 1 species of LC on the IUCN Red List. A list of plants near the proposed site is provided in APTable 18-56.

APTable 18-56 List of plants near Meghnaghat site

No.	Local Name	English Name	Scientific Name	IUCN Global Status
1	Am	Mango	Mangifera indica L. (Anacard)	--
2	Arjun	--	Terminalia arjuna	--
3	Bansh pata	--	Podocarpus nerifolia	--
4	Bash	Bamboo	Podocarpus nebifolia	LC
5	Bel	Indian apple	Aegle marmelos (L).	--
6	Beli	--	Jasmin sambac Ait (Olea)	--
7	Bokul	(Mimusops Elengi)	Mimusops elengi L	--
8	Boroi	Indian Jujube	Zizyphus rugosa Lam	--
9	Bot	Banayan tree	Ficus benghalensis L. (Mora)	--
10	Debdaru	Pine	Polyalthia longifolia	--
11	Dhol Kalmi	--	Ipomoea fistolosa	--
12	Dhutra	--	Barringtonia acatangula	--
13	Golap	Rose	Rosa centifolia L. (Rosaceae)	--
14	Halencha	--	(Altermanthere philoxeroides)	--
15	Hyacinth	--	(Eichhomia crassipes)	--
16	Jaba	--	Hibiscus rosa sinensis L. (Malvaceae)	--
17	Jam	Black berry	Syzygium cumini skiel. (Myrtaceae)	--
18	Jambura	Citron	Citrus grandis	--
19	Jamrul	Star apple	Syzygium samraogense (Bl.)	--
20	Jhau	Poplar	Thysanolaena maxima	--
21	Kachu	Date Plam	Colocasia esculenta (L.)	--
22	Kadbel	Wood apple	Feronia limonia (L.)	--
23	Kalmi	--	(lpomoea aquatica)	--
24	Kamranga	Carambola	Averrhoa carambola	--
25	Kathal	Jack fruit	Artocarpus heterphyllus Lamk	--
26	Khejur	Date palm	Phoenix sylvestris	--
27	Kola	Banana	Musa Sapientum	--
28	Krishnachura	Delonix regia	Delonix regia (Boj.) Raf. (Leguminosae)	--
29	Lazzaboti	--	M. pudica L	--
30	Lebo	Lemon	Citrus aurantifolia	--
31	Madar	--	Erythriana variegata L. var. orientalis Merr.	--
32	Man Kochu	--	Alocasia indica	--
33	Mehedi	--	Lawsonia inermis	--
34	Mehogoni	--	Swietenia mahagoni	--
35	Narikel	Coconut	Cocos nucifers L. (Palmae)	--
36	Nim	--	Azadirachta indica	--
37	Pakur	--	Ficus Infectoria	--
38	Patabahar	Patabahar	Acalypha welkesiana (Euphorbiaceae)	--
39	Pepe	Papaya	Carica papaya L (caricaceae)	--
40	Peyara	Guava	Psidium Guajava (L) Bat. (Myrtaceae)	--
41	Pui Shak	--	Basella alba L.	--
42	Radhachura	--	Caesalpinia pulcherrima Sw. (Leguminosae)	--
43	Rain tree	--	Samea Samon	--

No.	Local Name	English Name	Scientific Name	IUCN Global Status
44	Rashun	Garlic	Allium sativum	--
45	Sajina	--	Moringa Oleifera Lamk. (Moringa)	--
46	Shimul	--	Bombax ceiba L. (Bombacaceae)	--
47	Sofeda	Sapodilla	Manilkara Achras	--
48	Supari	Colloq		--
49	Tal	Palm tree	Borassus flabellifer L. (Palmae)	--
50	Tentul	Tamarind	Tamarindus indica	--
51	Thankuni	--	Centella asiatica	--
52	Topa pana	--	(Pistia stratiotes)	--
53	Ulatkambal	--	Abroma augusta	--

Source： PSMP Study Team

2) Fauna

The animals found within a 1km circumference around the site include a total 55 species – 17 species of mammalian animals, 30 species of birds, 7 species of reptiles and 1 species of amphibian. Out of the animals on the 2007 Red List of the International Union for the Conservation of Nature (IUCN), there are 16 species of LC, 1 species of NT, 1 species of EN, and 2 species of CR. Special care must be given to the protection of Red Headed Vultures, Panited Roofed Turtles (CR) and Fishing Cats, (ER). APTable 18-57 is a list of animals found around the Meghnaghat site.

APTable 18-57 List of animals found around Meghnaghat site

No.	Local Name	English Name	Scientific Name	IUCN Global Status
MAMMALS				
1	Badur/Daini	False Vampire	Megaderma Lyra	--
2	Bagdash	Large Indian civet	Viverra Zibetha	--
3	Bon Biral/Wab	Jungal Cat/Swamp Cat	Felis chaus	--
4	Bara Benji	Common Mongoose	Herpestes edwardsi	--
5	Bhera	Sheep	Bovidae : Ovis	--
6	Biral	Cat	Felis : Catus	--
7	Indur	Common House Rat	Rattus rattus	--
8	Ghora	Horse	Equus caballus	--
9	Goru	Cow	--	--
10	Kathbirali	Malayan Giant Squirrel	Rataufa bicolor	--
11	Khek Shiyal	Bengol Fox/Indian Fox	Vulpes bengalensis	LC
12	Khargosh/Shashak	Rufous-tailed Hare	Lepus nigricollis	LC
13	Kukur	Dog	Cannis Familiaris	--
14	Mecho Biral/Mecho Bagh	Fishing cat	Prionailurus viverrinus	EN
15	Mohish	Bafallow	--	--
16	Sagol	Goat	Capra Hircus	--
17	Shojaru	Indian crested Porcupine	Hystrix Indica	LC
BIRDS				
1	Babui-Batan	Small Pratincole	Glareola Lactea	LC
2	Baj	Crested Groshawk	Accipiter trivirgatus	LC
3	Bok	Intermediate Egret	Mesophoyx intermedia	--
4	Bulbuli	Red-vented Bulbul	Pycnonotus cafer	--
5	Hutum Pecha	Rock Eagle Owl	Bubo bengalensis	LC
6	Chil	Pariah Kite	Passer domesticus	--

No.	Local Name	English Name	Scientific Name	IUCN Global Status
7	Chorai	House Sparrow	Passer Domesticus	--
8	Dahuk	White Breasted water hen	Amaurornis phoenicurus	LC
9	Doyel	Magpie Robin	Copsychus saularis	LC
10	Eagal	Bazzard -Eagal	Butastur teesa	LC
11	Fingey	Black Drongo	Dicrurus macrocercus	--
12	Gang Shalik	Bank Myna	Acridotheres ginginianus	LC
13	Ghughu	Oriental Turtle Dove	Streptopelia orientalis	LC
14	Gung Chil	Whiskered Tern	Chlidonias hybridus	LC
15	Hash	Duck	Anatidae Anseriformes	--
16	Jalali Kobutor	Rock Pigon	Columba Livia	LC
17	Kak	House Crow	Corvus splendens	--
18	Kana Bok	Indian Pond Heron	Ardeola grayii	--
19	Kat Tokra	Woodpecker	Picoides pubescens	--
20	Kokil	Asian Koel	Eudynamys scolopacea	--
21	Konch Bak.	Pond Heron.	Ardeola grayii	--
22	Machhranga	White Throated Kingfisher	Halcyn smyrensis	--
23	Mohanchura	Hoopoe	Upupa epops	--
24	Paira	Pigeon	Columba livia domestica	--
25	Pencha	Sport-bellied Owl	Bubo nipalensis	LC
26	Rajhans	Bar-headed Goose	Anser indicus	LC
27	Shalik	Indian mynah	--	--
28	Raj Shokun	Red Headed Vulture	Sarcogyps calvus	CR
29	Tia	Rose-ringed Parakeet	Psittacula krameri	LC
30	Tuntuni	Tailor bird	Orthotomus sutorius	--
REPTILE				
1	Tiktiki	House Lizard	Hemidactylus brookii	--
2	Ajogor	Rock Python	Python molurus	NT
3	Kasim	Painted Roofed Turtle	Kachuga Kachuga	CR
4	Gui Shap	Bengal Monitor	Varanus bengalensis	--
5	Sabuj Dhora	Green Keel back Snake	Macrophistodon plumbicolor	--
6	Kalo Mete Dhora Shap	Dark-Bellied Marsh Snake	Xenochrophis cersogaster	--
7	Gokhra Shap	Monocellate Cobra	Naja kaouthia	--
AMPHIBIA				
1	Beng	Frog	*Anura : Ranidae*	

Source : PSMP Study Team

(b) Aquatic Communities

1) Aquatic Flora

The freshwater dependent plants such as the helencha (Altermanthere philoxeroides), kalmi (Ipomoea aquatica), daokalmi (Ipomoea fistulosa), ichadal (Potamo seton) and water hyacinth (Eichhomia crassipes) are common in the ponds, canals and rivers near the Meghnaghat site. Khuda pana (Lemna minor), topapana, (Pistia stratiotes) and chaicha (Saipus articulatus) are also common.

2) Aquatic Fauna

The Meghnaghat site is on bank of the Meghna River. The crabs inhabit ditches and ponds on the bank of Meghna River. Fresh water snails (Charonia Variegate) and mussels (Mytilus Edilis) are also common. The fishes found within around the site include a total of 41 species of river fishes. APTable 18-58 shows a list of fishes available near the Meghnaghat site.

APTable 18-58 List of fishes available near Meghnaghat site

No.	Local Name	English Name	Scientific Name	IUCN Global Status
1	Ayer	Long Whiskered cat fish	Aorichthys aor	--
2	Bata	Giantscale Mullet	Lizamelinoptera	--
3	Bele	Scribbled goby	Awaous grammepomus	--
4	Bhol/Bol	Indian Trout	Raiamas bola	--
5	Chanda	Elongate glass perchlet	Chanda nama	--
6	Chingri	Shimp	---	--
7	Chitol	Humped Featherback	Notopterus chitala	--
8	Dhela/ Dipali/ ketti(Cotio)	Cotio	Osteobrama cotio	--
9	Foli	Grey Featherback	Notopterus notopterus	--
10	Ghaura	(Gaura Bacha)	Clapisoma gaura	--
11	Ghonia/Gonainya	(Kuria Lebeo)	Labeo gonius	--
12	Gojar/ Gojal	Giant snake head	Channa marulius	--
13	Golsa/ Golsa Tengra	Gangetic Mystus	Mystus cavaslus	--
14	Ilish	Hilsa	Tenualosa ilisha	--
15	Jhinuk	--	--	--
16	Kajli / Banshpata	Jamua ailia	Ailia punctata	--
17	Kalibaush (kalbasu)	Orange-fin labeo	Labeo calbasu	--
18	Kani Pabda / Boali Pabda	(Indian Butter cat fish)	Ompak bimaculatus	--
19	Katol	Catla	Catla Cattla	--
20	Khailsha	Banded gourami	Colisa fasciata	--
21	Kucha / Kuchia	Gangetic Mud Eel Cuchia	Monopterus cuchia	--
22	Meni / Bheda/ Rayan/ Bheduri	Mottled Nandus	Nandus nandus	--
23	Mrigal	Mrigal	Cirrhinus mrigala	--
24	Napit Koi/ Koi Banedi	Dwarf chemeleon fish badis	Badis badis	--
25	Pabda	Pabo Cat fish	Ompak pabo	--
26	Poa	Pama croaker	Otolithoides pama	--
27	Potka	Green pufferfish	Tetraodon fluviatilis	--
28	Pungash (river)	Yellowtail catfish	Pangasius pagasius	--
29	Puti	Fry	Puntius puntio (Hamilton)	--
30	Rui	Rohu	Labeo rohita	--
31	Sarputi / Swarnaputi	(Olive barb)	Puntias Sarana	--
32	Shal baim/ Baim Bam	Tire trach spinyeel	Mastecembelus armatus	--
33	Shamuk	Snail	--	--
34	Shol	Banded Snakehead	Channa striatus	--

No.	Local Name	English Name	Scientific Name	IUCN Global Status
35	Sisor / Chenua	Sisor cat fish	Sisor rhabdophorus	--
36	Tara Baim	One Strip spiny eel	Macroganthus aral	--
37	Tatkini/Bata/Bangla	Reba carp	Cirrhinuss reba	--
38	Telo Taki / Rana Cheng/ Ganchua	Asiatic snake head	Channa Orientalis	--
39	Tengra	Assamese Batasio	Batasio Tengana	--
40	Titpunti	Ticto barb	Puntias Ticto	--
41	Darkina (Gangetic scissortail rasbora)	Flying barb	Esomus Danricus	--

Source : PSMP Study Team

18.4.2 Detailed Information on Meetings with Local Stakeholders

APTable 18-59 Profile of Household Interviewees (Meghnaghat Site)

No	Sex	Age	Village	Distance from Power Plant	Education	Occupation	Household Monthly Income
1	M	45	Islampur	100 m	Nil	Business	8,000
2	M	35	Islampur	100 m	Nil	Business	4,000
3	M	52	Islampur	200 m	Nil	Service	6,000
4	M	32	Islampur	100 m	four	Carpentar	6,000
5	M	27	Islampur	100 m	Nil	Service	4,000
6	M	35	Islampur	100 m	Nil	Business	5,000
7	M	50	Islampur	100 m	Nil	Boat man	6,000
8	M	37	Islampur	100 m	Nil	Service	4,000
9	M	25	Gonga Nogar	400 m	Six	Service	6,000
10	M	30	Gonga Nogar	500 m	Eight	Business	6,000
11	M	40	Gonga Nogar	500 m	three	Service	8,000
12	M	49	Gonga Nogar	400 m	Nil	Business	6,000
13	M	42	Gonga Nogar	500 m	Nil	Business	6,000
14	M	30	Gonga Nogar	500 m	Yes	Business	6,000
15	M	41	Gonga Nogar	500 m	Nil	Agriculture	4,000

Source: Household interview

APTable 18-60 Profile of FGD Participants (Meghnaghat Site)

No	Age	Education	Occupation	Household Monthly Income
Male Participants				
1	57	Only Signature	Unemployed	6,000
2	46	Only Signature	Day Labourer	5,000
3	32	V	Business	6,000

No	Age	Education	Occupation	Household Monthly Income
4	77	Only Signature	Unemployed	15,000
5	65	Only Signature	Business	30,000
6	50	Only Signature	Unemployed	15,000
Female Participants				
1	36	Only Signature	Housewife	6,000
2	20	S.S.C.	Housewife	7,000
3	30	V	Housewife	6,000
4	38	Only Signature	Housewife	6,000
5	46	VI	Housewife	9,000
6	23	IX	Job	5,000
7	18	IV	Housewife	9,000
8	40	Only Signature	Housewife	5,000

Source: Focus group discussions

APTable 18-61 Participants Profile of Local Stakeholder Meeting (Meghnaghat Site)

No.	Designation and Organization
Participants from Meghnaghat	
1	Asst. Commissioner (Land), Sonargaon
2	Upazila Chairman
3	Chairman, Pirozpur Upazila
4	Upazila Statistical Officer
5	LGED, UE, Sonargaon
6	Asst. Accountant Upazila Office
7	UP. Vice Chairman
8	Head Teacher, Mograpara H.G.G.S. Smriti Biddyaloy
9	Credit Supervisor
10	Sr. UP. Fisheries Officer, Sonargaon
11	UD Asst. Jr. Accountant
12	Sub-Asst. Secondary Education Office
13	Sub-Asst. Settlement Office
14	Member
15	Electrician
16	Imam (Religious leader)
17	Islampur (Villager)
18	Islampur (Villager)
19	Islampur (Villager)
20	Islampur (Villager)
21	Islampur (Villager)
22	Islampur (Villager)
23	Gonga Nagar (Villager)
24	Islampur (Villager)
25	Islampur (Villager)
26	Islampur (Villager)
27	South Sonargaon
28	Gonga Nagor (villager)
29	Nuner Tek (villager)
30	Villager

No.	Designation and Organization
31	Dohor Para (villager)
GOB	
1	Asst. Chief, Power Division
2	EGCB Ltd.
3	BPDB, Sub-Divisional Engineer
PSMP Study Team and Local Consultants	
1	PSMP Study Team
2	PSMP Study Team
3	EAL, Executive Director
4	EAL, Engineer
5	EAL, Social Specialist
6	EAL
7.	EAL
8	Computer Operator, EAL
9	Sound Operator

Source: PSMP Study Team

18.4.3 Problem Analysis and Problem Solution

Problem analysis on environmental pollution and natural environment is as found in the following table.

AP Table 18-62 Problem Analysis: Assessment Results on Environmental Impact (Meghnaghat)

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
1	Air Pollution	Air pollution can occur due to the exhausted gas from transportation vehicles and construction machinery. And dust particles may be scattered near the construction site and roads.	B	Planned coal-fired power plant burns imported coal as main fuel. And it burns light oil as an auxiliary fuel (fuel for starting up). NOX, SOX and soot will be generated due to combustion of these fuels. Coal transportation may generate coal dust. If there are no adequate measures taken for these air pollutant, operation of adjacent Meghnaghat CCPP will be affected due to clogging of the gas turbine inlet filter.	A
2	Water Contamination	Rainfall drainage, equipment washing drainage, and sewage will be generated during the construction work. And if waste management isn't appropriate, effluents from waste may be generated.	B	Thermal discharge will be produced during those cases where river water is used as cooling water. Plant effluent and domestic waste water will be generated according to plant operation. And if waste management isn't appropriate, effluents from waste may be generated.	A
3	Soil pollution	Soil pollution can occur due to lubrication oil or fuel oil spillage from transportation vehicles and construction machinery.	B	Soil pollution can occur due to lubrication oil or fuel oil spillage through the unit operation.	B
4	Bottom Sediment	In case of discharged water spillage to the Meghna River, there is a possibility of bottom sediment accumulation.	C	There is a possibility of bottom sediment accumulation if plant effluent and domestic waste water discharges after inadequate treatment. If an ash pond is used, it is necessary to pay attention to the bottom sediment of the pond.	B

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
5	Noise and vibration	There will be noise and vibrations due to transportation vehicles and construction machinery. And steam blowing during commissioning will generate significant noise.	A	Noise and vibration will be generated through the operation of the power facilities. If a cooling tower is used, there will be significant noise and vibration from the cooling fan of the tower. During periodic inspections, noise and vibration will arise due to the vibration of the transportation vehicle and construction machinery.	A
6	Offensive Odor	If the domestic waste management isn't applicable to workers' stations, offensive odor may be generated due to waste decomposition.	B	If ammonia, which is used at SCR leaks, it may be a source of offensive odor. If domestic waste management isn't applicable to workers' stations for maintenance work etc., an offensive odor may be generated due to waste decomposition.	B
7	Waste	Construction work will generate metal chips, waste plastic, wood shavings, waste glass and waste oil. And domestic wastes such as cans, bottles and food residue will be generated from construction workers' station.	B	By-products through the operation of coal-fired power plant are coal ash, gypsum (if limestone-gypsum FGD is used), sludge from waste water treatment facility, and cooling water canal fouling (if the river water or sea water is used for the cooling water). These by-products will be wasted if they are discarded without recycling. Maintenance work will generate metal chips, waste plastic, wood shavings, waste glass and waste oil And domestic wastes such as cans, bottles, and food residue will be generated from workers' stations.	A
8	Ground Subsidence	There will be no impact to water usage as the Meghna River water is available as cooling water and makeup water of power plant.	C	Ground subsidence will not occur as cooling water and makeup water can be taken from the Meghna River, not from the underground water.	C
9	Geographical Feature	There is little impact since the proposed site is plain and doesn't possess any outstanding geographical features.	C	There is little impact since the proposed site is plain and doesn't possess any outstanding geographical features.	C
10	Biota and Ecosystem	There is a possibility of Red Headed Vulture and Painted Roofed Turtle categorized CR and Fishing Cat categorized EN in IUCN Red List existing around the site.	B	There is a possibility of Red Headed Vulture and Painted Roofed Turtle categorized CR and Fishing Cat categorized EN in IUCN Red list existing around the site.	B
11	Water Usage	There is no impact to water usage as the Meghna River water is available as water for construction work.	C	There is no impact to water usage as the Meghna River water is available as cooling water and makeup water of power plant.	C

No.	Item	Impact during Construction Stage		Impact during Operation Stage	
12	Accident	Construction accidents can occur due to the defects of the health and safety management of construction work. It is necessary to pay attention to especially potential accidents due to falling from high-places, construction vehicle road accidents and electrical accidents.	A	There is a possibility of accidents occurring such as fires due to oil spillage or instantaneous combustion of coal, accidents due to leakage or spillage of chemicals like caustic soda and sulfuric acid, accidents or incidents involving maintenance work.	B
13	Global Warming	Transportation vehicles and construction machinery will emit CO2.	C	It is estimated that approximately 3.79 million ton of CO2 will be exhausted from per 600MW unit per year through the operations of coal-fired power plants. In light of its cost-effectiveness, brown coal will be imported. Brown coal emits more CO2 than domestic coal which has been classified as bituminous coal.	B

source： PSMP Study Team

Social impact assessment results can be found in AP Table 18-63.

AP Table 18-63 Problem Analysis: Assessment Results of Social Impact (Meghnaghat Site)

No	Item	Impact during Construction Stage		Impact during Operation Stage	
1	Involuntary Resettlement	Involuntary resettlement can be caused by land acquisition. The degree of adverse impact on local residents however is not expected to be large-scale since the potential site is located in the bank of the Meghna River.	B	Damage to houses and health hazards can be caused by smoke extraction, noise pollution, water pollution and land subsidence if the environmental management plan is not appropriately planned and implemented. Political intervention and/or local movement against the operation of power stations can occur when the adverse impacts to local residents' lives and livelihoods are severe.	C
2	Local Economy such as Employment and Livelihood etc.	Loss of employment and livelihoods can be caused by temporary loss of agricultural lands during the construction period. The Bangladesh regulation stipulates that displaced persons are entitled to compensation for loss of land, property and standing crops in monetary terms at the fixed rates. It however does not compensate for loss of employment or livelihoods.	B	Permanent loss of employment and livelihoods can be caused by land acquisition for the power station operation and surrounding areas. Further, agricultural laborers may lose their jobs. In case water treatment is not properly conducted, local fishing industry may be affected. The Bangladesh regulation stipulates that displaced persons are entitled to compensation for loss of land, property and standing crops in monetary terms at the fixed rates. It however does not compensate for loss of employment or livelihoods. The destitute and poor, particularly landless farmers can become further distressed in case job opportunities or at the least, skill training opportunities for them are not secured.	C

No	Item	Impact during Construction Stage		Impact during Operation Stage	
3	The Poor, Indigenous and Ethnic People	There are no ethnic minorities living in the site. The destitute, poor and landless farmers may lose their jobs when agricultural land is lost due to the construction of power station.	C	There are no ethnic minorities living in the site. The destitute, poor and landless farmers can become further distressed if job opportunities or at least skill training opportunities for them are not secured.	C
4	Misdistribution of Benefit and Loss	The disparity between land owners and the rest (landless farmers, wage laborers etc.) may widen. In case an ample number of job opportunities and skill training opportunities are not provided to meet the demand, the disparity between those with such opportunities and those without may widen.	B	Landless farmers and wage laborers may become further distressed and the disparity between land owners and them can be widened when job opportunities and skill training opportunities are not provided to them. Local livelihoods may be affected and health hazards may be caused by land subsidence, smoke extraction, noise pollution, water pollution and water shortage if the environmental management plan is not appropriately planned and implemented.	C
5	Local Conflict of Interests	Local conflict may occur between the relocated people and the host community. Excessive interventions by various stakeholders can trigger local conflict among residents, and the disruption of the local community.	C	Local conflict can become constant between the relocated people and the host community.	C
6	Gender	Appropriate information and knowledge may not be properly disseminated to the illiterate, particularly women. Gender gap may widen in terms of job opportunities.	C	Appropriate information and knowledge may not be properly disseminated to the illiterate, particularly women.	C
7	Children's Rights	Child labor may occur due to their parents' loss of job. Children may lose education opportunities. Playgrounds for children may be lost. Children may catch infectious diseases triggered by outsiders' entry into the community.	C	Child labor may occur due to their parents' loss of job. Children may lose education opportunities. Playgrounds for children may be lost. Children may catch infectious diseases triggered by outsiders' entry into the community.	C
8	Land Use and Utilization of Local Resources	The present potential site that has been selected is away from the city center, residential area, local market, and the protected forest. Temporary loss of present land use pattern and/or economic infrastructure may occur.	C	The present potential site that has been selected is away from the city center, residential area, local market, and the protected forest. Permanent loss of present land use pattern and/or economic infrastructure may occur.	C
9	Social Institutions such as Social Infrastructure and Local Decision Making Institutions	Disruption of local community may be caused by the conflict of interests among politicians, government offices, and residents. It may cause a delay in procedures of land acquisition and resettlement.	C	-	C

No	Item	Impact during Construction Stage		Impact during Operation Stage	
10	Existing Social Infrastructure	Temporary loss of existing social infrastructure may occur due to the construction works.	C	Traffic to/from power station may become heavier. Social services may become insufficient.	C
11	Cultural Heritage	There is no cultural heritage existing in the site. Careful consideration however should be given to the Tomb of Sultan Giasuddin and Shah Abdul Alla located 4 km away from the site. Landscape may be lost.	C	Careful consideration however should be given to the Tomb of Sultan Giasuddin and Shah Abdul Alla located 4 km away from the site.	C
12	Infectious Diseases such as HIV/AIDS	Infectious diseases may spread via the construction workers into the community.	C	Infectious diseases may spread via the operation workers into the community.	C

Source: PSMP Study Team

Mitigation measures on environmental pollution and natural environment are as found in AP Table 18-64.

AP Table 18-64 Mitigation Measures for Environmental Impact (Meghnaghat)

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
1	Air pollution	Countermeasures for air pollution by exhaust gas from transportation vehicles and construction machinery, and dust scattering due to construction traffic are studied as in AP Table 18-67 and AP Table 18-68. As for the reduction of exhaust gas from transportation vehicles and construction machinery, idling stops and keeping proper exhaust condition by routine inspection of vehicles are judged to be applied. As for countermeasures for dust scattering, load cover, periodical vehicle washing and periodic peripheral road cleaning are judged to be applied.	AP Table 18-62 shows countermeasures for NO_X, AP Table 18-63 shows countermeasures for SO_X, AP Table 18-64 shows countermeasures for soot, and AP Table 18-66 shows countermeasures for coal dust. Besides conducting flue gas treatment by system including FGD, SCR, and ESP etc., mitigation of coal dust scattering is paid attention to.
2	Water contamination	Countermeasures for water contamination due to excavation waste soil outflow are suitable via a fence installation utilizing sandbags etc. As for the effluent due to equipment washing, it is suitable to install a temporary precipitation tank and to drain the supernatant water. As for sewage, it is suitable to put up a septic tank. As for waste, water contamination can be prevented if waste treatment is conducted promptly and the waste is not left for long time.	There is no warm effluent water generation since cooling tower or air cooled condenser will be adopted as cooling system from consideration to impact of warm effluent water and local fishery. Plant effluent and sewage according to plant operations are discharged after waste water treatment including coagulating sedimentation, neutralization, and oil separation. Appropriate waste water facility capacity design is needed as condensed cooling water blow effluent is a large amount.

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
3	Soil pollution	AP Table 18-69 shows the study result of countermeasures for soil pollution by oil spillage from transportation vehicles and construction machinery. Periodic maintenance implementation and conducting pre-operational machinery checks of machinery is judged important to be applied.	Oil and grease treatment procedures make it clear to prevent the spillage of lubrication oil or fuel oil. The management organization has been established to implement works according to designated procedures. And action procedures are prepared in order not to spread the adverse impact in case of an oil spillage occurrence. An oil dike has been set around the oil storage tank.
4	Bottom sediment	Implement measures described in 2) Water contamination.	It is necessary to dump ash properties in dumping site with water proof seat to prevent bottom sediment leakage out of the ash pond.
5	Noise and vibration	AP Table 18-70 shows the study result of countermeasures for noise and vibration due to vibrations from transportation vehicles and construction machinery. Leveling the construction process, using low-noise machinery, and lowering vehicle speed in residential areas are judged to be proper countermeasures. As for countermeasures for noise by steam blowing during commissioning, the establishment of a work schedule without the blowing of steam during night time is judged to be applied.	Developing the green belt along the site border is a costless and effective way to mitigate noise and vibrational impact. If the boundary noise simulated in the detail EIA exceeds the noise regulations which is decided on each category (AP Table 18-8), the introduction of a green belt, sound insulating material and a sound insulating wall will be examined. Chittagong site is categorized in Industrial Zone[1].
6	Offensive Odor	Offensive odor caused by domestic waste decomposition from workers' camps can be prevented by the separate collection and periodic disposal of waste.	NOx mitigation without SCR which uses ammonia is an effective measure against offensive odor. When using ammonia, storage tanks, pipes, and valves must surely be inspected periodically. In addition to preventing operational mishaps, operations of the ammonia facility are to be strictly managed by the person in charge. With regards to garbage treatment, it is suitable to dump periodically and not keep in storage for a long time.
7	Waste	Reduction of waste amount can be conducted by establishing a waste management program including reduction, reuse, and recycling. Implementation of a thorough separate collection of the waste is also needed, especially for paint sludge and batteries. These items should be collected separately and disposed in designated areas.	Reduction of waste amount can be conducted by establishing a waste management program including reduction, reuse, and recycling. Because by-products due to plant operations are large amount, they should be recycled as much as possible. AP Table 18-71 shows examples of by-products recycling.

[1] Interviewed with DoE.

No.	Item	Mitigation measures during Construction Stage	Mitigation measures during Operation Stage
8	Biota and Ecosystem	Nest building of Red Headed Vulture, Painted Roofed Turtle and Fishing Cat should be examined in detail EIA, and the nest relocation should be conducted if there are any. Existence of endangered species should be carefully paid attention to during construction stage and necessary protection action should be conducted if there are any.	Nest building of Red Headed Vulture, Painted Roofed Turtle and Fishing Cat is examined in detail EIA, and the nest relocation should be conducted if there are any. Existence of each endangered species is carefully paid attention to during operation stage, and necessary protection act should be conducted if there are any.
9	Accident	A suitable OHS organization (policy, manual, announcement of policy, safety training and safety patrol) should be established to prevent accidents. It is also important to conduct quality control in construction work to prevent accidents during commissioning and operation period.	A suitable OHS organization (policy, manual, announcement of the policy and manuals, safety training, safety patrols) should be established for accident prevention. It is also important to conduct quality control in maintenance work prevent accidents.
10	Global warming	-	It is estimated that approximately 3.54 million ton of CO_2 will be emitted from per 600MW unit per year according to the operations of a coal-fired power plant. An ultra-super critical boiler with high thermal efficiency is being planned to be introduced into this master plan. Due to the introduction of a high efficiency unit, 1.07 million tons of CO_2 can be reduced per 600MW unit per year compared with the case of the Barapukuria class unit introduction. These figures are calculated based on designed value. It is important to keep designed output and efficiency from adequate O&M.

Source : PSMP Study Team

18.5 Other Information

APTable 18-65 Earthquake occurrence record in Bangladesh

Year	Scale								Annual total	Maximum magnitude
	Not clear	M3	M3 to M3.99	M4 to M4.99	M5 to M5.99	M6 to M6.99	M7 to M7.99	Over M8		
1918							1		1	7.6
1923							1		1	7.1
1927						1			1	6.5 ,
1930							2		2	7.1
1932							5		5	7.4
1933							1		1	7.6
1934						1		1	2	8.3
1935						3			3	6.5
1936							2		2	7.5
1938						3	1		4	7.2
1940						1			1	6.5
1941					1	3			4	6.8
1943							1		1	7.2
1954						1	1		2	7.4
1955						1			1	6.8
1956						3			3	6.3
1957						2			2	6.8
1958						1			1	6.4

Year	Scale								Annual total	Maximum magnitude
	Not clear	M3	M3 to M3.99	M4 to M4.99	M5 to M5.99	M6 to M6.99	M7 to M7.99	Over M8		
1959					1	1			2	6.1
1960					1				1	5.7
1963				5	7				12	5.6
1964				4	3	4			11	6.7
1965				1	5				6	5.9
1966				3	4				7	5.7
1967				4	8				12	5.8
1968				2	2				4	5.2
1969		2		3	6				11	5.9
1970				4	6	1			11	6.5
1971				6	5				11	5.5
1972	1			6	2				9	5.0
1973				6	5				11	5.3
1974			2	9	1				12	5.1
1975				4	4	1			9	6.5
1976	2		1	8	1				12	5.3
1977	1				1				2	5.6
1978	3								3	
1979	3								3	
1980	3					1			4	6.0
1982	2								2	
1983	3								3	
1984	1				4				5	5.6
1985	9								9	
1986	5								5	
1987	5								5	
1988	6								6	
1989	24								24	
1990	8								8	
1991	4			2	2				8	5.3
1992	7			12	6				25	5.8
1993	6		1	10	2	1			20	6.3
1994	4			2	3	2			11	6.2
1995	6			3	2	1			12	6.4
1996	7								7	
1997		11	1	1	3			1	17	8.5
1998		9		1					10	4.9
1999	21								21	
2000	14	3	4	6	3				30	5.5
2001	3	2	13	16	4				38	5.5
2002	2	4	16	23	3				48	5.5
2003	1	2	6	5	5				19	5.8
2004			3	8			1		12	7.4
2005		2	10	8	5				25	5.6
2006		1	4	8	3				16	5.9
2007		7	21	19	33	42	11	1	134	8.5
2008		7	16	55	158	73	13		322	7.7

Source： Bangladesh Meteorological Dept.

APTable 18-66 Major cyclonic storms from 1960 to 2007 in Bangladesh

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed (m/s)
11.Oct.1960	Severe Cyclonic Storm	Chittagong	44.4
31.Oct.1960	Severe Cyclonic Storm	Chittagong	53.6
09.May.1961	Severe Cyclonic Storm	Chittagong	44.4
30.May.1961	Severe Cyclonic Storm	Chittagong (Near Feni)	44.4
28.May.1963	Severe Cyclonic Storm	Chittagong- Cox's Bazar	58.1

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed (m/s)
11.May.1965	Severe Cyclonic Storm	Chittagong-Barisal Coast	44.4
05.Nov.1965	Severe Cyclonic Storm	Chittagong	44.4
15.Dec.1965	Severe Cyclonic Storm	Cox's Bazar	58.3
01.Nov.1966	Severe Cyclonic Storm	Chittagong	33.3
23.Oct.1970	Severe Cyclonic Storm of Hurricane intensity	Khulna-Barisal	45.3
12.Nov.1970	Severe Cyclonic Storm with a core of hurricane wind	Chittagong	62.2
28.Nov.1974	Severe Cyclonic Storm	Cox's Bazar	45.3
10.Dec.1981	Cyclonic Storm	Khulna	33.3
15.Oct.1983	Cyclonic Storm	Chittagong	25.8
09.Oct.1983	Severe Cyclonic Storm	Cox's Bazar	37.8
24.May.1985	Severe Cyclonic Storm	Chittagong	42.8
29.Nov.1988	Severe Cyclonic Storm with a core of hurricane wind	Khulna	44.4
18.Dec.1990	Cyclonic Storm (crossed as a depression)	Cox's Bazar Coast	31.9
29.Apr.1991	Severe Cyclonic Storm with a core of hurricane wind	Chittagong	62.5
02.May.1994	Severe Cyclonic Storm with a core of hurricane wind	Cox's Bazar-Teknaf Coast	77.2
25.Nov.1995	Severe Cyclonic Storm	Cox's Bazar	38.9
19.May.1997	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	64.4
27.09.97	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	41.7
20.05.98	Severe Cyclonic Storm with core of hurricane winds	Chittagong Coast near Sitakunda	48.1
28.10.00	Cyclonic Storm	Sundarban Coast near Mongla	23.1
12.11.02	Cyclonic Storm	Sundarban Coast near Raimangal River	18.1-23.6
19.05.04	Cyclonic Storm	Cox's Bazar Coast between Teknaf and Akyab	18.1-25
15.11.07	Severe Cyclonic Storm with core of hurricane winds	Khulna-Barisal Coast near Baleshwar river	61.9

Source : Statistical Yearbook of Bangladesh 2008

APTable 18-67 List of noise level on transportation vehicles, construction machinery[1]

Machine type	Specification	Noise level (dB)
Truck crane (hydraulic)	50t	116
Dump truck	11t	113
Back hoe	$0.6m^3$	110
Bulldozer	11t	99
Earth auger	25t	98
Hydraulic hammer	4.5t	95
Vibro-hammer	—	80
Concrete pumping car	$65\sim85m^3/h$	113
Concrete mixer	$4.5\ m^3$	105
Air compressor	$10.5\sim11.0m^3/min$	105

Source: The Study on Bheramara Combined Cycle Power Station in Bangladesh, Final Report

[1]Noise source level has been calculated from the A-characteristic correction value at a distance of 7m from the construction machinery.

APTable 18-68 Countermeasures for NO_X

Countermeasures	Note	Evaluation
Reduction over-rich-air ratio	-	+
Low NO_X burner	-	+
Two-stage combustion	-	+
Flue gas recirculation	-	+
Denitrification equipment (SCR)	-	+
Denitrification equipment (Noncatalytic Reduction)	Low denitrification efficiency	-
Denitrification equipment (Activated carbon adsorption))	Enable to remove SO_X in the same time	+

Source： PSMP Study Team

APTable 18-69 Countermeasures for SO_X

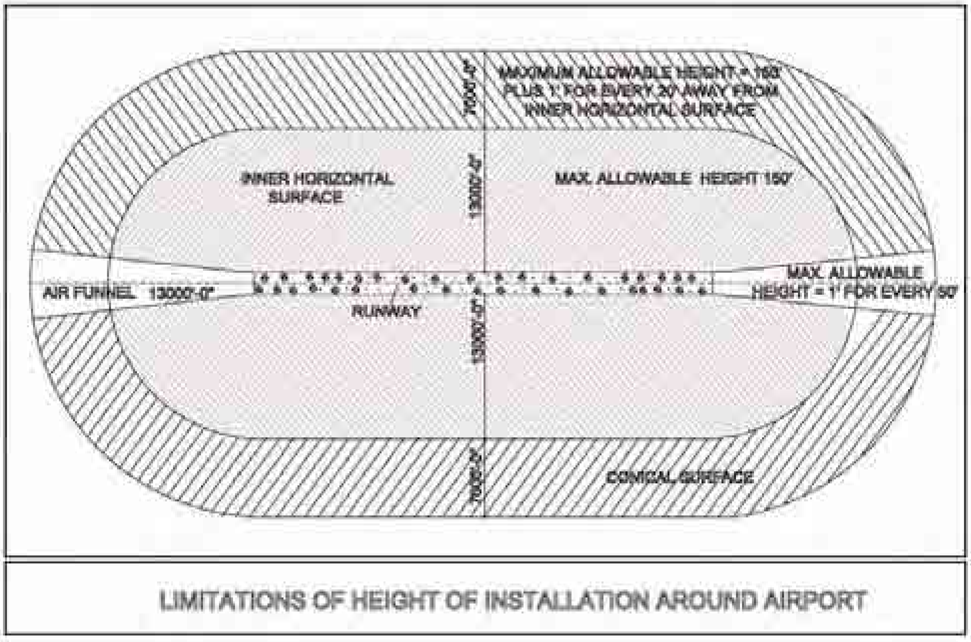
Countermeasure	Note	Evaluation
Reduction of sulfur content of fuel	-	+
FGD (Wet method : limestone gypsum method)	-	+
FGD (Wet method: Sea water scrubber method))	Impossible to get sea water	-
FGD (Dry method: Activated carbon adsorption)	-	+

Source： PSMP Study Team

APTable 18-70 Countermeasure for Soot

Countermeasures	Note	Evaluation
Dry ESP（high temperature）	There are some issues (increase the amount of treatment gas, heat resistant material for high temperature usage, heat extension and contraction).	-
Dry ESP（low temperature）	Need to pay attention to lower dust collection efficiency due to high resistivity of dust.	+
Dry ESP（low-low temperature）	Enable to compactify by decreasing amount of treatment gas. Adopted with wet FGD.	+
Wet ESP	Need to prepare large amount of water. Not suitable for high concentration dust.	-
Bag filter	It needs to replace the filter periodically and the running cost is high. There is the possibility of clogging according to ash conditions.	-

Source： PSMP Study Team



Source： Traffic service department, Civil Aviation Authority, Bangladesh

APFig. 18-13 Height regulation around airport

System	Gas Flow
Low-low temp. ESP system	Boiler – De-Nox – A/H – GGH – **Low-low temp. ESP** – IDF – De-Sox (Wet) – GGH – BUF – STACK
Low temp. ESP system	Boiler – De-Nox – A/H – **Low temp. ESP** – IDF – GGH – De-Sox (Wet) – GGH – BUF – STACK
Low temp. ESP (with Dry De-Nox, De-Sox) system	Boiler – A/H – **Low temp. ESP** – IDF – De-Nox De-Sox (Dry) – **Low temp. ESP** – STACK
High temp. ESP system	Boiler – **High temp. ESP** – De-Nox – A/H – GGH – IDF – De-Sox (Wet) – GGH – BUF – STACK

Source： PSMP Study Team

APFig. 18-14 Example of flu gas treatment system

APTable 18-71 Study items of flue gas treatment system

No.	Item
1	Desulfurization efficiency
2	Denitrification efficiency
3	Dust collection efficiency
4	Construction cost
5	Running cost ◆ Power consumption of fans and pumps ◆ Chemical consumption (ammonia, limestone) ◆ Water consumption ◆ Cost for catalyst
6	By-products
7	Any other necessary items

Source: PSMP Study Team

APTable 18-72 Countermeasure for coal dust

Countermeasures	Note	Evaluation
Covered conveyer	-	+
Sprinkler for coal storage yard	Effective also as measure for self-ignition	+
Windbreak fence	Average wind speed around site is under 2m/s throughout a year	-
Dust collector for coal conveyer	Effective also as measure for explosion protection	+

Source : PSMP Study Team

APTable 18-73 Countermeasure for air pollution due to exhaust gas from transportation vehicles and construction machinery

Countermeasure	Note	Evaluation
Decrease needles exhaust by idling stop	—	+
Use electric vehicles as transportation vehicles	Impractical	-
Keep proper exhaust condition by routine inspection	—	+

Source : PSMP Study Team

APTable 18-74 Measure for dust scattering due to construction traffic

Countermeasures	Note	Evaluation
Prevent dust scattering by load cover	—	+
Wash a vehicle periodically	—	+
Clean peripheral road periodically	—	+
Water peripheral road	It causes service water consumption increase.	-

Source : PSMP Study Team

APTable 18-75 Countermeasure for oil spillage during construction period

Countermeasure	Note	Evaluation
Implement periodically maintenance of machinery and exchange deteriorated seals	-	+
Check before operation and don't use deteriorated vehicles	-	+
Cover whole traffic area by sheet	Impractical	-

Source : PSMP Study Team

APTable 18-76 Countermeasure for Noise and Vibration during construction period

Countermeasure	Note	Evaluation
Level construction process and limit number of operation machinery at the same time	-	+
Use low-noise machinery (silencer, muffler)	Effective though it costs	+
Lower vehicle speed when passing inhabitant neighborhood such as residential area	-	-
Put temporary sound barrier work place surroundings	Impractical	-

Source： PSMP Study Team

APTable 18-77 Examples of by-product recycling

By-product	Examples of recycling
Coal ash (Fly ash)	Cement mixture material, Soil improvement material, brick, tile
Gypsum	Cement material, Gypsum board

Source： PSMP Study Team

APTable 18-78 Air cooled condenser precedents to 600MW class thermal power plants in China

Plant Name	Capacity
Zangshan Electric Power	2unit of 600MW
Datong Second plant	2unit of 660MW
Yanshan Lake power plant	2unit of 600MW

Source： PSMP Study Team

APTable 18-79 Items of environmental consideration regarding coal mine development

No.	Item	Content	Example
1	Land Use	Topsoil management	● Scrap the topsoil prior to drilling and blasting ● Scraped topsoil should be used immediately for plantation/agriculture ● If it is not possible to use the topsoil immediately, then it should be stacked at a designated area. ● The topsoil heap’s height should not exceed more than 6 meters. Storage must be done in a pyramidal form, with garland drains all around. ● If the topsoil is to be stored for a long duration, it should have a vegetal cover of leguminous species.
		Overburden management	● Backfilling de-coaled areas ● Proper stacking and waste water treatment in the case of internal overburden dump
		Land subsidence management	● Planned subsidence by considering surface structures and human lives ● Simultaneous backfilling de-coaled area ● Fencing of the subsidence zone during active mining operation ● Filling of surface cracks and leveling of the area ● Preparing a subsidence monitoring program that covers the impact of subsidence on surface and ground water and its management ● Compensation to and rehabilitation of the affected people
2	Water Use	Water conservation	● Plan the mines in such a way that the impact on water bodies as well the surface drainage system remain minimal ● The area of influence of the cone of depression of groundwater should be estimated beforehand and the affected settlements should be provided with alternate

			water supply ● Reinjection of prior drainage of the aquifer
		Water pollution prevention	● Reuse of mine seepage water to mining operation ● Effluents from the colony and the workshop should be treated
3	Air environment	Air pollution prevention	● Drills should be provided with dust extractors ● Water spray before blasting ● Covering of the trucks to avoid spillage ● Provision water sprinklers on haul roads ● Use covered crusher unloading point, the crusher should be fitted with bag filter ● Closed conveyor transportation ● Put green belt around coal stock pile
4	Biodiversity	Biodiversity conservation	● Conduct sufficient biodiversity assessment at planning stage ● If it necessary, biodiversity conservation and relocation or rehabilitation of protected species are conducted. ● If the mining activity exercises high adverse impacts, then 'No Mining' is the best alternative.
5	Noise and vibration	Impact mitigation of noise and vibration to surrounding area and workers	● Use of controlled and advanced blasting techniques ● Conducting blasting only during the day time, as per a predetermined time schedule ● Reducing the exposure time of workers by practicing work rotation ● Noise attenuation by green belt
6	Mine closure	Proper mine closure plan	● Plan of environmental pollution prevention after mine closure ● Settling on final closure plan to create productive and sustainable land use of the mined area and accept the plan by stakeholders
7	Occupational health and safety issue	Safety measure of drilling	● Reduce workers exposure to noise and dust ● Wearing helmets, groves, earplugs, and masks ● Setting safety zone ● Prevent overburden collapse ● Prevent mine inundation (under ground mine)
		Mine fires prevention	● Organize initial fire fighting system ● Implement fire fighting training
		Roof collapse prevention (applicable in underground mine)	● Proper roof support design ● Mechanization of loading operations
		Worker's health surveillance	● Health survey programs for workers and local community ● Regular training and awareness of employees

Source：EIA Guidelines for Coal Mining 2009.3 DoE

18.6 Outline of simple diffusion calculation

(1) Summary

A simple diffusion calculation regarding the SO_X, SPM was conducted for the purpose of a rough impact analysis of the air environment by a 600MW coal-fired power plant based on this MP. Detailed diffusion calculation should be conducted after deciding on the site and the arrangements and specification of equipment appropriate to the site location's climate are conducted.

(2) Methodology

(a) Fuel specification

Two kinds of fuels, domestic coal and imported coal are selected as fuel. The specifications of domestic coal are determined from the analysis results of sample coal which were acquired from the Barapukuria power plant. The PSMP Study Team has proposed the specifications of imported coal. Ash content and sulfur content are assumed to be the highest in the band.

APTable 18-80 Fuel specification

	Domestic Coal	Import Coal
Result of elementary analysis (%)		
Carbon	73.2	74.8
Hydrogen	4.84	5.3
Nitrogen	1.54	1.1
Total Sulfur	0.68	1.2
Sulfur in ash	0.08	-
Phosphorus	0.057	-
Oxygen	7.15	18.0
Industrial analysis(%)		
Water	9.5	17.3
Ash	12.6	11.2
Volatile matter	32.7	38.2
Fixed carbon	54.7	36.0

Source: PSMP Study Team

(b) Emission specification

APTable 18-81shows the emission specifications for this simple diffusion calculation. As for the stack height, it is set to 275m in adherence to emission regulations regarding sulfur dioxide from ECR and 140m in adherence to local stakeholder requirements. Further, in order to satisfy the World Bank guideline of emission concentration, high efficiency FGD and ESP usage is an assumed factor that is part of the calculation.

APTable 18-81 Emission specification

Item	Unit	Mine mouth power plant		Import coal power plant	
		Domestic coal		Import coal	
Emission volume (wet)	Nm^3/h	$1,516\times10^3$		$2,353\times10^3$	
Exhaust temperature	°C	90		90	
Exhaust velocity	m/s	21.5		33.3	
Actual Stock height	M	275	275	275	140
Desulfurization efficiency	%	97		97	
Dust removing efficiency	%	99.6		99.6	
Sulfur Oxide emission	k g/h	59.9		162.3	
Emission of soot and dust	k g/h	72.3		90.9	

Source: PSMP Study Team

APTable 18-82 Emission Concentration

Item	New mine mouth power plant	Import coal power plant	Emission standard of Bangladesh	IFC(WB) guide line
Emission concentration of sulfur dioxide	$39.5mg/m^3$	$45.1mg/m^3$	—	$850mg/m^3$
Emission concentration of soot and dust	$47.7mg/m^3$	$38.6mg/m^3$	$500mg/m^3$	$50mg/m^3$

Source: PSMP Study Team

(c) Other calculation condition

Because this estimation is a simple calculation, special climate conditions such as the inversion layer and down draft are not considered.

(d) Atmospheric diffusion estimation model

The diffusion estimation was conducted with the Plume formula, and it calculated a 10 minute average value and a 24 hour average value for SOx, 8 hours average and 24 hour average values for SPM. The estimation of diffusion width σ_y, σ_z was from the Pasquill STABILITY classification. Stability class A (very unstable) was excluded from the calculation conditions since the stack height was 275m. Further, the diffusion width σ_y is proportional to the p involution of average time s. The P was set 0.2 in the range of 3 minutes to a 1 hour average time, and 0.3 in the range of 1 hour to a 24 hour average time.

(e) Emission concentration formula

$$C = \frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left\{-\frac{(z-H_e)^2}{2\sigma_z^2}\right\}+\exp\left\{-\frac{(z+H_e)^2}{2\sigma_z^2}\right\}\right]$$

symbol

C : Above-ground concentration at a leeward distance R (m)

Q : Emission volume (g/s)

σ_y : Parameter in the horizontal direction(m)

σ_z : Parameter in the vertical direction(m)

u : Wind speed(m/s)

R : Horizontal distance between the smoke source and calculated point (m)

Z : Above-ground height

He : Effective stack height (m) $He = H + 0.65 (H_m + H_t)$

H: Actual stack height (m)

Further, effective stack higher 'He' was calculated from Bosanquest's formula.

$$H_m = \frac{4.77}{1+\frac{0.43u}{v_g}}\sqrt{\frac{Q_{T1}v_g}{u}}$$

$$H_t = 6.37g\frac{Q_{T1}\Delta T}{u^3 T_1}\left(\log_e J^2 + \frac{2}{J} - 2\right)$$

$$J = \frac{u^2}{\sqrt{Q_{T1}V_g}}\left(0.43\sqrt{\frac{T_1}{g(d\theta/dz)}} - 0.28\frac{v_g}{g}\frac{T_1}{\Delta T}\right) + 1$$

Symbol

H_m : Elevation by emission velocity(m)

H_t : Elevation by buoyancy(m)

u : Wind speed(m/s)

v_g : Emission velocity(m/s)

Q_{T1} : Emission volume (m^3/s) at temperature T1

T_1 : Ambient temperature(K)

ΔT : Difference between emission temperature and T_1 (K)

g : Gravity's acceleration(m/s^2)

$d\theta/dz$: Inclination of ambient temperature (°C /m)

(3) Result

As a calculation result, the maximum ground concentration satisfies the ambient air standard for both Bangladesh and World Bank guidelines based on the emissions specifications in AP Table 18-83.

AP Table 18-83 Maximum ground concentration

Item	Average time	Newly mine mouth power plant		Import coal power plant		ECR	IFC(WB guideline)
		275m	140m	275m	140m		
Sulfur oxide	24-hour	0.4μg/m^3	0.5μg/m^3	1.7μg/m^3	2.0μg/m^3	365μg/m^3	20μg/m^3
	10 minute	3.0μg/m^3	3.9μg/m^3	8.4μg/m^3	10.2μg/m^3	-	500μg/m^3
Soot and Dust	24-hour	0.7μg/m^3	1.0μg/m^3	1.1μg/m^3	0.5μg/m^3	65μg/m^3[1]	25μg/m^3[2]
	8-hour	1.3μg/m^3	1.7μg/m^3	2.0μg/m^3	0.9μg/m^3	200μg/m^3[3]	-

Source: PSMP Study Team

As for domestic coal that has low sulfur content, the ground concentration is able to meet World Bank guidelines even if there are no desulfurization conditions with 275m of stack height. However, the SOx concentration at the stack outlet is 1,316mg/Nm^3 and this value has not satisfied World Bank guideline 850 mg/Nm^3. Sulfur content needs to be below 0.4% to satisfy World Bank guidelines pertaining to stack outlet SOx concentration. Further, this result has been acquired from a condition of no other emission source and under sulfur contents other than assumed.

APTable 18-84 Estimated maximum ground concentration in the case of no desulfurization

Item	Average time	Newly mine mouth power plant (0% desulfurization rate)	ECR	IFC(World bank guideline)
Sulfur oxide	24-hour	16μg/m^3	365μg/m^3	20μg/m^3
	10 minute	80μg/m^3	-	500μg/m^3

Source: PSMP Study Team

[1] $PM_{2.5}$
[2] $PM_{2.5}$
[3] SPM

18.7 Terms of Reference for Resettlement Action Plan (DRAFT)

Table of Contents

Definition of Terms

Resettlement Plan is a time-bound action plan with resettlement strategy, objectives, impact, entitlement, socio-economic survey, policy framework, legal framework, measures to minimize impacts, resettlement site, compensation, income restoration, resettlement implementation arrangement, resettlement schedule, participation and consultation, grievance redresses, monitoring and evaluation, monitoring and evaluation, and possibly indigenous people development plan.

Project Affected Persons (PAPs) indicates any juridical person being as it may an individual, a household, a firm or a private or public who, on account of the execution of the project, or any of its components or sub-projects or parts thereof would have their:
right, title or interest in any house, land or any other asset acquired or possessed, in full or in part; or
business, occupation, work, place of residence or habitat adversely affected; or
standard of living adversely affected.

Compensation means payment in cash or n kind to replace losses of land, housing, income, and other assets caused by a project.

Entitlement defines a right to receive mitigation measures such as compensation, income restoration, relocation assistance, and other support.

Income restoration/Livelihood restoration/Rehabilitation means the process to restore income earning capacity, production levels and living standards in a longer term.

Replacement cost is the method of valuation of assets that helps determine the amount sufficient to replace lost assets and cover transaction costs.
For agricultural land, it is the pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes.
For land in urban areas, it is the pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes.
For houses and other structures, it is the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor

and contractors' fees, plus the cost of any registration and transfer taxes.
In determining the replacement cost, depreciation of the asset and the value of salvage materials are not taken into account, nor is the value of benefits to be derived from the project deducted from the valuation of an affected asset.

Census is a data collection technique of completing enumeration of all PAPs and their assets through household questionnaire. Census's objectives are (i) to prepare a complete inventory of PAPs and their assets as a basis for compensation, (ii) to identify non-entitled persons, and (iii) to minimize impact of later influx of "outsiders" to project area.

Socio-economic survey is carried out in order to prepare profile of PAPs and to prepare for Basic Resettlement Plan. About 20 percent sample of PAPs population is surveyed through household questionnaire. The survey result is used (i) to assess incomes, identify productive activities, and plan for income restoration, (ii) to develop relocation options, and (iii) to develop social preparation phase for vulnerable groups.

Cut-off date determine eligibility for entitlement. It is normally the date census begins. The cut-off date could also be the date the project area was delineated, prior to the census, provided that there has been an effective public dissemination of information on the area delineated, and systematic and continuous dissemination subsequent to the delineation to prevent further population influx.

Vulnerable group is defined as the indigenous people, ethnic minorities, the poorest, women, children, the aged, the disabled, and other socially/economically vulnerable groups who would be adversely affected from a project.

Grievance Redress procedures set out the time frame and mechanisms for resolutions of complaints about resettlement from PAPs. Grievance redress can be provided through informally-constituted local committees with representation from key stakeholder groups. Grievances can also be addressed through formal channels, with unresolved grievances being dealt with at progressively higher levels.

Introduction

Project Scope
Project background
Objectives of the project
Project Scope
Project location map
1.2 Objectives of Resettlement
Land acquisition and resettlement principles and objectives
Consideration under the "JBIC Guidelines for Confirmation of Environmental and Social Considerations (2002. 4)"
Legal framework

Scope of Land Acquisition and Resettlement

Land acquisition
Map of the area and villages affected by land acquisition
Total land area acquired for the project
Population/households affected from land acquisition and resettlement
Total number of PAPs
Size of relocation (number of population/households to be relocated)
Size of those who lose their assets
Size of those whose business, occupation, work are adversely affected
Socio-economic profiles of PAPs
Size, gender, age, number of school children of each household
Occupation and means of livelihood
Income level and economic activities of PAPs, including vulnerable groups
Race, language, religion

Social support system, infrastructure of the community
Needs of PAPs regarding the income restoration program and relocation
Perception towards the project and resettlement, etc.
Census and Inventory of losses
Demographic, education, income and occupational profiles of PAPs
Land type and land use(agricultural, residential, commercial land)
Type of crops and trees
Buildings type (size, materials used)
Inventory of common property resources
Inventory of assets to be acquired
Existing civic facilities and infrastructure, etc.
Information on those without legal title to land or assets

Measures to minimize Land Acquisition and Losses
Actions and measures to be conducted for minimizing impact
Consideration of alternatives with special attention to avoid and minimize involuntary resettlement

Resettlement Policy and Entitlement
Compensation policy
Eligibility for compensation/assistance/rehabilitation
Entitlement Matrix
Assistance, support, compensation options
Cut-off date
Compensation/assistance policy towards those who without legal title

Resettlement Site
Method of site selection and site alternatives
Location, layout, and design of resettlement site
Resettlement site development (infrastructure, social service, etc.)

Income Restoration Program
Background of Income Restoration
Objective and policy of income restoration
Income Restoration Program
Constraints and opportunities for income generation
Analysis of needs, capacity, and existing skills of PAPs
Analysis of economic activities of PAPs and communities
Consultation and participation process
On-going income-generating or livelihood development programs (e.g., poverty alleviation) in the project area
Provisions for group-specific, targeted income restoration plans (e.g., microcredit or small development)
Income restoration options
Financial source of income restoration plans
Implementing arrangement of the program (e.g., assistance from government agencies, community organizations, NGO, or CBO)
Consideration of vulnerable people
Program implementing schedule
Monitoring

Implementation Arrangement
Responsibilities and roles of related organization (organizations in charge of Basic Resettlement Plan preparation, resettlement execution, land acquisition, monitoring, consultation, resettlement site preparation, income restoration, etc.)
Description of cooperation between related organization (e.g., coordination between an executing agency and NGO/CBO.

Implementation Schedule
Schedule of resettlement-related activities (see attachment for sample schedule form)

Participation and Consultation
Policy of participation and consultation
Place, timing, method, topics, meeting memorandum of public consultation meeting held in the past (including PAPs' opinion regarding the project and resettlement)
Plan of participation and consultation
Leaflet of resettlement distributed to PAPs, including followings:
Objectives of the Project
Service area of the Project and Project site
Cost estimation and sources of capital
Project Implementation Planning (i.e., F/S, EIA, and Basic Resettlement Plan preparation)
Project Impact
Definition of Eligibility
Resettlement and compensation principles
Compensation policy
Subsidize allowances
Settling complain (Grievance Redress procedure)
Note: Leaflet should be attached in the Annexes.

Monitoring and Supervision
Monitoring of flowing aspects:
Performance monitoring: physical progress against milestones established in the Resettlement Plan
Impact monitoring: assessment for the effects of resettlement (effectiveness of the Resettlement Plan and its implementation in meeting the needs of the PAPs)
Internal performance monitoring process (method, indicators, period, frequency, implementation arrangement of the monitoring)
Methodology of for external monitoring
Frequency of reporting and content for internal and external monitoring
Evaluation method of monitoring result
Process for integrating feedback from internal monitoring into implementation

Grievance Redress
Step-by-step process for registering and addressing grievances and specific details regarding a cost-free process for registering complaints, response time, and communication modes
Mechanism for appeal
Provisions for approaching civil courts if other options fail

Cost Estimate
Statement of financial responsibility and authority
Source of funds and the flow of funds
Estimated budget, by cost and by item, for all resettlement costs including planning and implementation, management and administration, monitoring and evaluation and contingencies
Provisions to account for physical and price contingencies

18.8 Terms of Reference for Environmental Impact Assessment (DRAFT)

18.8.1 Objective:

To conduct an EIA study regarding the coal-fired power project (600MW 2-3units) planned in PSMP2010.

18.8.2 Scope of Work

The scope of work covers mainly the EIA study of proposed project. The study should specifically include the following:

A review of the findings of the IEE study concentrating on important environmental components which are likely to be impacted from the project.
To collect baseline environmental and social condition data from both primary and secondary data.
To conduct a detailed air quality assessment
To conduct ambient noise monitoring
To conduct a surface water and ground water laboratory analysis.
To implement Thermal Plume modeling regarding the proposed coal fired power plant
To conduct a laboratory analysis of the dredged river, sea or pond material
To conduct an ecological survey
To review Bangladesh's cyclonic storms
To conduct a road and river traffic survey
To implement a detailed land-use survey conducted utilizing an appropriate method (e.g. spatial decision support system)
To assess environmental and social impacts and study mitigation or avoidance measures
To prepare an environmental management plan (EMP) which should include mitigation measures, enhancement measures compensation measures and an environmental monitoring plan

18.8.3 Content of EIA study report

EIA study report should include following:

- Policy and Legislation related to environmental issues in Bangladesh
- The role of the Department of Environment in the institutional analysis
- A detailed study on the potential impacts, mitigation measures and environmental management plan
- Environmental monitoring reports and final evaluation report of the project
- Identification and Analysis of Potential Impacts
- Analysis and Description of the Mitigation Measures
- A detailed technical and financial proposal shall be operated by the proponent's own resources (equipments and expertise)
- Other necessary information