No.

The STUDY on BHERAMARA COMBINED CYCLE POWER STATION in BANGLADESH

Final Report (Summary)

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Abbreviations

A&G	Administrative and General
AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating Current
ACCPAC	ACCPAC (Name of Software)
ACE	Advanced Computing Engine
ACI	American Concrete Institute
ADB	Asian Development Bank
ADP	Annual Development Programme
AE	Assistant engineer
AEO	Annual Energy Outlook
AES	American Energy Services Inc. (AES, Inc.)
AIS	Air Insulated Switchgear
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AM	Assistant Manager
ANSI	American National Standards Institute
APC	Auxiliary Power Consumption
APR	Annual Performance Report
APSCL	Ashuganj Power Station Company Limited
ASCE	American Society of Civil Engineering
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AVR	Automatic Voltage Regulator system
AWS	American Welding Society
AWWA	American Water Works Association
B/S	Balance Sheet
BADC	Bangladesh Agriculture Development Corporation
BAPEX	Bangladesh Petroleum Exploration Company Ltd
BAS	Bangladesh Accounting Standard
BB	Bangladesh Bank
BDM	Break Down Maintenance
BEI	Bangladesh Enterprise Institute
BERC	Bangladesh Energy Regulatory Commission
BIWTA	Bangladesh Inland Water Transport Authority
BNBC	Bangladesh National Building Code
BPDB	Bangladesh Power Development Board
BPHE	Bangladesh Public Health Engineer

BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
C/P	Counterpart
CB	Cash and Bank Management
CBM	Condition Based Maintenance
CCDB	Christian Commission for Development in Bangladesh
CCGT	Combined Cycle Gas Turbine
CCPP	Combined Cycle Power Plant
CCR	Central Control Room
CD	Custom Duty
CE	Chief Engineer
CEMS	Continuous Emission Monitoring System
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CGS	City Gate Station
CHCO	Chief Human Capital Officer
CHRO	Chief Human Resource Officer
CIO	Chief Information Officer
CMD	Chairman and Managing Director
CNG	Compressed Natural Gas
COD	Commissioning Date
COO	Chief Operating Officer
CPA	Certified Public Accountant
CPDO	Chief Planning & Development Officer
CPF	Contributory Provident Fund
CPI	Consumer Price Index
CRO	Chief Risk Officer
CSR	Corporate Social Responsibility
CV	Calorific Value
CWIP	Capital Work In Progress
CZPDC	Central Zone Power Distribution Company
DC	Direct Current
DCCI	Dhaka Chamber of Commerce & Industry
DCS	Distributed Control System
DESA	Dhaka Electricity Supply Authority
DESCO	Dhaka Electricity Supply Company
DG	Director General
DGM	Deputy General Manager
DM	Deputy Manager
DO	Diesel Oil

DOE	Department of Environment
DPA	Direct Project Aid
DPP	Development Project Proforma
DR	Discount Rate
DSCR	Debt Service Coverage Ratio
Dy	Deputy
E&Y	Ernst & Young
EBIT	Earnings Before Interest and Tax
EBITD	Earnings Before Interest, Tax and Depreciation
ECNEC	Executive Committee of National Economic Council
ED	Executive Director
EE	Executive Engineer
EGCB	Electricity Generation Company of Bangladesh Ltd.
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EOH	Equivalent Operation Hour
EPC	Engineering, Procurement and Construction Contract
ERC	Energy Regulatory Commission
ERD	Economic Relations Division
ERP	Enterprise Resource Planning
ES	Escalation rate of power Sales tariff
F(&)A	Finance & Accounting
F.eX	Foreign Exchange
FBCC	Federation of Bangladesh Chambers of Commerce and Industry
FD	Fixed Deposit
FE	Foreign Exchange
FIFO	First In and First Out
FIRR	Financial Internal Rate of Return
FOB	Free on Board
FRRP	Power Sector Financial Restructuring and Recovery Plan
FSA	Fuel Supply Agreement
FY	Fiscal Year
GCB	Gas Circuit Breaker
GCC	Gas Combined Cycle
GCV	Gross Calorific Value
GFA	Gross Fixed Assets
GIS	Gas Insulated Switchgear
GJ	Giga Joules
GL	General Ledger
GM	General Manager

GNI	Gross National Income
GOB	Government of Bangladesh
GOJ	Government of Japan
GSA	Gas Sales Agreement
GT	Gas Turbine
GTCL	Gas Transmission Company Limited
GTG	Gas Turbine Generator
HMS	Human Machine System
HO	Heavy Oil
HR	Human Resource
HRA	House Rent Allowance
HRD	Human Resource Development
HRSG	Heat Recovery Steam Boiler
HSD	High Speed Diesel
HSE	Health Safety & Environment
HSEQ	Health Safety, Environment & Quality
HT	High Tension
I&C	Instrumentation and Control
IAS	International Accounting Standards
IASB	International Accounting Standard Board
Ic/R	Inception Report
ICAB	Institute of Chartered Accountants of Bangladesh
ICMAB	Institute of Cost and Management Accountants of Bangladesh
IDA	International Development Agency
IDB	Islamic Development Bank
IDC	Interest During Construction
IEB	Institute of Engineers of Bangladesh
IEE	Initial Environmental impact Examination
IFRS	International Financial Reporting Standards
IMED	Implementation, Monitoring and Evaluation Division
IMS	Information Management System
INA	Information Not Available
IOC	International Oil Company
IPB	Isolated Phase Bus
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
ISA	Instrumentation, System, and Automation Society
ISO	International Standard Organization
IT	Information Technology
JAM	Junior Assistant Manager

JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
KEM	Key Executive Manager
KLHEP	Kargi Langpi Hydro Electric Project
KPI	Key Performance Indicator
KSAO	Knowledge, Skills, Abilities and Other traits or factors
KYT	Kiken Yochi Training
L/A	Loan Agreement
L/T	Long Term
LA	Lightening Arrester
LCD	Liquid Crystal Display
LDC	Load Dispatch Center
LTPM	Long Term Parts Management
LTSA	Long Term Service Agreement
MBO	Management by Objective
MD	Managing Director
MES	Manufacturing Execution System
MIS	Management Information System
MLA	Multilateral Lending Agency
mmscfd	Million standard cubic feet per day
MOH	Major Overhaul
MOL	Ministry of Land
MOM	Minutes of Meeting
MoPEMR	Ministry of Power, Energy & Mineral Resources
MP	Master Plan
MS	Multi-shaft
MSCF	Mil (Thousand) Standard Cubic Feet
MTMF	Medium Term Macroeconomic Framework
MU	Million Unit
MW	Mega Watt
NFPA	National Fire Protection Association
NLDC	National Load Dispatch Center
NOx	Nitrogen oxide
NRV	Net Realizable Value
NTPC	National Thermal Power Corporation Ltd
NWPGCL	North-West Power Generation Company Ltd.
O&M	Operation and Maintenance
OA	Office Automation
OCB	Oil Circuit Breaker
OCGT	Open Cycle Gas Turbine

OECD	Organization for Economic Cooperation and Development
OEM	Original Equipment Manufacturer
OH	Overhaul
OJT	On the Job Training
OMCO	Operation & Maintenance Chief Officer
OPGW	Optical Ground Wire
P/S	Power Station
PAT	Profit After Tax
PBITD	Profits Before Interest, Tax and Depreciation
PBS	Palli Bidyut Samities
PC	Personal Computer
PC	Power Cell
PCS	Process Control System
PDA	Personal Digital Assistant
PDCA	Plan Do Check Action
PDPAT	Power Development Planning Assist Tool
PGCB	Power Grid Company of Bangladesh
PI	Plant Information
PIMS	Plant Information Management System
PIU	Project Implementation Unit
PLC	Programmable Logoc Controller
PM	Plant Manager
PMB	Plant Management Board
PMC	Plant Management Committee
POAE	Plant Operating Availability on an Energy basis
POAH	Plant Operating Availability
PP	Power Purchased
PP	Project Proforma
PPA	Power Purchase Agreement
PPE	Personal Protective Equipments
PSMP	Power System Master Plan
PSP	Power Sales Tariff
PTW	Permit to Work
PwC	Pricewaterhouse Coopers Pvt. Ltd.
QC	Quality Control
R&M	Repair and Maintenance
RAO	Regional Administration Office
RDPP	Revised Development Project Proforma
REB	Rural Electrification Board
RMS	Regulative Metering Station

ROA	Return on Asset
RPA	Residual Project Aid
S/S	Substation
SBU	Strategic Business Unit
SCADA	Supervisory Control And Data Acquisition
SCGT	Simple Cycle Gas Turbine
SCI	Statement of Corporate Intent
SDE	Sub Divisional Engineer
SE	Superintending Engineer
SGV	SyCip Gorres Velayo & Co,
SHR	Sensible Heat Ratio
SL	Subordinated Ledger
SL	Transmission and Distribution System Loss
SLDC	State Load Dispatch Center
SOP	Sale of Power
SPP	Small Power Producer
SS	Single-shaft
ST	Steam Turbine
STG	Steam Turbine Generator
SUS	Stainless Used Steel
SZPDC	South Zone Power Distribution Company
TBM	Time Based Maintenance
TBM	Tool Box Meeting
TFD	Time of Flight Diffraction
TGTDCL	Titas Gas Transmission and Distribution Company Ltd.
Tk	Bangladesh Taka
TL	Transmission Line
TMT	Top Management Team
TNA	Training Needs Assessments
TOR	Terms of Reference
TQM	Total Quality Management
UEEP	Used Energy End Point
USD	United States Dollar
UT	Ultrasonic Testing
VAT	Value Added Tax
VC	Variable Cost
VCT	Voltage Circuit Transformer
W/S	Work Shop
WACC	Weighted Average of the Capital Cost
WASP	Wien Automatic System Planning Package

WB	World Bank
WBSEDCL	West Bengal State Electricity Distribution Company Limited
WPI	Wholesale Price Index
WTP	Willingness to Pay
WZPDCL	West Zone Power Distribution Company Ltd.
XEN	Executing Engineer

UNITS

Prefixes

μ	:	micro- = 10^{-6}
m	:	milli- = 10^{-3}
c	:	centi- = 10^{-2}
d	:	deci- = 10^{-1}
da	:	deca- = 10
h	:	hecto- = 10^{2}
k	:	kilo- = 10^{3}
M	:	mega- = 10^{6}
G	:	giga- = 10^{9}

Units of Length

m	:	meter
mm	:	millimeter
cm	:	centimeter
km	:	kilometer
in	:	inch
ft	:	feet
yd	:	yard

Units of Area

cm^2	:	square centimeter
m^2	:	square meter
km^2	:	square kilometer
ft^2	:	square feet (foot)
yd^2	:	square yard
ha	:	hectare

Units of Volume

m^3	:	cubic meter
l	:	liter
kl	:	kiloliter

Units of Mass

g	:	gram
kg	:	kilogram
t	:	ton (metric)
lb	:	pound

Units of Density

kg/m^3	:	kilogram per cubic meter
t/m^3	:	ton per cubic meter

mg/m^3N	:	milligram per normal cubic meter
g/m^3N	:	gram per normal cubic meter
ppm	:	parts per million
μg/scm	:	microgram per standard cubic meter

Units of Pressure

kg/cm^2	:	kilogram per square centimeter (gauge)
lb/in^2	:	pound per square inch
mmHg	:	millimeter of mercury
mmHg abs	:	millimeter of mercury absolute
mAq	:	meter of aqueous
lb/in^2, psi	:	pounds per square inches
atm	:	atmosphere
Pa	:	Pascal
bara	:	bar absolute

Units of Energy

kcal	:	kilocalorie
Mcal	:	megacalorie
MJ	:	mega joule
TJ	:	tera joule
kWh	:	kilowatt-hour
MWh	:	megawatt-hour
GWh	:	gigawatt-hour
Btu	:	British thermal unit

Units of Heating Value

kcal/kg	:	kilocalorie per kilogram
kJ/kg	:	kilojoule per kilogram
Btu/lb	:	British thermal unit per pound

Units of Heat Flux

$kcal/m^2h$	:	kilocalorie per square meter hour
Btu/ft^2H	:	British thermal unit per square feet hour

Units of Temperature

deg	:	degree
°	:	degree
C	:	Celsius or Centigrade
°C	:	degree Celsius or Centigrade
F	:	Fahrenheit
°F	:	degree Fahrenheit

Units of Electricity

W	:	watt
kW	:	kilowatt
A	:	ampere
kA	:	kiloampere
V	:	volt
kV	:	kilovolt
kVA	:	kilovolt ampere
MVA	:	megavolt ampere
Mvar	:	megavar (mega volt-ampere-reactive)
kHz	:	kilohertz

Units of Time

s	:	second
min	:	minute
h	:	hour
d	:	day
y	:	year

Units of Flow Rate

t/h	:	ton per hour
t/d	:	ton per day
t/y	:	ton per year
m^3/s	:	cubic meter per second
m^3/min	:	cubic meter per minute
m^3/h	:	cubic meter per hour
m^3/d	:	cubic meter per day
lb/h	:	pound per hour
m^3N/s	:	cubic meter per second at normal condition
m^3N/h	:	cubic meter per hour at normal condition

Units of Conductivity

μS/cm	:	microSiemens per centimeter

Units of Sound Power Level

dB	:	deci-bell

Units of Currency

Sum	:	Uzbekistan Sum
US$	:	US Dollar
¥	:	Japanese Yen

Exchange Rate : US$ 1 = 68 taka

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Part II Proposal for Corporation Plan and Organiazation of NWPGCL nad Bheramara Combined Cycle Power Station

Part I

Feasibility
of
Bheramara Combined Cycle Power Station Construction Plan

Chapter 1 Preface

1.1 Background of the study

Bangladesh is aiming for to be able to supply electric power for all the citizen by 2020. However electrification rate is still 42% in 2007. In comparison to 4,700 MW as the peak power demand, the maximum power capacity is approximately 3,800 MW yet. They cause planned power cut because of power supply shortage. On the other hand, power demand growth is forecasted as 8% a year from now on and it is necessary to built approximately 5,500 MW of new power supply for next five years to satisfy power demand growth.
Also natural gas field as the significant natural resource in Bangladesh is unevenly distributed at eastern area in Bangladesh. It leads to built power stations at eastern area not to western area. This unevenly distributed situation causes power supply shortage in western area, transmission loss from eastern power to western area and drop in voltage. Generally western area is late to be developed and it is a matter of great urgency to aim to raise their living standard.
Meanwhile Bangladesh has been reforming the electric power sector in order to improve of administrative management and power supply since 1994. BPDB has been divided into APSCL, EGCB and PGCB so far. The Plant is supposed to belong to NWPGCL and dividing company plan is also the subject.
Bangladesh requested a feasibility study of Bheramara combined cycle power plant in western Bangladesh to Japan government in August, 2007. ODA task force in Bangladesh is examining to ODA loan from JBIC concerning The Plant construction.
In order to decide the scope of F/S and study the power sector and dividing company project, JICA executed on-site study of The Plant in October, 2007 and confirmed the necessary condition of the Plant. Then, JICA agreed with local party concerning contents of S/W afterward.

1.2 Objectives of the Study and scope of the Study

1.2.1 Objectives of the Study

Objectives of the study are as follows.

(1) To execute the Feasibility Study concerning Bheramara 450MW Combined Cycle Power Plant Construction in The People’s Republic of Bangladesh and necessary technology transfer to the staff concerned of local C/P for The Study term.
(2) To support NWPGCL what will manage The Plant concerning administrative system and management plan.

1.2.2 Scope of the Study

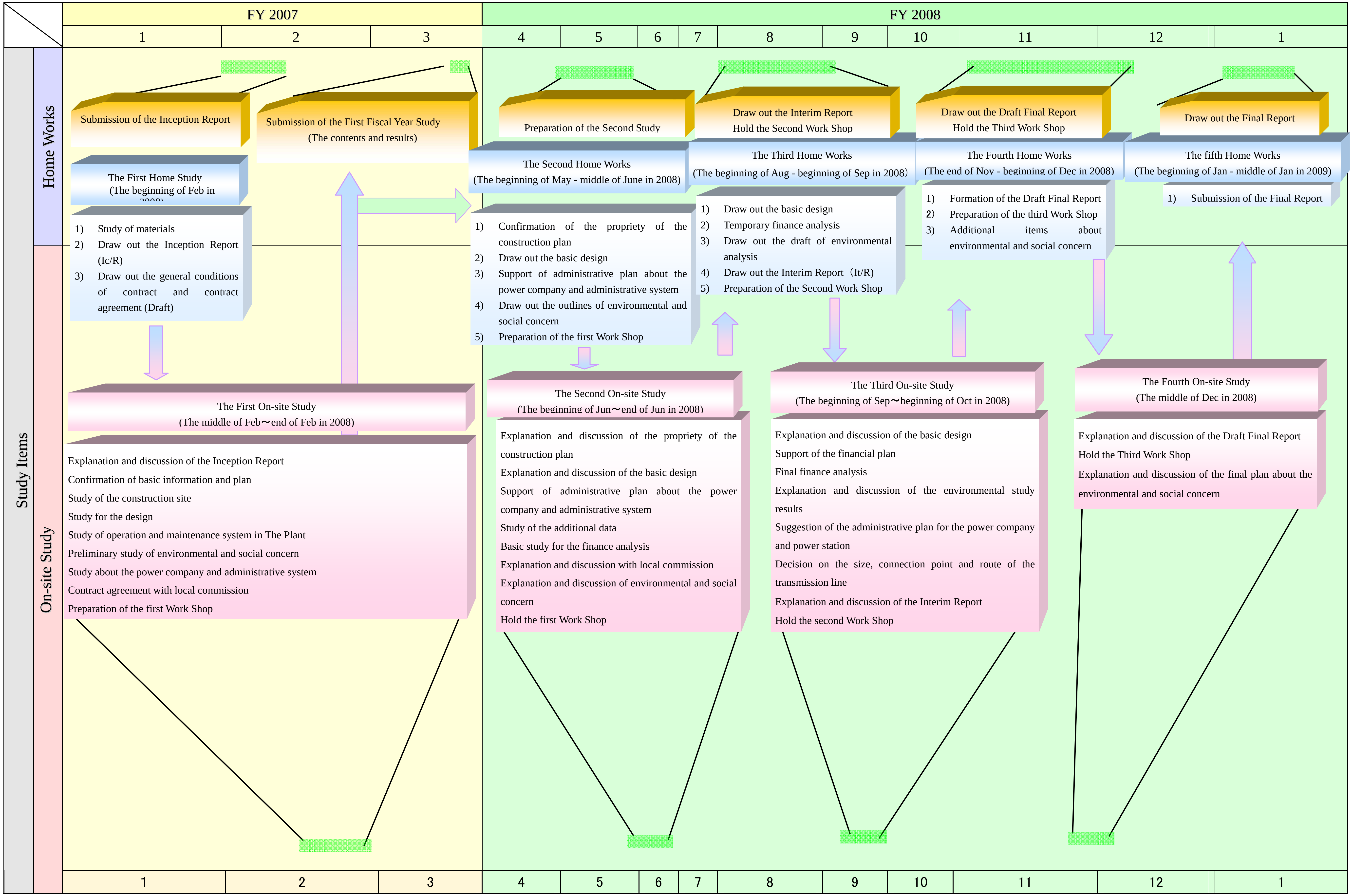
Based on the Minute of Meeting and Scope of Works which were signed in December, 2007 between the Preliminary Study Team of JICA and Bangladesh, the following components of the Study will be carried out:

(1) Collection and confirm of Basic information and plan
(2) Study for construction site
(3) Study for engineering
(4) Suggestion for administrative system of The Plant
(5) Study for financial analysis and management effect index
(6) Environment and social concern

(7) Support of administrative plan about the power company and administrative system
(8) Technology transfer for whole study -term
(9) Work Shop (hereinafter called as “W/S”)

1.2.3 Duration of the Study

Schedule of the Study is shown in the next page.



FY 2007
FY 2008
1
2
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4
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6
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11
12
1
Study Items
Home Works
On-site Study
Submission of the Inception Report
Submission of the First Fiscal Year Study
(The contents and results)
Preparation of the Second Study
Draw out the Interim Report
Hold the Second Work Shop
Draw out the Draft Final Report
Hold the Third Work Shop
Draw out the Final Report
The First Home Study
(The beginning of Feb in 2008)
1) Study of materials
2) Draw out the Inception Report (Ic/R)
3) Draw out the general conditions of contract and contract agreement (Draft)
The Second Home Works
(The beginning of May - middle of June in 2008)
1) Confirmation of the propriety of the construction plan
2) Draw out the basic design
3) Support of administrative plan about the power company and administrative system
4) Draw out the outlines of environmental and social concern
5) Preparation of the first Work Shop
The Third Home Works
(The beginning of Aug - beginning of Sep in 2008)
1) Draw out the basic design
2) Temporary finance analysis
3) Draw out the draft of environmental analysis
4) Draw out the Interim Report (It/R)
5) Preparation of the Second Work Shop
The Fourth Home Works
(The end of Nov - beginning of Dec in 2008)
1) Formation of the Draft Final Report
2) Preparation of the third Work Shop
3) Additional items about environmental and social concern
The fifth Home Works
(The beginning of Jan - middle of Jan in 2009)
1) Submission of the Final Report
The First On-site Study
(The middle of Feb～end of Feb in 2008)
Explanation and discussion of the Inception Report
Confirmation of basic information and plan
Study of the construction site
Study for the design
Study of operation and maintenance system in The Plant
Preliminary study of environmental and social concern
Study about the power company and administrative system
Contract agreement with local commission
Preparation of the first Work Shop
The Second On-site Study
(The beginning of Jun～end of Jun in 2008)
Explanation and discussion of the propriety of the construction plan
Explanation and discussion of the basic design
Support of administrative plan about the power company and administrative system
Study of the additional data
Basic study for the finance analysis
Explanation and discussion with local commission
Explanation and discussion of environmental and social concern
Hold the first Work Shop
The Third On-site Study
(The beginning of Sep～beginning of Oct in 2008)
Explanation and discussion of the basic design
Support of the financial plan
Final finance analysis
Explanation and discussion of the environmental study results
Suggestion of the administrative plan for the power company and power station
Decision on the size, connection point and route of the transmission line
Explanation and discussion of the Interim Report
Hold the second Work Shop
The Fourth On-site Study
(The middle of Dec in 2008)
Explanation and discussion of the Draft Final Report
Hold the Third Work Shop
Explanation and discussion of the final plan about the environmental and social concern

Chapter 2 Social / Economic State of Conditions in Bangladesh

2.1 Overview

The Gross National Income (GNI) per capita in the country remains at the level of US$ 450 (2006 constant price) and is classified as one of the Least Developed Countries as defined by United Nation[1]. World Bank is summarizing its long term outlook on the strategy for economic development of Bangladesh which spells out that, the country has the necessary assets; much-improved economic fundamentals; success in implementing many first-generation reforms; a young, rapidly growing labor force; and an established entrepreneurial culture and the country could join the ranks of middle-income countries within a decade (by 2016) or some time after[2].

2.2 Population and Labor Force

2.2.1 Population Census

In Bangladesh, Bangladesh Bureau of Statistics is conducting the national census once every 10 years. The latest survey was conducted in July 2001 which captured the total population as 124.35 million out of which 23.5% resided in the urban area and 76.5 in the rural area. The annual growth rate of population after the census is recognized as 1.58%. The government is vigorously pursuing the family planning campaign and the growth of population is expected to slow down gradually. The population is expected to reach 145.5 million in 2011 after consideration of the slow down of increase and the extension of average life expectancy,

2.2.2 Labor Force Survey

Bangladesh Bureau of Statistics is conducting the Labor Force Survey. The total population of Bangladesh is known to have increased approximately three times from 52 million in 1960 to 140 million of today. The predominant majority of the population lives in the rural areas and so is the labor force with 76% residing in the rural areas. There exists the trend of urbanization in the labor market, too, as the share of the urban labor force among the total increased from 23% in 1996 to 24.5% in 2003.Industry- wise, almost 90% of male workers are engaged in agriculture (50%) or in services (38%), while only about 10% are engaged in the manufacturing and construction industries which jointly comprise about a quarter of GDP. Among the female jobs, share of agriculture rose from 28% in 1996 to 59% in 2003 and this increase of female labor pushed up the total labor force in agriculture.

The definition of unemployment in Bangladesh is any person of age 15 years or above if he or she did not work at all during the preceding week of the survey and was actively looking for work[3]. According to the definition, the unemployment rate in 2003 is recorded as 4.3% or in the absolute number of 2 million. The unemployment rate increases with the education levels of the labor force. Should we consider monthly income of Taka 2,000 which is equivalent to one dollar

[1] United Nations Conference for Trade and Development (UNCTAD) initiated classification of countries by GNI per capita in 1971. The list of the countries is periodically reviewed and updated. The criteria used at present are; for a new country to be listed is the three year average of GNI per capita staying below US$ 750 and for a country to graduate from the list, the GNI per capita must exceed US$ 900. In addition to the criteria by income, other criteria are used by UN to review the classification; the level of human assets as measured through Human Assets Index and economic vulnerability measured through Economic Vulnerability Index.

[2] World Bank, "Bangladesh: Strategy for Sustained Growth", July, 2007

[3] World Bank, "Bangladesh: Strategy for Sustainable Growth", June 2007

a day, definition set up by UN for absolute poverty, about half of the self-employed fell below the poverty level in 2003[4].

2.3 Macro Economy

2.3.1 Economic Growth

During the 5 years between 2002/03 – 2006/07, the macro economy performed comfortably well. The real term of GDP has been on the growth orbit by growing at average annual rate of 6.13%. The good performance has been supported primarily by the domestic consumption and the remittance from oversea workers. Investment is showing sluggishness while an acute shortage of infrastructure is obvious. The bottlenecks of the power supply and the transportation infrastructure are balking the international trading beyond the borders. Bangladesh is assessed by PricewaterhouseCoopers that it embraces a potential capability to attain GDP growth at an average of 7%. As one of such assessments of the country, there reportedly exists a specific evaluation that classifies Bangladesh as one of the 13 countries[5].

2.3.2 Fiscal Balance

In the fiscal year of 2004, the revenue grew by 9.5% from the preceding yea which was short of meeting the growth of nominal GDP but attained the growth of 14.8% in 2005 and 14.0% in 2006 in line with the growth of nominal GDP. The expenditure is also on an increasing trend. Approximately 20% of the expenditure is routed to the subsidies which include fuel, fertilizer, food, etc. The expansion of expenditure caused the fiscal deficit to inflate and such is causing the public debt balance to expand. The deficit for 2008 is reported to have been 4.8% of GDP[6]. The recipient of the subsidies are primarily to Bangladesh Petroleum Corporation, PETROBANGLA, and the food sector who are reported to have granted with 14.1% of the total expenditure as subsidies[7].

2.3.3 Monetary Policy

Monetary policy is in purview of the Central Bank, Bangladesh Bank. Bangladesh Bank exercises the monetary policy through the control of money supply. The money record of the money supply shows the increase in keeping pace with the nominal growth of GDP and to be understood being sufficient enough to endorse the economic growth. The official discount rate has been fixed and maintained at 5.0% as a result of lowering in 2004. The weighted average of interest rates at commercial banks has been fluctuating within the ranges of 5.6-6.9% for deposits and 10.9-12.9% for lending during such period. The spread between the two rates is seen to be as large as 5-6%. The magnitude of the spread margin indicates the inefficiency of financial intervention function. In addition, the level of non-performing loans at the commercial banks are staying at about 12% implying the high cost involved with the financial intervention.

2.3.4 Balance of Payments

The exports of Bangladesh are predominantly, approximately two thirds, are occupied by the

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[4] ditto
[5] PricewaterhouseCoopers, “The World in 2050: Beyond the BRICS: A broader Look at Emerging Market Growth Prospects”, 2008
[6] ADB, “Bangladesh: Quarterly Economic Update”, March 2008
[7] ADB, “Bangladesh: Quarterly Economic Update”, June 2008

readymade garments. The export of readymade garments took a setback due to the lifting of quota by U.S.A. but regained its momentum in 2004 and has been growing steadily ever since. With exception of the readymade garments, exports are composed of the commodities such as; fish & shrimp; raw jute and jute products; leather; others (items processed at export processing zones) but noe of such items occupy a substantial share among the country's total. On the other hand, the growth of imports used to be lower than that of exports up till 2006, but in 2007 and later the imports of food staff sharply increased by 26% in 2008[8] from the preceding year. On top of this, the skyrocketing prices of international commodities caused the imports of petroleum products and industrial intermediary goods to soar. The sharp increase of imports caused the deficit in the trade balance to inflate. The remittances from the oversea workers amounting as much as 50% of the total exports on constant basis has contributed the current account to be in surplus.

2.3.5 Foreign Exchange Rate

Foreign exchange is also under the purview of Bangladesh Bank. Against the US Dollar, Taka had been depreciating consistently up till March 2006 when Taka recorded US$ 1 = Taka 68.0. The currency then began to show somewhat stabilized move ever since till today. Having the ample and accumulating foreign exchange reserves, the Central Bank has been providing the foreign currency sufficient enough to meet the demand in the market with the aim to keep the market stabilized.

2.3.6 Government Budget

In June 2008, the national budget for the fiscal year of 2009 has been compiled. The budget reflects the Medium Term Macroeconomic Framework (MTMF) of the government and incorporates the growth target of GDP at 6.5%; the inflation at 9%; the growth of exports to be 16.5% and imports at 21%. The total expenditure budgeted for 2009 is Taka 1 trillion, which includes Annual Development Programme (ADP) for Taka 256 billion (16% of GDP) and recurrent expenditure for Taka 744 billion.

2.4 Industrial Structure

Bangladesh has long been dependent on the agriculture. However, the country's dependence on agriculture is gradually decreasing and a variety of new industries are burgeoning. In 2007, the industry that appeared on top of the industry-wise GDP output list was manufacturing with its contribution for 17.3%, followed by agriculture for 14.5% and wholesale and retail trades for 14.1%. The industries that have expanded their shares between 1995 and 2007 include; manufacturing; wholesale and retail trades; construction; and transportation and communication. The industries that have decreased their shares include; agriculture which is particularly noteworthy; fishing and shrimp and real estate.

2.5 Household Economy

Bangladesh Bureau of Statistics is conducting another periodical survey, Household Income and Expenditure Survey" once in every 5 years, the latest one of which has been done in 2005.
During the five years between 2000 and 2005, the population data indicates the progress of urbanization by showing its increase in the urban areas by 36% whereas that in rural areas is by

[8] ditto

10%. The average monthly income per capita is recognized as Taka 1,485 (equivalent to US$ 24), of which the urban is Taka 2,217 (US$ 36) and the rural is Taka 1,246 (US$ 20). The line of absolute poverty is defined by the United Nations as one dollar per capita per day which is converted to Taka 1,860 per month by using the exchange rate then prevailing. The average income in the urban areas is exceeding the poverty line by about 20%, whereas that of rural areas is undermining the line by about 40% and so is the national total by about 20%. From such data, one can surmise that more than half of the population belongs to the absolute poverty level. The average expenditure per household is recognized as Taka 6,134 per month out of which the consumption expenditure occupies Taka 5,964 per month. With respect to the electrification rate of the country, 83% of the urban areas are connected to the grid whereas the rate of access to the grid in the rural areas grew from 19% in 2000 to 31%. In its result, the national average rate of access to the grid has increased from 31% in 2000 to 44% in 2005.

2.6 Inflation and Prices

The annual increase of CPI has hit the bottom at 1.9% in 2001 and has been on the continuous increase for 7 years since then. The indexes were; 2.79% in 2002; 4.38% in 2003; jumped to 6.49% in 2005; and climbed high closer to 10% in 2008. Curbing of the inflation remains to be one of the important tasks of the government in its economic policy. With respect to the basket comprising the CPI, the largest among the components is food which occupies 58.8% of total CPI. The inflation appears to be a lot severe in the food category. CPI (food) that used to be stagnant in 2001 and 2002 has moved to the higher layer in 2004 and it has eventually hit the annual average of 12.28% in 2008, or 14.10% in the point-to-point at the year end of 2008, due primarily to the increase of food prices in the international market.

Chapter 3 Power Sector in Bangladesh

3.1 Brief of Power Sector in Bangladesh

(1) Power generation facilities

In fiscal year 2006 the total installed capacity was 5,202 MW, which comprised a thermal power capacity of 4,972 MW (95.6%), and a hydroelectric power capacity of 230 MW (4.4%). In terms of fuels, natural gas-fired power stations represent 81.3% of the total capacity. In terms of the installed capacity of different electric power utility companies, as of March 2004 the installed capacity of the BPDB (Bangladesh Power Development Board) was 3,429 MW while that of the IPPs (independent power producers) was 1,260 MW. However, the percentage of power generating facilities that were inoperable due to aging was high, between 30% and 40%.

And the locations of power plants in Bangladesh are shown in Figure I-3-1-5.

Table I-3-1-1 Power Generating Facilities using Fuel

Fuel	MW	%
Natural Gas	4,228	81.28
Heavy Oil	280	5.38
Diesel	214	4.11
Hydraulic Power	230	4.42
Coal	250	4.81
Total	5,202	100.0

(source) BPDB Annual Report 2006/2007

Table I-3-1-2 Power Generating Facilities using a Generation Method

Fuel	MW	%
Hydraulic Power	230	4.42
Steam Turbine	2,638	50.71
Gas Turbine	1,106	21.26
Combined Cycle	990	19.03
Diesel	238	4.58
Total	5,202	100.0

(source) BPDB Annual Report 2006/2007

(2) Power transmission facilities

In fiscal year 2006, transmission facilities comprised 230 kV lines and complementary 132 kV lines. The constant length of the lines was 3,796.5 km. The 230 kV bulk transmission lines all comprise two transmission lines and form a loop together with the 132 kV lines in the area around the capital. The 230 kV system links the main substations around the capital and interconnects the eastern and western regions.

(3) Power distribution facilities

As the high-voltage distribution lines, 33 kV and 11 kV lines are used, and 400V and 230V lines are used as the low-voltage distribution lines. Power is distributed by means of three-phase, four-wire systems and single-phase systems. The single-phase systems are primarily used in rural areas for the purpose of rural electrification. The constant length of the distribution lines is 47,646 km.

(4) Generated power and peak load

The generated power of the BPDB in Bangladesh is shown in Figures I-3-1-1. Maximum demand is shown in Table I-3-1-2.

The generated power increased by more than 10% over the decade of the 1980s, which corresponds to a period of rapid economic growth. Since then, generated power has continued to grow in response to economic growth.

The significant reduction in the rates of increase in generated power for 2006/2007 was due to serious gas supply shortage.

The average rate of increase in generated power over the past 27 years has been 8.95%.

The peak load has increased in the same way as generated power, with the exception of 1996, at an average rate of 7.1% for the past 20 years.

As the above shows, the demand for electrical power in Bangladesh is rising rapidly. Normally, this rise in demand would be accompanied by gas field development and increased gas production, but in recent years gas production has leveled off, making it impossible to increase power generation. Thus, it is desirable that the thermal power plants that have been dependent on natural gas be switched over rapidly to alternative fuels such as coal.

(5) Breakdown of generated power

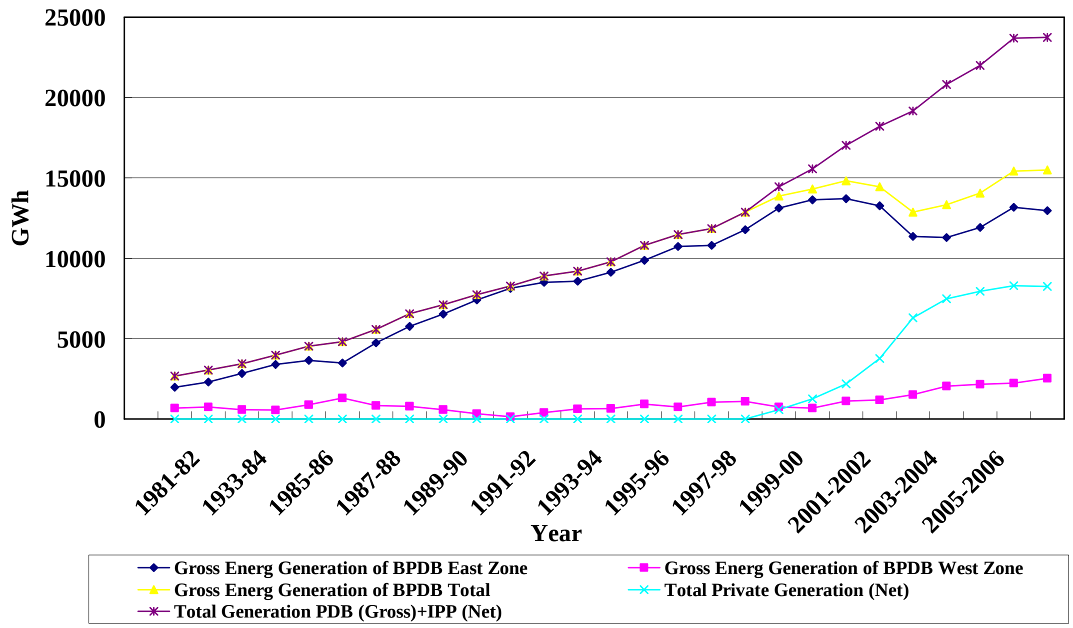
The breakdown of generated power by fuel is shown in Figure I-3-1-3. As the table clearly shows, thermal power generation is dominant and hydroelectric power generation is supplemental in Bangladesh, and thermal power stations are largely dependent on natural gas as fuel.

(6) Supply and demand conditions

As shown in Figure I-3-1-4, the available power in Bangladesh is less than the estimated demand, making regular scheduled outages necessary.

Especially since 2005, the amount of scheduled outages has been increasing, due in large part to gas supply shortages.

Also, as noted above, because of the chronic power shortage in Bangladesh, power-generating facilities cannot be stopped, and thus appropriate maintenance cannot be performed. As a result, facilities are often rendered inoperable due to failures and many are unable to generate their rated power.



(source) BPDB Annual Report 2006/2007

Figure I-3-1-1 Generated Power of BPDB and IPP

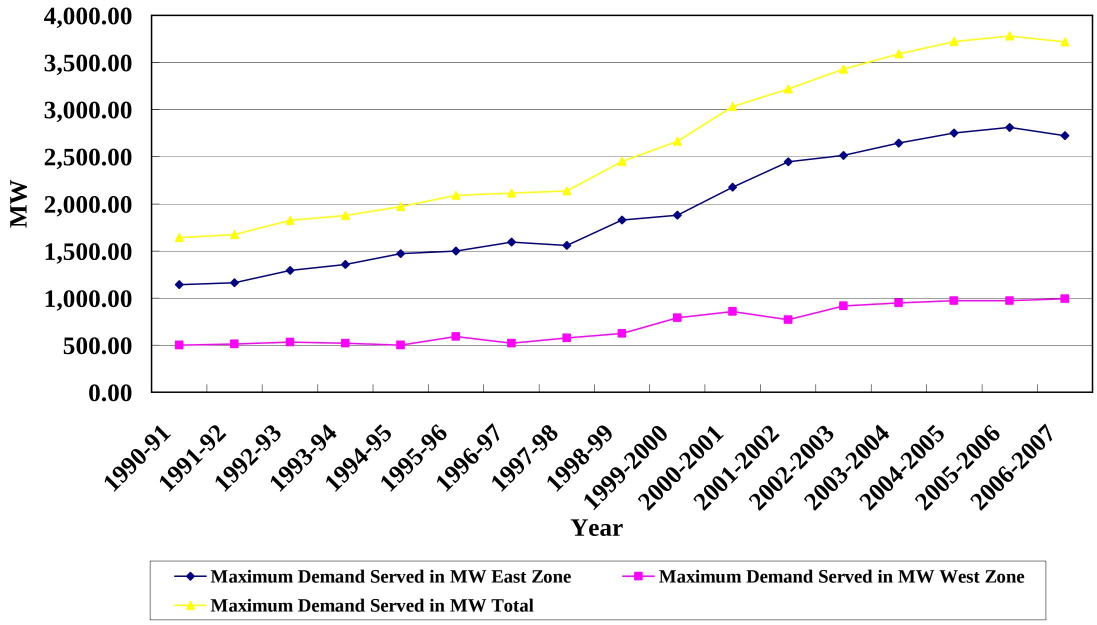


Figure I-3-1-2 Maximum Power Demand

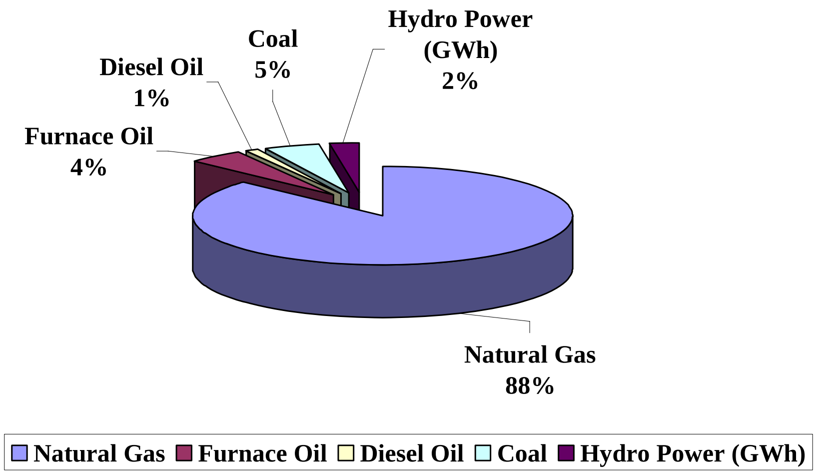


Figure I-3-1-3 Generated Power by Fuel

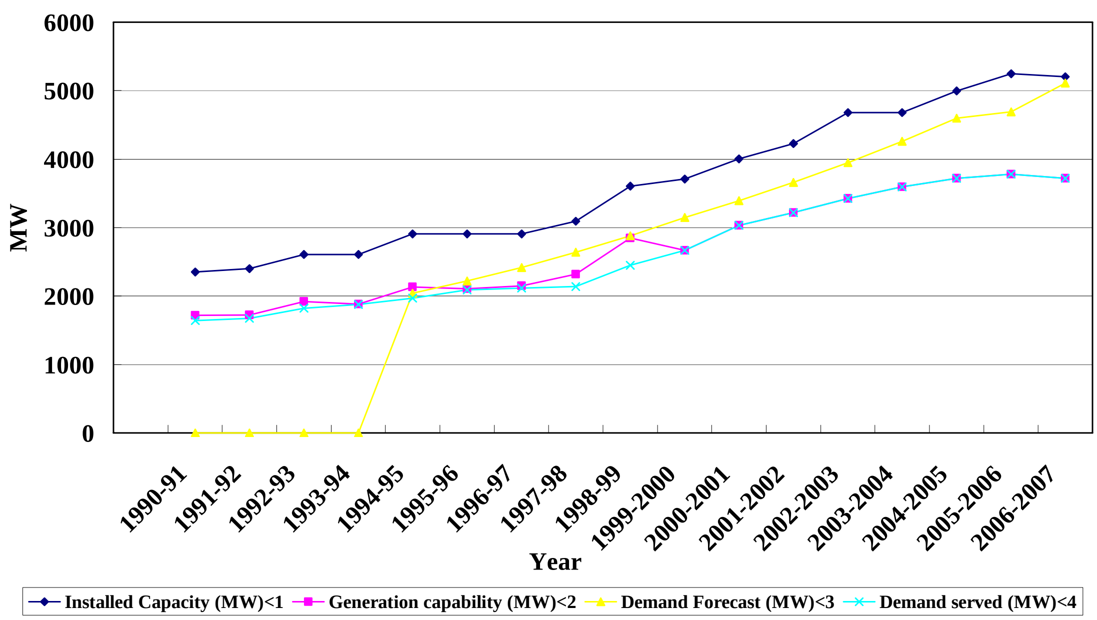


Figure I-3-1-4 Facility Capacities, Available Power, Demand Estimates, and Scheduled Outages

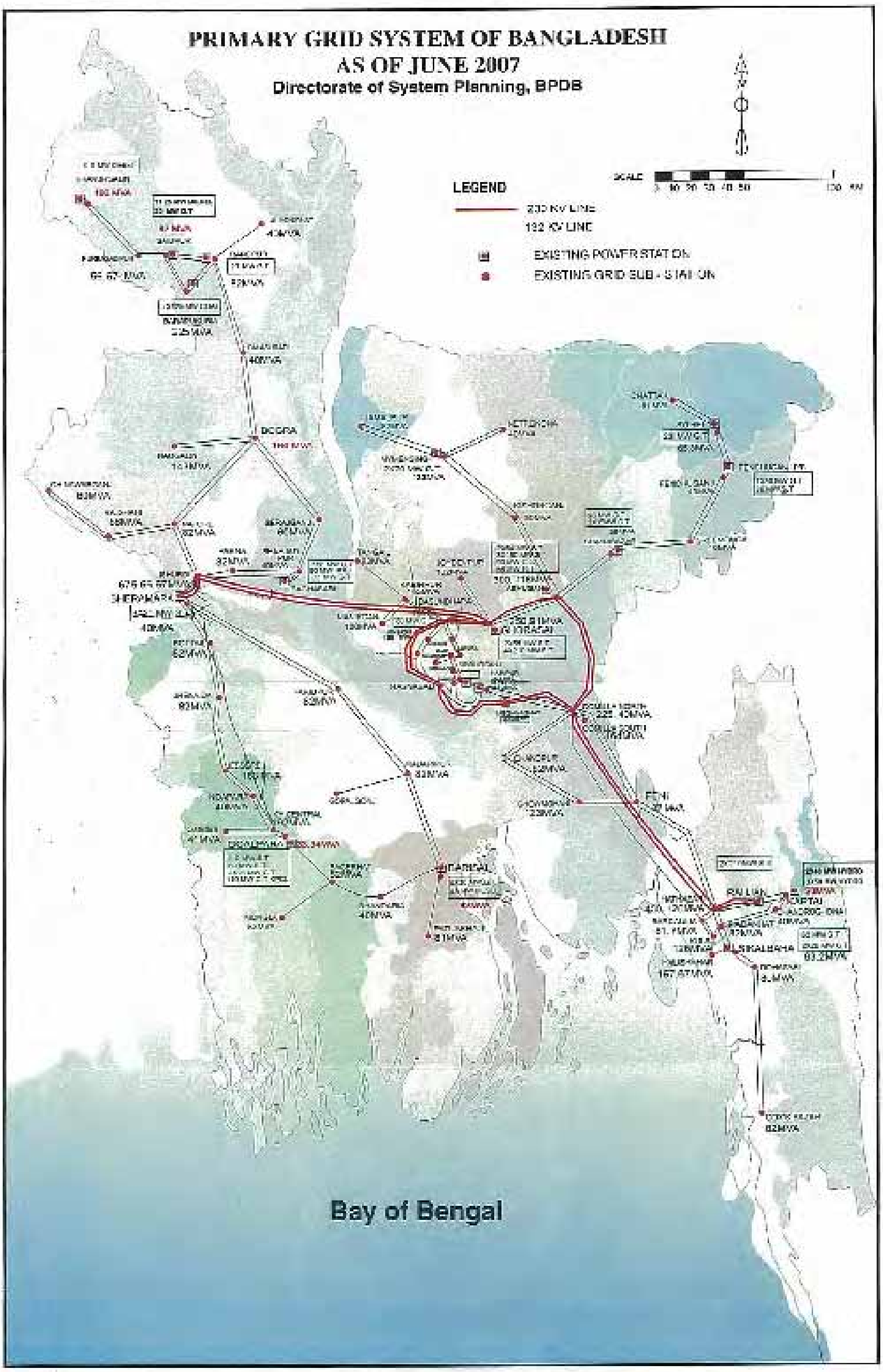


Figure I-3-1-5 Locations of Existing Power Stations

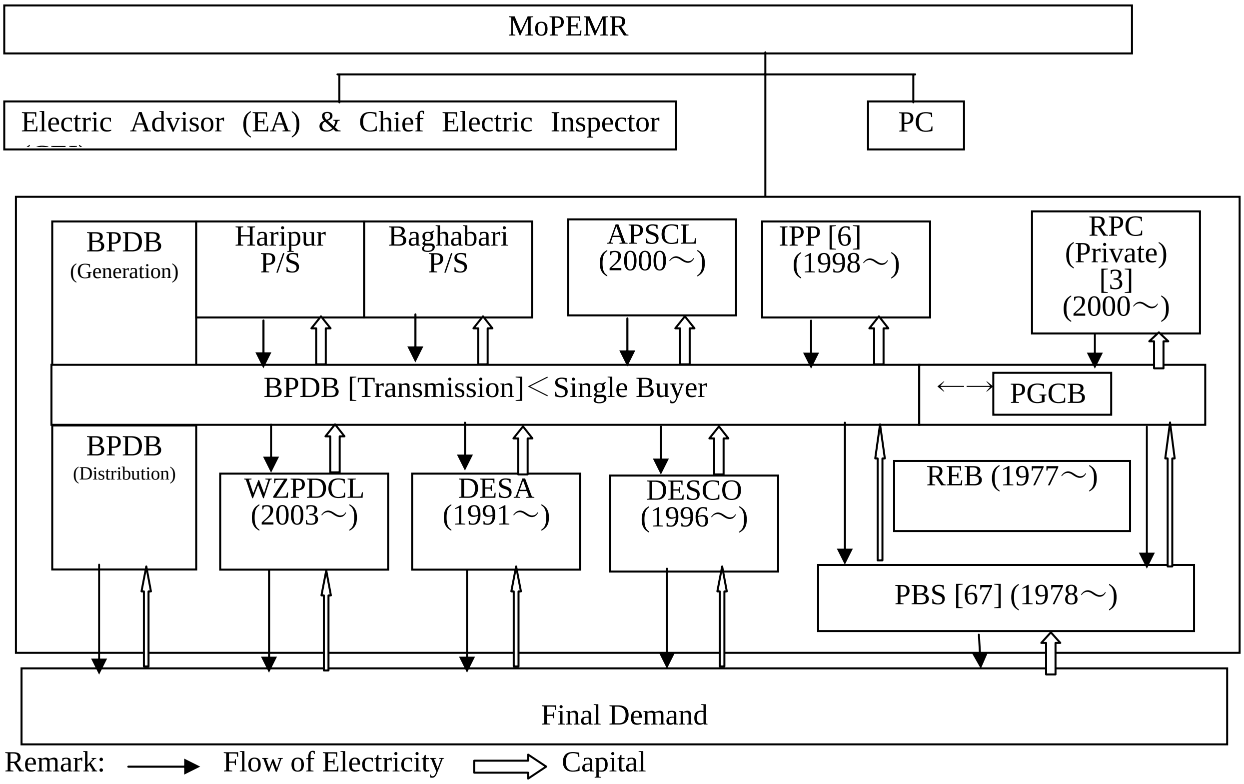
3.2 Organization of Power Sector in Bangladesh

The long-term vision of the government of Bangladesh is to supply electricity to all citizens by 2020. The government has announced a reform of the power sector so as to achieve a reliable, high quality supply of power at appropriate charges. The BPDB is acting in line with this government strategy.

(1) Company form

In Bangladesh, the Ministry of Power, Energy, and Mineral Resources (MoPEMR) manages the power industry. Under the management of MoPEMR, power is generated by the Bangladesh Power Development Board (BPDB), independent power producers (IPP) that were created as spin-offs or subsidiaries of the BPDB, and investor-owned utilities. Power is supplied to consumers via BPDB transmission facilities by the BPDB for provincial cities, by the Dhaka Electricity Supply Agency (DESA) and the Dhaka Electricity Supply Company (DESCO) in Dhaka, and by rural electrification cooperatives called Palli Bidyut Samities (PBS) in rural areas. Figure I-3-2-1 shows the organization of the power sector in Bangladesh.

As per Government dicision, Dhaka Power Distribution Company (DPDC) has taken over DESA activities from 1st July 2008.



(source) Japan Electric Power Information Center, Inc.

Figure I-3-2-1 Electrical Power Sector in Bangladesh

(2) Reforms in the power sector and the current organization

The Ministry of Power, Energy, and Mineral Resources (MoPEMR) embarked in 1994 on a reform of the power sector that is ongoing and includes the participation of IPPs and the break-up and privatization of the BPDB. In 1994, the Power Sector Development & Reform Program was implemented, and in 1996 the Power Sector Power Generation Policy was enacted to open up the power generation sector to private interests. In 2000, a Vision

Statement/Policy Statement announced the goal of supplying inexpensive and reliable electrical power to all citizens by 2020 and set the direction for power sector reforms. In 2003, the Energy Regulatory Commission Act was enacted in preparation for the establishment of an independent and fair Energy Regulatory Commission (ERC) for the energy sector.

Regarding the power generation division of the BPDB, the Haripur power station became a division based on the Vision Statement/Policy Statement of January 2001. The Ashganj power station became a spin off. With the Energy Regulatory Commission Act of May 2003, the Baghabari power station became a division.

Similarly, in the distribution division of the BPDB, the West Zone Power Distribution Co. Ltd. (WZPDCL), which distributes power to the Khulna and Barisal districts, was spun off from the Energy Regulatory Commission Act.

3.3 Financial Standing of Bangladesh Power Development Board

3.3.1 Business Performance

The business performance of BPDB has been in the chronic slump for a long time till today, with the accumulation of the insurmountable losses which amounts for Taka 83.8 billion. The paid up capital of BPDB has been deeply encroached to virtually zero level by the accumulated losses.To be specifically noteworthy, BPDB has undergone the deficits at the level of gross margin subtracting the operational expense from the operational revenue during the three years since the fiscal year of 2004/05. In 2006/07, the accumulated deficits went up to Taka 83.8 billion which is the level equal to 1.7 times of annual revenue and is beyond the capability of BPDB to restore the financial health. The prime most reason causing the slump in the business performance of BPDB rests with the low electricity tariff that can not cover the electricity supply cost.

BPDB has been faced with the serious problem of power loss incurred in its supply system. Although the steady trend of decrease is in place during recent years, the amount of the auxiliary consumption stays as high as 7% while BPDB is suffering from the aggregate system loss 16.6% if it includes the generation, transmission and distribution. The high percentage of system loss indicates the urgent necessity BPDB is confronted in reducing the loss of the precious energy reaching to the end beneficiaries. The nation-wide system loss in the power sector is followed by Power Cell of the Ministry of Power, Energy and Mineral Respurces which indicates the astonishing level of losses; the auxiliary consumption at 6.0%; transmission loass at 5.63%; distribution loss at 20.97%; making the total losses at 32.60%[1]. The statistics implies that out of the total volume generated, one third is lost before it reaches to the end-users.

3.3.2 Equity Capital Account

BPDB practiced the revaluation of assets twice in recent history, once in the fiscal year 2000 and the second time in 2007 which generated the revalued surplus of Taka 117.0 billion into the capital accounts with the effect to save the capital account going into negative balance. In addition, the government has periodically converted BPDB’s debt to the equity so that the capital account of BPDB has been kept from plunging into the deficit ridden position. While the revaluation had the effects of saving BPDB’s capital account from falling to the negative balance, it has failed to generate fresh money.

[1] Power Cell, MOPEMR, “Bangladesh Power Sector Databook”, June 2006

3.3.3 Asset Accounts

The power sector business is the one of highly capital intensive nature with a large amount of long term investment in its operational assets. At BPDB, the current assets are swollen to be a significant existence constituting a large position due to the expansion of the accounts receivable. With respect to the accounts receivable, the turnover of BPDB's account receivable stands at about 360 days though the indicator showed the sign of downtrend during the past two years. With respect to the turnover of the fixed assets against the total revenue which checks how many times the fixed assets roll over through the amount of total revenue. It is learnt that the fixed assets turned over 0.25 times at BPDB. The total assets of BPDB are swollen due to the revaluation and such fact causes the turnover at lower rate which should be much higher as the power sector of the country is suffering from the acute shortage of power due to the insufficient investment.

An attention is invited to the next important point among the asset accounts which is concerned with the depreciation. BPDB has seen its assets expanded due to the revaluation carried out in the fiscal year of 2000. From the very moment of the revaluation done, the depreciation should have been done based on the increased value of the properties. In reality, no such change has taken place in the practice of BPDB during the period of fiscal year of 2000/01 through 2005/06. The change of depreciation has been instituted only in the fiscal year of 2006/07 and the delay in the implementation of the change caused BPDB to lose the opportunity to recover the capital invested.

3.3.4 Liability Accounts

There exists an account which should never be overlooked, i.e. Debt Service Liabilities. The account represents the liabilities that had been owed but had not been met by BPDB on the due dates of both principal and interest payments. Those are the arrears accumulated with the debt service of BPDB owed to the government who borrowed the funds from the donor institutions and on-lent to BPDB. The fundamental structure of BPDB's debt service is that BPDB collects the electricity bill which covers including but not limited to the depreciation and should make payments of the principal and interest of debts out of the proceeds collected through the electricity bills. Should the tariff be set at the level that covers the cost incurred for the supply, the amounts collected through the billing should be sufficient to pay the expenses of fuel and others and make payment of principal and interest of the loans taken.

3.3.5 Ratio Analysis

One can learn the solvency of the business entity by measuring the current ratio through dividing the current assets by the current liabilities. The ratio checks whether the entity maintains sufficient liquid assets that should be appropriated to pay the liquid liabilities. The general rule of thumb for the solvency is often quoted to be 150%. BPDB used to maintain momentarily the ratios above 100% during the fiscal years 2003 through 2005 but submerged below 100% in the fiscal year of 2006. The ratio for the fiscal year of 2006/07 was 91.2%. There is a serious problem underlying before arguing the ratio calculated. The current assets that are divided by the current liabilities include the gigantic sum of the account receivable the major part of which are deemed irrecoverable. The ratio calculated, thus, needs to be discounted by a considerable margin.

Another point of concern surfaces at the calculation of debt service coverage ratio (DSCR). The ratio is calculated through the net operating income before debt service divided by the sum of loan repayment and interest paid. Against the prevailing standard for the ratio of 1.3 in general,.BPDB recorded DSCR hitting 2.2 in 2002/03. The ratio took a sharp decline starting from 2003/04 at the level of 1.1 to 0.1 in 2004/05 and went deep into the minus territory by aggravating the ratio to -0.6 in 2005/06. The ratio contains a hidden danger that cannot be identified from the outcome. Whereas the deflator of the equation needs to cover all the sums of payment of principal and interest that falls due in any particular year, BPDB appears to have relocated and hid the sums that cannot be paid for the debt services into the debt service liability account and therefore excluded them from the deflator. The ratios calculated apparently took only the amount BPDB actually paid which may or may not include any amount included in the debt service liability account during the period. What is indicated here is the fact that the actual financial condition of the entity is undoubtedly serious and needs immediate actions to cope with.

3.4 Electricity Tariff

3.4.1 International Comparison of Electricity Tariff

Bangladesh has the universal tariff which covers the entire country under one tariff system with exception of Rural Electricity Board who distributes the power in rural areas. The power tariff prevailing in the Asian countries as of 2004 are; Bangladesh: US ¢ 5.56/kWh[2]; Pakistan: US ¢ 6.98/kWh[3]; Indonesia: US ¢ 6.51/kWh; Malaysia: US ¢ 6.18/kWh; Philippines: US ¢ 11.10/kWh; Thailand: US ¢ 6.34/kWh; Vietnam: US ¢ 5.07/kWh and India: US ¢ 6.10/kWh[4]. The Philippines is way out high in comparison with the other countries while Vietnam is the lowest trailing the others. The average tariff of Bangladesh is recognized as US ¢ 5.56/kWh which is ahead of Vietnam but is lower than the countries of India, Pakistan, Thailand, Malaysia and Indonesia as the second lowest among the compared countries.

3.4.2 Electricity Tariff

In Bangladesh, entities engaged in the power sector wholesale and/or retail trades are regulated to obtain the approval of Bangladesh Energy Regulatory Commission (BERC) for the tariff of the electricity. The prevailing tariff was updated as of January 1, 2007 and has been in force ever since. BPDB submitted an application for the revision of its tariff BERC made its official announcement on the revision of wholesale tariff on September 29, 2008. BERC has made its decision to approve the increase of such tariff based on the actual cost of operation in 2007/08 by 16% to be immediately effective.

The revision of the wholesale tariff is understood to invoke the revision of the retail tariff at distribution companies. Depending upon the ultimate decision to be reached by BERC, the universal tariff might cease to exist. A new tariff regime might be created, should BERC pursue the principle of “actual cost plus reasonable margin”. As of present, BERC is stating that its policy has not been established on the issue[5].

3.4.3 Tariff Policy at Bangladesh Energy Regulatory Commission

Bangladesh Energy Regulatory Commission (BERC) has been established in 2004. The wholesale and retail tariffs at which power entities sell the electricity have to be approved by

2 DESCO, “Annual Report 2007”, 2008
3 Water and Power Development Authority of Pakistan
4 Japan Electric Power Information Center, Inc,, “Kaigai Shokoku no Denki Jigyo”, 2006

5 Interview at BERC on November 26, 2008.

BERC before they become effective. The fundamental rules and regulations that are providing BERC with the authority to regulate and rule the power sector are; 1) Bangladesh Energy Regulatory Commission Act 2003 (Act No. 13 of 2003), 2) Licensing Regulation, 3) Electric Generation Tariff Regulation 2008, The rules and regulations for establishing the electricity tariff are being prepared by BERC which includes the regulations such as; 1) Electric Generation Tariff Regulation 2008, 2) (draft) Electricity Transmission Tariff Regulation 2008, 3) (draft) Electricity Distribution Tariff Regulation 2008. Out of those three tariff regulations, the generation tariff regulation has been approved and become effective in 2008 while the other two are in the stage of draft and are yet to be approved.
The Generation Tariff Regulation sets forth the following principles in setting up the electricity tariff[6]. The power tariff is composed of "fuel charge" and "service rate charge". The fuel charge is described to the effect that the licensed power companies will earn no profit or return on the cost and the rates for fuel recovery will change on a semi-annual basis. The service tariff rate is intended to establish the tariff rates which provide the least cost to consumers while providing the opportunity for licensed power companies to earn sufficient revenues to cover all of their operating expense and providing for the continued improvement of their operating system and attract capital for investment.

3.4.4 The Electricity Tariff of Independent Power Producer (IPP)

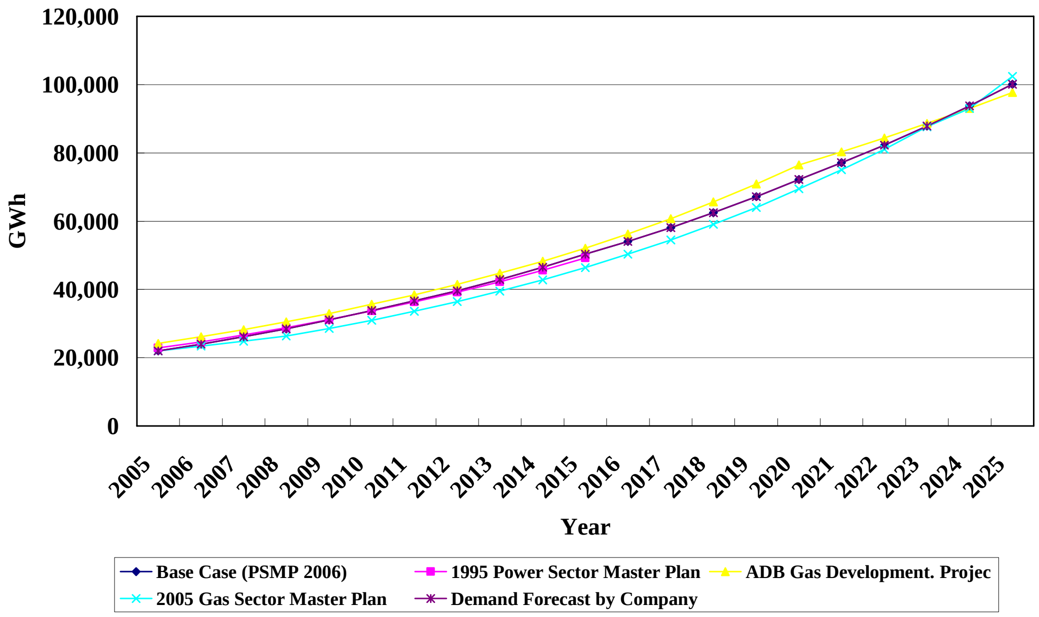
The IPPs are operating based on the long term power purchase contracts signed prior to the commencement of the projects with BPDB which governs the methodology of pricing and actual prices of power to be sold. Those contracts and the prices have been approved by the government before entering into the productive operation of their plants. All the electricity generated by IPPs is sold to the single buyer, BPDB. The average billing rate of BPDB is Tk 2.26/kWh for the fiscal year of 2006/07. In general, IPPs are approved for higher tariffs and higher plant factors. Based on those terms of the contract, they operate as the base load supplier while they are required to maintain their plants operative without any breaks at all times with the exception of the scheduled and agreed maintenance periods. The management of IPPs is carried out in confrontation with those pressures for constant operation.

[6] Bangladesh Energy Regulatory Commission, "Bangladesh Energy Regulatory Commission Electric Generation Tariff Regulation 2008"

Chapter 4 Technical Feasibility of the Project

4.1 Power Demand Forecast

Figure I-4-1-1 shows approximation curves which show power demand forecasts of Power System Master Plan in 1995, the ADB Gas Development Project, 2005 Gas Sector Master Plan and a company of BPDB, DECO, DESCO and PSMP 2006, and those curves show approximately same trend. Therefore, the power demand forecast in PSMP 2006 is proper and justified.



(source) PSMP 2006

Figure I-4-1-1 Comparison of Power Demand Forecast

4.2 Benefits

4.2.1 Electrification rate

Construction of the Bheramara Combined Cycle Power Plant (hereinafter referred to as "Bheramara CCPP") in the western zone (Khulna, Rajshai and Barisal Division) currently suffering from a power supply shortage will contribute to stable power supply in the western zone.

It will also improve the electrification rate in the western zone.

It is estimated that construction of the Bheramara CCPP is expected to achieve electrification of about 1,900,000 general households in the western zone.

Electrification rate of households in the western zone after operation of Bheramara Power Station shall be from 21.93% to 39.50%.

4.2.2 Benefits to Accrue in the Industrial Sector

Bangladesh is plagued with the acute power shortage which causes the load shedding both scheduled and unscheduled. In addition, the fluctuation of voltage is rampant and volatile and the industrial sector is suffering from the negative impact of significance. The Power Sector Master Plan Update conducted in 2006 reveals that the power demand was recorded as 3,925MW in the fiscal year of 2004 whereas 461MW of electricity was shedded representing 12% of the maximum demand[1] and the total volume of energy lost from the opportunity was 221GWh, being equivalent of 11% of the total volume of electricity generated. The volume of the energy lost for 221GWh due to load shedding in the fiscal year 2004 can be valued as Tk 716 million at the rate of Tk 3.24/kWh which used to be the average selling price of power by DESCO[2], the representative power distributor for the year of 2004. While the GDP used to stand at Tk 3,329.7 billion for the year of 2004, the energy lost is calculated to be equivalent of 0.2% of the country's GDP.

More recently, Transparency International Bangladesh has made a sampling survey[3] covering 1,027 consumers (corporate and individuals) over the impact of the power shortage and the quality of power. From the survey of the industrial sector, it has been learnt that out of the sample beneficiary industries, 39% has responded that they have suffered from the inferior quality of power in such manner that the fluctuating voltage has caused damages to the productive equipment. In the ready made garment industry, it has been reported that 90% of the industrial concerns were to suffer from the disruption of the operation for producing the export products due to the power failures. It has been also reported that they should have been able to produce approximately 5% more than what has been actually produced, should there have been no load shedding. The value of the loss of production has been estimated to be approximately Tk 18.2 billion and the damages caused to the machinery has been approximately US$ 1.7 billion.

The Bheramara CCGT Project is planned to operate as the base load supplier, a significant portion of the power shortage mentioned above will be covered by the project and the economic loss caused by the load shedding should be mitigated by a considerable extent.

4.3 Power Generation Development Planning

4.3.1 Existing power generation facilities

In Bangladesh, the deleted generation capacity as of July 26, 2008 is 4830 MW including the IPPs. All power output is provided by thermal power plants, except for 230 MW the Karnafuli hydro power plant.

4.3.2 Current Situation of Demand – Supply Balance

Looking demand – supply balansce on July 26, 2008, the generation at the time of maximum demand is only 3376 MW although deleted generation capacity is 4830 MW. To examine the reason, the shutdown of the power plant resulting from maintenance or trouble corresponds to 603 MW, on the other hand, the shortage of gas supply corresponds to 664 MW. This suggests that a shortage of gas supply in Bangladesh is very serious. On same day, the load shedding of 825 MW occurred at the time of maximum demand at 20:00. Should the aforementioned gas supply shortage problem be solved, there is still a shortage of electric power generating capacity of 161 MW. This requires quick action to be taken to launch a new power generation

[1] Power Cell, "Power System Master Plan Update", June 2006
[2] DESCO, "Annual Report" 2007
[3] Transparency International Bangladesh, "The State of the Governance in the Power Sector of Bangladesh", November, 2007

development project.
Further, 80 percent of the power plants in Bangladesh are concentrated in the eastern zone close to the natural gas filed. This requires power transmission of about 200 to 300 MW from east to west. Thus, from the viewpoint of system operation, power generation development in the western zone is an urgent necessity.

4.3.3 Power Generation Development Planning

BPDB is working out power generation development planning according to the demand assumption of the basic case carried out in PSMP 2006. In the meantime, as discussed in Section 4.5, outlook of gas supply for the future power plant is unclear due to a delay in gas development. The Government of Bangladesh has worked out a policy for screening of a gas-fired thermal power plant construction plan and for cancellation of construction of a gas-fired thermal power plant after Bheramara CCPP.
Bangladesh is facing retirement of some plants and cancellation or delays of the major power plants construction project. If the Bheramra CCPP Project is financed by Japanese ODA Loan and the commercial operation date will start as planned, the Project will make a significant contribution to secure generation capacity in Bangladesh.

Table I-4-3-1 Balance of Power Demand and Supply

	2008	2009	2010	2011	2012	2013	2014
Power Peak Demand (PSMP Base Case) / MW	5569	6066	6608	7148	7732	8364	9047
Planned Generation Capacity / MW	4830	5409	5709	6159	6684	7284	8394
Capacity Shortage / MW	-739	-657	-899	-989	-1048	-1080	-653

（source）Study Team makes from Power System Master Plan Update 2006

4.4 Power System Planning

4.4.1 Transmission and substation facilities owned by PGCB

Power Grid Company of Bangladesh Ltd. (PGCB) is in charge of grid planning, construction, operation and maintenance in Bangladesh. Voltage of transmission system is 230kV, 132kV and 66kV at present, and the voltage of Meghnahat – Aminbazar transmission line, which will be constructed in the future, is planned to be 400kV.
In addition, Figure I-4-4-1 shows the grid map of PGCB.
Electric power flows from eastern zone to western zone at present, because almost all power stations locate in the eastern zone of Bangladesh.

Figure I-4-4-1 Grid map

4.4.2 Transmission facilities related to this project

The survey and study of the items related to 230kV line near this project site, new 230kV Bheramara substation and existing 132kV Bheramara substation were carried out.

(1) Present situation of construction of transmission line

Figure I-4-4-2 shows the plan of connection of new Bheramara substation with 230kV transmission line.

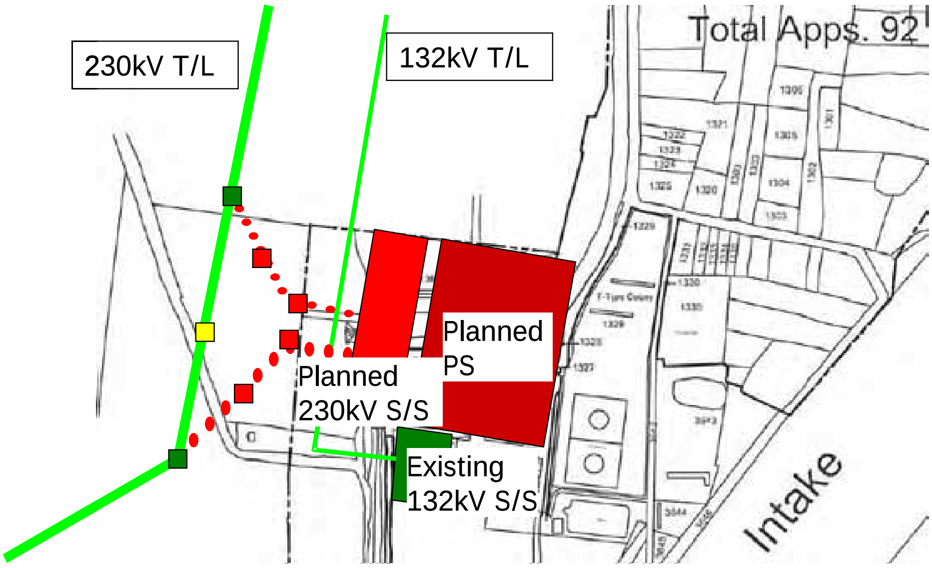


Figure I-4-4-2 Overview of transmission system around Bheramara substation

4.4.3 System analysis

The results of system analysis at the operation year of Bheramara power station were confirmed. PGCB uses the software prepared by CYME INTERNATIONAL for the power system.

(1) Power flow and voltage analysis

230kV line, which is under construction at present, is connected with new power plant (substation). Following table shows the case of one line fault (N-1) in order to confirm the transmission capacity. Because the thermal capacity of new power station is not determined, expected maximum thermal capacity (575MW), which is severe for transmission capacity, is applied for this study.

Case	Fault location
1	230kV Bheramara S/S - 230kV Jhndh S/S
2	230kV Bheramara S/S - 230kV Ishudri S/S
3	230kV Bheramara S/S - 132kV Bheramara S/S
4	230kV Bheramara S/S - Bheramara CCPP
5	230kV Ishudri S/S - 230kV Baghabari S/S
6	230kV Ishudri S/S - 230kV Ghorasal S/S

As a result, it was confirmed that the fault location between 230kV Bheramara S/S and 230kV Ishudri S/S was most severe case, and that the power flow was 184MW. This amount is less than 60% of transmission capacity (322MW), and it is confirmed that the transmission capacity is enough for power flow.

In addition, it was confirmed that voltage was satisfied with the criteria (between -10% and +10%).

(2) Fault current analysis

It was confirmed that maximum fault current at each substation was less than maximum allowable current of circuit breaker.

(3) Dynamic stability analysis

Dynamic simulation was carried out in order to confirm the effect of the accident of Bheramara power station. It was confirmed that the result was the same as the effect occurred by the accident of other power station.

4.5 Fuel Supply Planning

4.5.1 Gas production volume and forecast of gas reserve

Table I-4-5-1 shows the gas production volume in Bangladesh as of June 2008, gas production volume during the period from 2008 through 2020, and the forecast of gas reserve by fiscal year 2020.

The remaining reserve (P1+P2) of IOC-2 and IOC-3 is not verified by Petrobangla. Thus, total of gas reserve in Bangladesh in fiscal year 2020 is total of Petrobangla and IOC-1.

Table I-4-5-1 Gas production volume and forecast of gas reserve (unit: Bcf)

Company		Recoverable (P1+P2)	Cumulative Production (June 2008)	Remaining Reserve (P1+P2)	Production (2008 - 2020)	Remaining Reserve (P1+P2) (2020)
Petrobangla	BGFCL	10,876.0	5,374.1	5,501.9	4,726.0	775.9
	SGFL	3,476.0	914.8	2,561.2	1,799.0	762.2
	BAPEX	1,015.0	105.3	909.7	1,220.0	-310.3
IOC-1	CHEVRON	3,687.0	732.9	2,954.1	2,966.0	-11.9
	CAIRN	500.0	439.7	60.3	40.0	20.3
	TULLOW	305.0	47.3	257.8	274.0	-16.2
	NIKO	603.0	86.6	516.4	75.0	441.4
IOC-2	Block-5,7,10	0	0	0	621.0	0
	Block-16	0	0	0	329.0	0
	Block-17,18	0	0	0	274.0	0
IOC-3		0	0	0	949.0	0
Total		20,462.0	7,700.7	12,761.4	13,273.0	1,661.4

(source) Petrobangla (July, 2008)

4.5.2 Forecast of gas supply volume and gas demand

Table I-4-5-2 shows the forecast of gas supply volume during the period from 2008 through 2020 in Bangladesh.

Table I-4-5-2 Forecast of gas supply volume (Daily maximum supply volume, unit: mmcfd)

Company		2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Petrobangla	BGFCL	782	817	907	976	1,090	1,079	1,091	1,100	1,100	1,095	1,095	1,095
	SGFL	180	190	222	280	320	350	430	480	540	590	590	590
	BAPEX	53	112	185	230	260	328	348	345	365	364	363	363
IOC-1	CHEVRON	830	760	740	710	680	650	620	590	540	480	420	370
	CAIRN	50	0	0	0	0	0	0	0	0	0	0	0
	TULLOW	100	100	60	60	60	60	60	60	60	60	0	0
	NIKO	45	45	55	55	75	75	50	50	50	50	50	50
IOC-2	Block-5,7,10	0	0	0	100	200	200	200	200	200	200	200	200
	Block-16	0	0	0	100	100	100	100	100	100	100	100	100
	Block-17,18	0	0	0	0	50	100	100	100	100	100	100	100
IOC-3		0	0	0	0	0	0	300	300	500	500	500	500
Total		2,040	2,024	2,169	2,511	2,835	2,942	3,299	3,325	3,555	3,539	3,418	3,368

(source) Petrobangla (July, 2008)

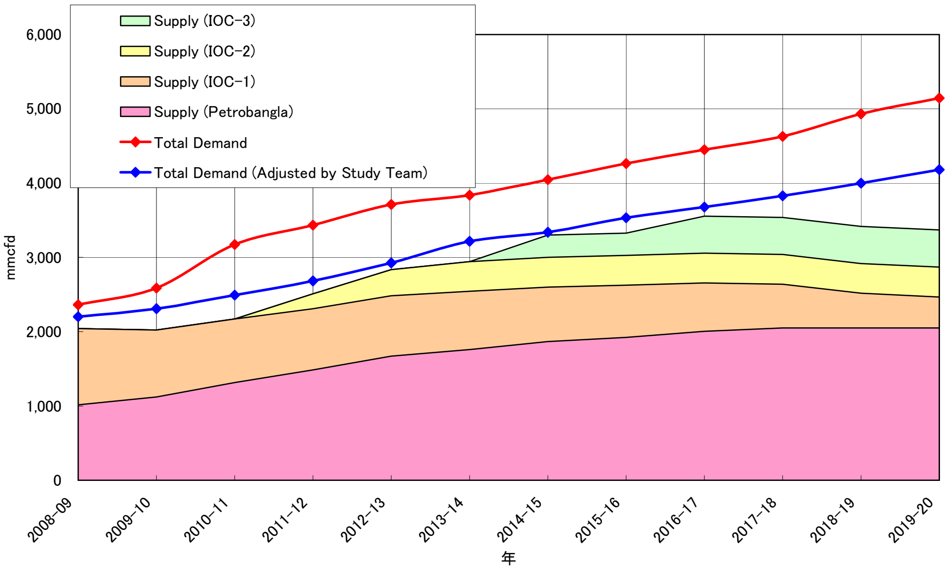
Table I-4-5-3 shows the gas demand forecast in Bangladesh during the period from 2008 through 2020.

Table I-4-5-3 Forecast of gas demand volume (Daily maximum demand volume, unit: mmcfd)

Company	Category	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
BGSL	Power	138.3	148.3	183.3	218.3	218.3	218.3	218.3	218.3	218.3	218.3	218.3	218.3
	Captive	29.6	32.0	34.5	37.3	40.3	43.5	47.0	50.7	54.8	59.2	63.9	69.0
	Fertilizer	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0
	Non-Bulk	122.7	132.5	143.1	154.6	166.9	180.3	194.7	210.3	227.1	245.3	264.9	286.1
	Sub-total	410.6	432.8	480.9	530.2	545.5	562.1	580.0	599.3	620.2	642.8	667.1	693.4
JGTDSL	Power	136.7	166.7	241.7	205.7	205.7	205.7	205.7	205.7	205.7	205.7	205.7	205.7
	Captive	5.8	6.2	6.7	6.9	7.0	7.2	7.4	7.6	7.8	8.0	8.3	8.5
	Fertilizer	15.0	15.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
	Non-Bulk	33.5	36.2	39.1	42.2	45.6	49.2	53.2	57.4	62.0	67.0	72.3	78.1
	Sub-total	191.0	224.1	312.5	279.8	283.3	287.1	291.3	295.7	300.5	305.7	311.3	317.3
PGCL	Power	85.0	85.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0	200.0
	Captive	4.0	4.8	5.8	6.9	8.3	10.0	11.9	14.3	17.2	20.6	24.8	29.7
	Fertilizer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.0	70.0	70.0	70.0	70.0
	Non-Bulk	11.0	13.2	15.8	19.0	22.8	27.4	32.9	39.4	47.3	56.8	68.1	81.7
	Sub-total	100.0	103.0	221.6	225.9	231.1	237.4	244.8	323.7	334.5	347.4	362.9	381.4
TGTDCL	Power	757.0	863.0	982.0	1147.0	1162.0	1179.0	1270.0	1288.0	1331.0	1356.0	1493.0	1523.0
	Captive	198.1	213.9	231.0	249.5	269.5	291.0	314.3	339.5	366.6	395.9	427.6	461.8
	Fertilizer	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0	155.0
	Non-Bulk	551.4	595.6	643.2	694.7	750.2	810.3	875.1	945.1	1020.7	1102.3	1190.5	1285.8
	Sub-total	1661.5	1827.5	2011.2	2246.2	2336.7	2435.3	2614.4	2727.6	2873.3	3009.2	3266.1	3425.6
SGCL	Power	0.0	0.0	135.0	135.0	298.0	298.0	298.0	298.0	298.0	298.0	298.0	298.0
	Captive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fertilizer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Non-Bulk	0.0	0.0	14.0	15.1	16.3	17.6	19.1	20.6	22.2	24.0	25.9	28.0
	Sub-total	0.0	0.0	149.0	150.1	314.3	315.6	317.1	318.6	320.2	322.0	323.9	326.0
Total Demand		**2363.1**	**2587.4**	**3175.2**	**3432.2**	**3710.9**	**3837.5**	**4047.6**	**4264.9**	**4448.7**	**4627.1**	**4931.3**	**5143.7**

(source) Petrobangla (July, 2008)

Lastly, Figure I-4-5-1 shows a summary of the gas supply and demand forecast.
MoPEMR readjusted that postpone of gas supply for new gas thermal power plant as shown on Table I-4-5-4. The forecast of gas demand for electric power (line: total demand (adjusted by Study Team)) according to this readjustment, the forecast of gas supply is slightly lower than the forecast of gas demand when Bheramara CCPP will be commercial operation in the vicinity of 2014 if all the supply plans of Petrobangla, IOC-1, IOC-2, and IOC-3 have been achieved. This forecast of gas demand indicates maximum gas demand. Thus, it is hard to say that there is shortage of gas supply at any time and if the gas could be supplied to efficient thermal power plants when peak of gas demand, the Study Team deems that it is possible to supply gas for Bheramara CCPP.



(source) Petrobangla (July, 2008)
(Total Demand (Adjusted by Study Team) was made be the Study Team)

Figure I-4-5-1 Forecast of gas demand and supply

Table I-4-5-4 Period of gas supply for new gas thermal power Plant

No.	Generating Station	Type of Fuel	Expected Commissioning date by BPDB	Revised Commissioning date by MoPEMR	Gas Demand (mmcfd)
1	Sikalbaha 150 peaking Power Plant	Gas	FY 2009	FY 2012	35
2	Siddhirganj 2x120 MW peaking power Plant	Gas	FY 2008	FY 2008	65
3	Khulna 150 MW Peaking PP	Gas/Oil	FY 2010	FY 2013	35
4	Sirajganj 150 MW Peaking Power Plant	Gas	FY 2010	FY 2013	35
5	Chandpur 150 MW CCPP	Gas	FY 2010	FY 2012	30
6	Sylhet 150 MW CCPP	Gas	FY 2010	FY 2010	30
7	Haripur 360 MW CCPP	Gas	FY 2012	FY 2014	55
8	Siddhirganj 2x150 MW peaking power Plant	Gas	FY 2010	FY 2014	70
9	210 MW Khulna Thermal Power Station	Gas/Oil	FY 2011	Cancel	
10	Bheramara 360 CCPP	Gas	FY 2012	FY 2016	55
11	Bhola 150 MW CCPP	Gas	FY 2011	FY 2012	30
12	Bibiana 450 MW CCPP IPP	Gas	FY 2010	FY 2011	75
13	Sirajganj 450 MW Combined Cycle IPP	Gas	FY 2010	FY 2013	75
	Total				590

(source) MoPEMR (August, 2008)

4.5.3 Gas pipeline construction project

Much of the gas being produced in Bangladesh is located in the northeastern region. Thus, when the ADB financed gas pipeline is used to transport the gas produced in the northeastern region to the western or southwestern region where Bheramara CCPP is located, gas pressure may be reduced because of the pressure loss of the gas pipe line, and gas may not be easily supplied to the gas consumers including the Bheramara CCPP.
To solve this problem, the ADB loan includes the plan of constructed gas compressors in Ashuganj and Elenga so as to solve the problem of insufficient gas supply pressure.
It has been confirmed that construction of the gas pipe line (up to Khulna) and gas compressors will be completed by 2011.

4.5.4 Possibility of gas supply to the Bheramara CCPP

As indicated in section 4.5.2, since there is concern about insufficient gas supply in Bangladesh, the Study Team make a judgment that it is necessary to ensure stable gas supply to the Bheramara CCPP which is planned to commence commercial operation in 2014, the Government of Bangladesh should set up a policy as followings.

- Exploration and development of new gas fields should be accelerated.
- Gas should be supplied to efficient thermal power plants, especially CCPP with priority.
- Old and low efficient gas thermal power plants should be stopped, if required after the high efficient thermal power plants such as Haripur and Bheramara CCPPs will be put into operation.
- A long term agreement stipulated minimum gas supply should be signed.

4.5.5 Supply of fuel oil to Bheramara CCPP

The Bheramra CCPP will use HSD for emergency not in a continuous from technical and economical points of view as followings and described on section 4.7.1;

- Bangladesh Petrouleum Corporation (BPC) should import more HSD from abroad. (2,000 KL/day x 365 days = 730,000 KL/year)
- BPC should prepare tanker for importing HSD.
- BPC should construct HSD storage tank in Khulna.
- The railway company should upgrade (40 kL x 25 vehicles x 2 trains = 2,000 kL) the existing railway for transportation of HSD from Khulna to Bheramara CCPP.
- Two (2) Large HSD storage tanks having a capacity of 50,000 kL and HSD unloading facilities should be constructed at Bheramara CCPP.
- It is necessary to huge investment for above-mentioned.

4.6 Site conditions

4.6.1 General

The Project site is located approximately 150km northwest from Dhaka, adjacent to north boundary of the existing Bheramara Thermal Power Plant approximately 20km northwest from Kushtia City, the capital of the Kushtia district in the Khulna administrative division of western Bangladesh.
Normally the climate of the Bheramara area is tropical with a mild winter from October to March (dry season), a hot, humid summer from March to June. A warm and humid monsoon

season lasts from June to October (rainy season) and supplies most of the rainfall. Based on the data at the meteorological observatory in Ishwardi, the average high temperature is 36.5°C in May and the average low is 8.2°C in January. Annual rainfall average is 1,506 millimeters.

4.6.2 Site Planning

As shown in the Figure I-4-6-1, two (2) candidate sites of SITE-A and SITE-B are nominated for the construction of new power plant. SITE-A is situated close to north boundary of the existing Bheramara Thermal Power Plant. SITE-B is situated north east side between the existing oil tank yard and the right bank of Padma River. The comparison of 2 candidate sites is shown in the Table I-4-6-1.

Table I-4-6-1 Comparison of 2 sites

	SITE-A	SITE-B
Cost (Construction)	Base	Same
(Transmission Line)	Connecting line to the existing line is shorter.	Connecting line to the existing line is longer.
(Gas Pipeline)	Connecting line is shorter.	Connecting line is longer.
Economical (Compensation)	BWDB and BPDB Land acquisition is not necessary	BWDB and BPDB Land acquisition is not necessary, but compensation for relocation of long term
Technical (Area)	Enough area for construction, but limited free hand for site layout	Enough area for construction, and free hand for site layout
Environment (Terrestrial Ecosystem)	Base	Same
(Residents)	8 families live in quarters. They are staffs of existing power station and not farmer.	72 families live on the site. Almost all of them lost houses caused by flood or something and are not farmer.
Conclusion	selected	

SITE-A is more efficient from economical point view, and is free from relocation of the socially vulnerable residents, which is serious issue from environmental point of view. From technical point of view, there is no significant difference between SITE-A and SITE-B, therefore, SITE-A was selected for the construction site.

Figure I-4-6-1 Site Boundary

4.6.3 Topography and Soil Conditions

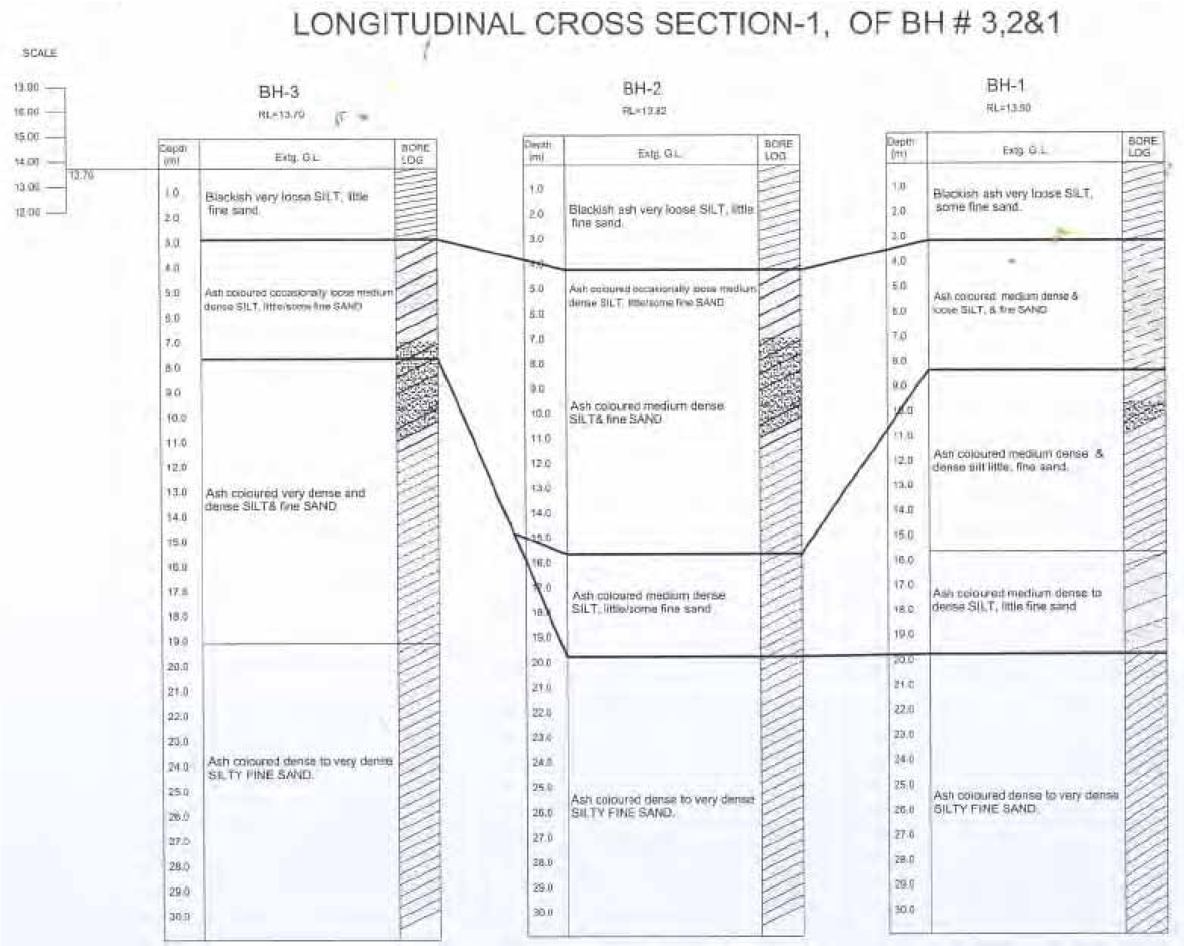
(1) Topographic Survey

Surveyed ground levels are following;

Existing power station area:	approximately between EL+15.1m and EL+15.9m
Surrounding farmland:	approximately between EL+13.0m and EL+13.8m
Toward the bank of Padma River:	approximately between EL+13.7m and EL+14.5m

(2) Soil Conditions

Due to non-plastic behavior and non cohesive nature of the investigated soil throughout the depth of 30.0 m, Unconfined Compression Test could have not been performed. However, the soil of the site is typical Quaternary sand sediments. The non-cohesive sand-silt mix and silty fine sand have been observed in a dense state from the depth of 20m. The power plant structures such as Power House and others could be constructed with pile foundation supported by this dense layer.



4.6.4 Water Source

(1) Hydrological and morphological data of Padma River

Hydrological and morphological data of Padma River has been corrected by BWDB at Harding Bridge and crossing line of RMG-13 shown in the Figure I-4-6-2.

Figure I-4-6-2 Bheramara site and Padma River

Figure I-4-6-3 shows the water level at Harding Bridge between 1976 and 2006.
In generally, the Padma River starts rising at the-end of June and attains its peak level in August or September, with a corresponding increase in its sediment load in the period. After mid November, water level in the Padma River becomes lower, and naturally very little sediment is borne by the river during the season.
Water levels of Padma River at Harding Bridge are following;

LLWL = EL+4.22 m
LWL = EL+5.47 m*
MWL = EL+8.74 m*
HWL = EL+13.63 m*
HHWL = EL+15.19 m
(*: average between 1976 and 2006)

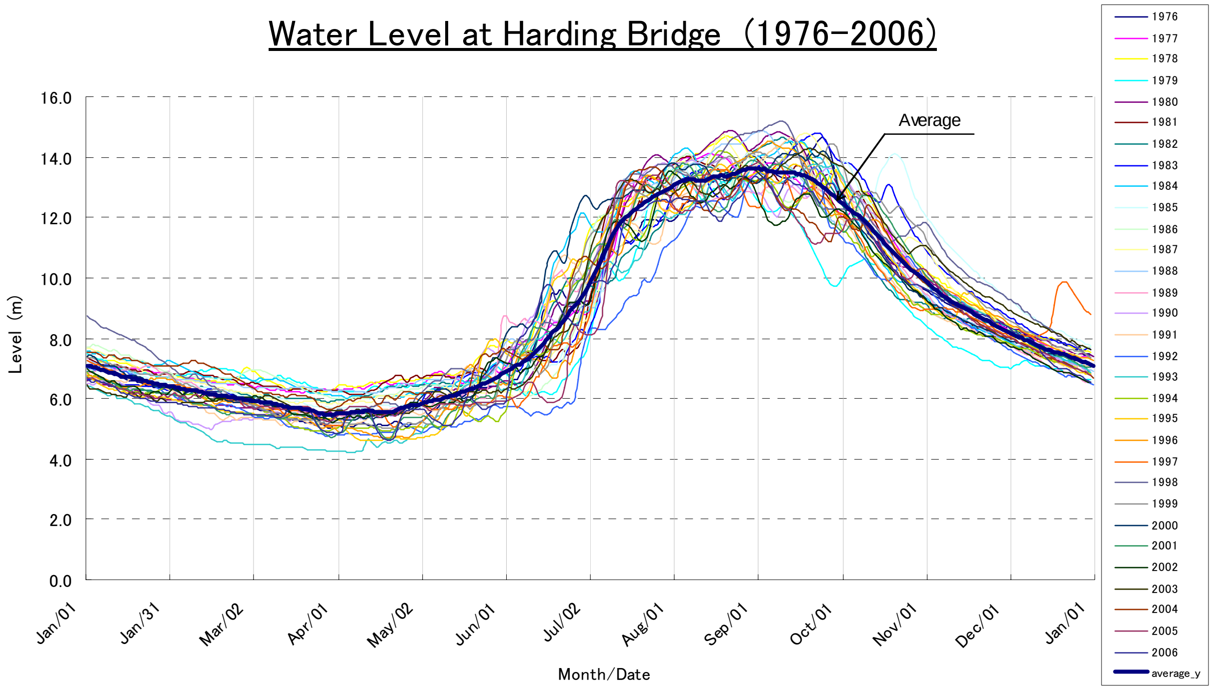


Figure I-4-6-3 Water level at Harding Bridge

Figure I-4-6-4 shows the bed elevation of Padma River at cross section of RMG-13. The bed elevation has been measured almost once a year during dry season.

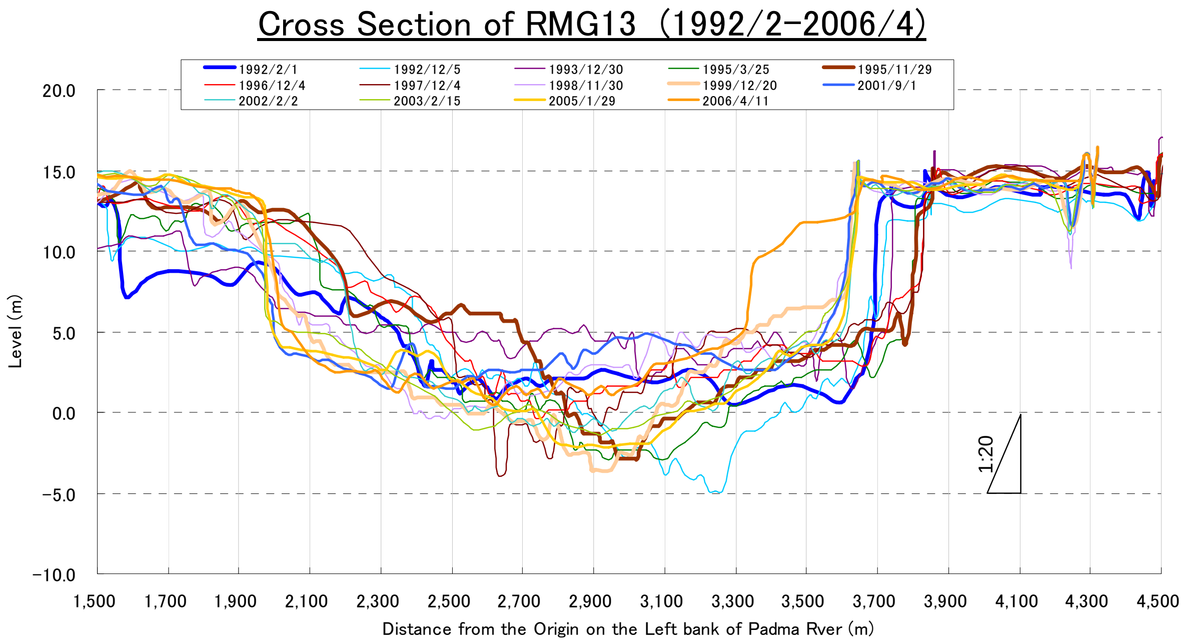


Figure I-4-6-4 Bed elevation of Padma River at cross section RMG13

(2) Ground water Investigation

Ground water may be pumped up to secure the makeup water for the cooling tower, therefore, in order to obtain information on the baseline situation of aquifer condition present in the site area and assess any impact on the existing wells by long-term constant pumping, ground water investigation/study was conducted.

1) groundwater investigation

Groundwater investigation with a set of one 100m pump well and twelve 100m observation wells was conducted.

Groundwater investigation includes the following physical works:

- Test drilling and analysis
- Drilling, installation and development of pumping well and observation wells
- Geo-electrical logging of borehole
- Recording of pumping test (continuous pumping test of 72 hours duration and recovery)
- Evaluating results

Aquifer of the site area was determined by sieve analysis of drilled samples from pumping well and observation wells and also electrical logging.

Longitudinal cross sections of aquifer W-E direction is shown in the Figure I-4-6-5.

The cross sections reveal two hydrostratigraphic units up to the drilling depth of approximately 100m. The upper aquitard is the top unit, which is composed of clay, silty clay and sandy clay. The thickness of this unit is approximately 6.5m of average (3m-12m). The aquifer unit lies below the upper aquitard and continues up to the drilling depth. The upper part of the aquifer unit is composed of finer sand fractions up to the depth of approximately 40m of average (25m-55m). The main part comprises interlayer of medium to fine sand and fine to medium sand with occasional coarse sand up to the depth of approximately 90m of average (80m-more than 100m) and gravel at the bottom part.

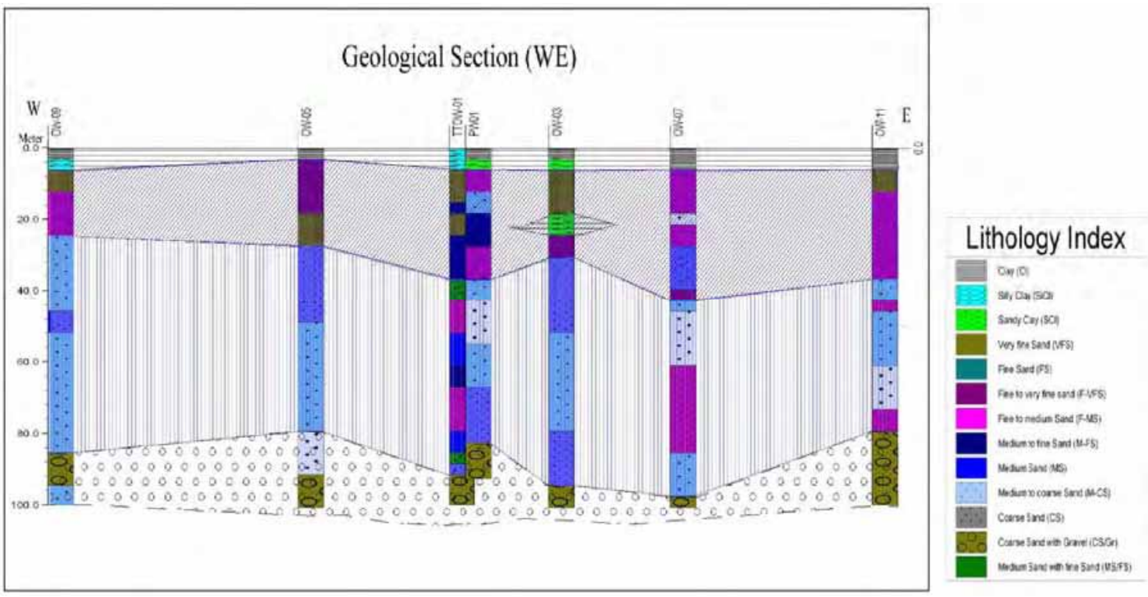
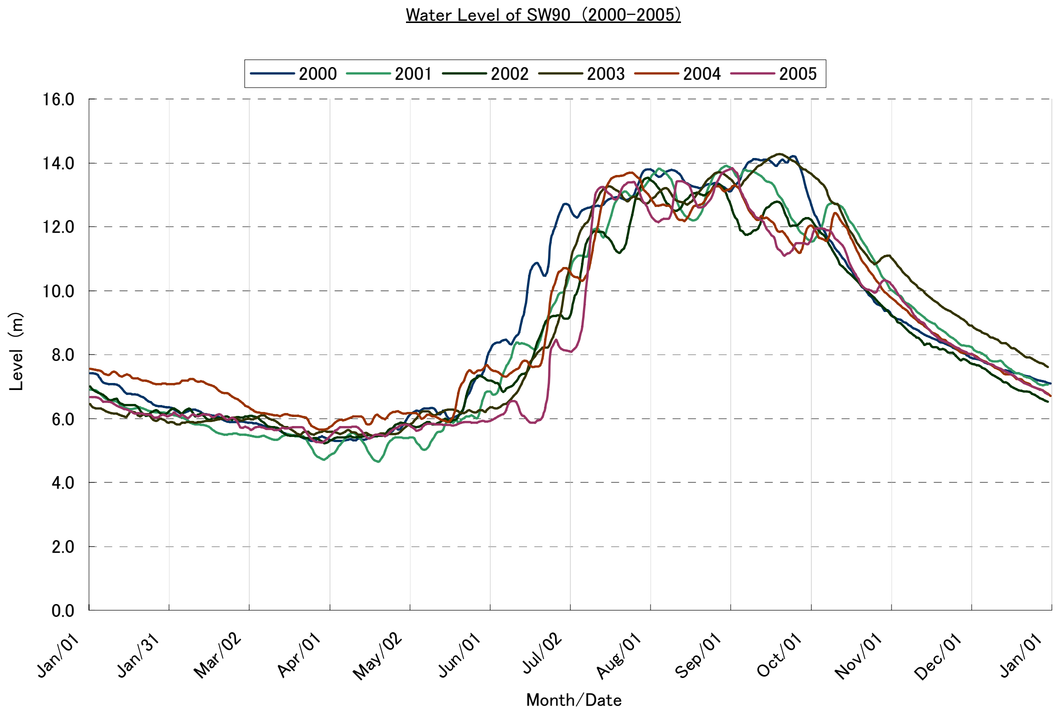


Figure I-4-6-5 Longitudinal cross section (W-E)

The Allen's sedimentary facies model shows that point bar sequence of meandering river comprises a fining upward sequence. At the bottom gravels are deposited, then gradually coarse sand, medium sand, fine sand, and very fine sands are deposited. Clay layer is only deposited on the surface. The cross section shows the above typical meandering river model sedimentation. Therefore, it is very unlikely that significant land subsidence will occur due to slight lowering of groundwater table at the site area.

The hydraulic conductivity of unconsolidated fine sand ranges from $2x10^{-7}$ to $2x10^{-4}$ m/s and that of gravel ranges from $3x10^{-4}$ to $3x10^{-2}$ m/s (Domenico and Schwartz 1990). In the project area the average horizontal hydraulic conductivity (Kh) of the aquifer is found to be 42.5 m/d ($\approx 5\times10^{-4}$ m/s). This value is acceptable because this value is well within the range of fine sand to gravel by which the aquifer is composed.

Reference groundwater table of Well No. KTA-7, which is at the West side of the office of the Executive Engineer, O&M (Pump Station) Division of BWDB (About 3km away from G.K. Pump Station), and Padma River water table are shown in the Figure I-4-6-6. This figure shows that river water level and ground level are well related.



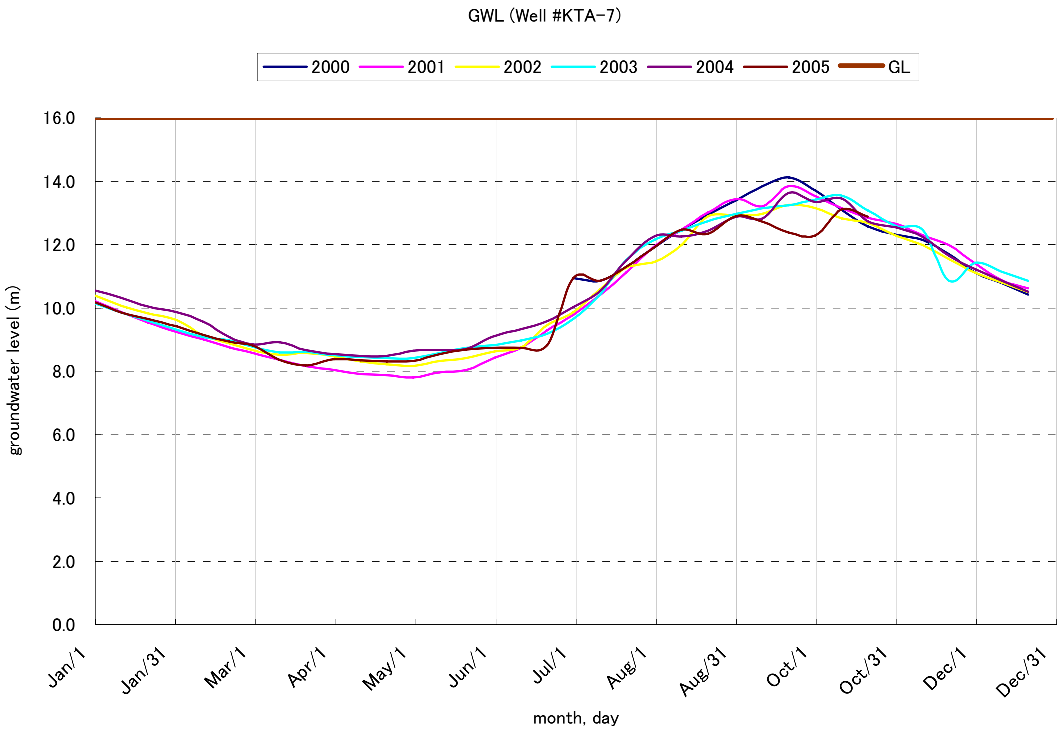


Figure I-4-6-6 Groundwater table of Well No. KTA-7 and Padma River water level

Water table contour maps for dry season has been drawn for the site area based on the water level monitoring data of observation wells including KTA-7.
In the dry season (April or May) water level elevation reaches to the minimum. Figure

I-4-6-7 gives the water table contour map of minimum elevation. The lowest elevation of water level generally occurs in wells nearer to the river.

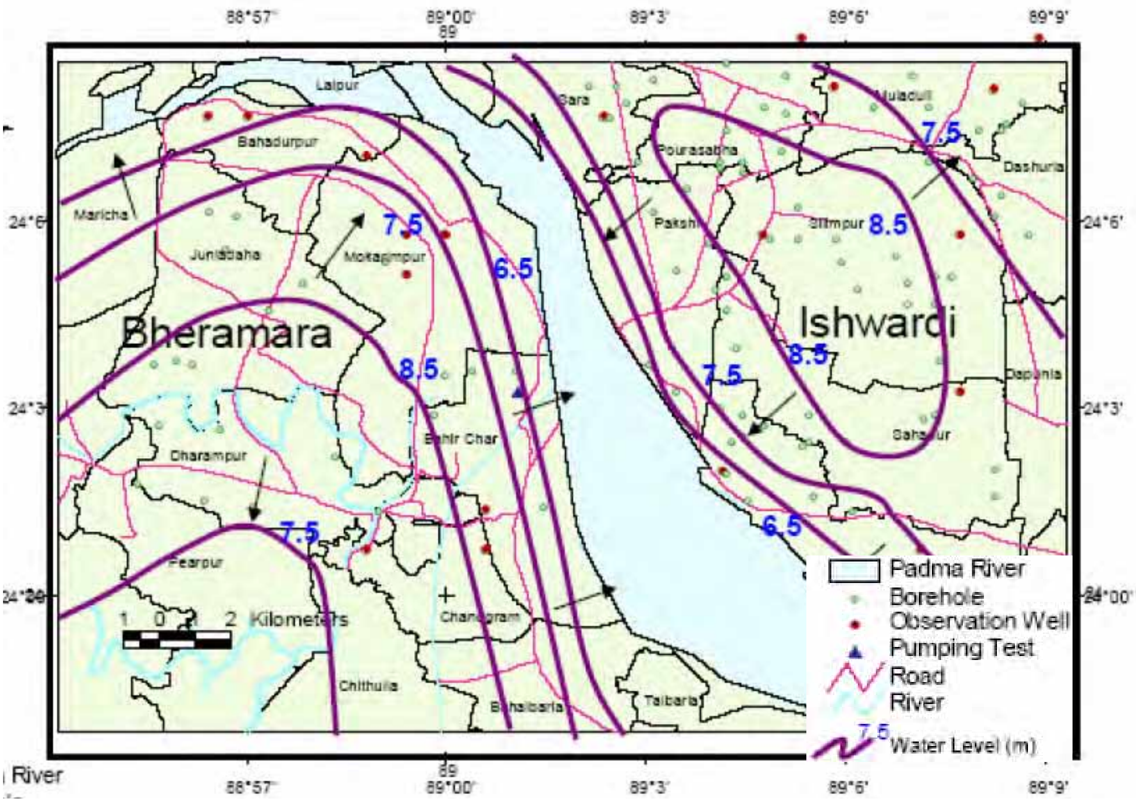


Figure I-4-6-7 Groundwater table contour map of minimum elevation (dry season)

2) existing tubewell survey

Existing tubewell survey was conducted in Bahirchar union.

Following three (3) types of tubewells are running in the union.

- Hand tubewell (HTWs) :
  approx. 0.3*l*/s (0.02m^3/m) of discharge rate, 8-16m of depth and for domestic potable water
- Shallow tubewell (STWs) :
  approx. 15*l*/s (0.9m^3/m) of discharge rate, 40-50m of depth and for irrigation
- Deep tubewell (DTWs) :
  approx. 160m^3/m of discharge rate, 90-100m of depth and for irrigation

HTWs could not suction more than one atmospheric pressure (10m water height) in principle and could operate only in suction limit of approximately 7.5m. Figure I-4-6-7 shows that groundwater table in dry season almost reaches the suction limit of hand tubewell. However, No HTWs which could not suction in dry season was found by this survey.

3) groundwater study

The objective of this study is to assess the potentiality of the aquifer system of Bheramara Upazila and surrounding areas to provide a continuous supply of 1,300m^3/hr for makeup water for the cooling tower. Groundwater models are generally used to determine the potentiality of development of any aquifer. The basis for modeling three dimensional groundwater flow forms the integrated modeling package MODFLOW. This is a generalized tool with comprehensive applicability range usable to accommodate the hydrological conditions can be visualized in cross-section or plan view at any time during the development of the model or displaying of the results.

A modeling study has been conducted using MODFLOW model with some of the readily available data of the investigated area. Model geometry was prepared using borelogs of the study area. Aquifer properties were determined by analyzing the pumping test data as mentioned the above and were assigned to the aquifer layers. River boundary, recharge and evapotranspiration boundaries were set up using estimated values. Model calibration was also made using observation well data of well KTA 7. The preliminary model was then used to predict the water level and groundwater conditions after 20 years of pumping at a rate of 31,200 m^3/day.

Modeled dry season (May) water table contour map of the study area after 20 years of pumping is shown in the Figure I-4-6-8.

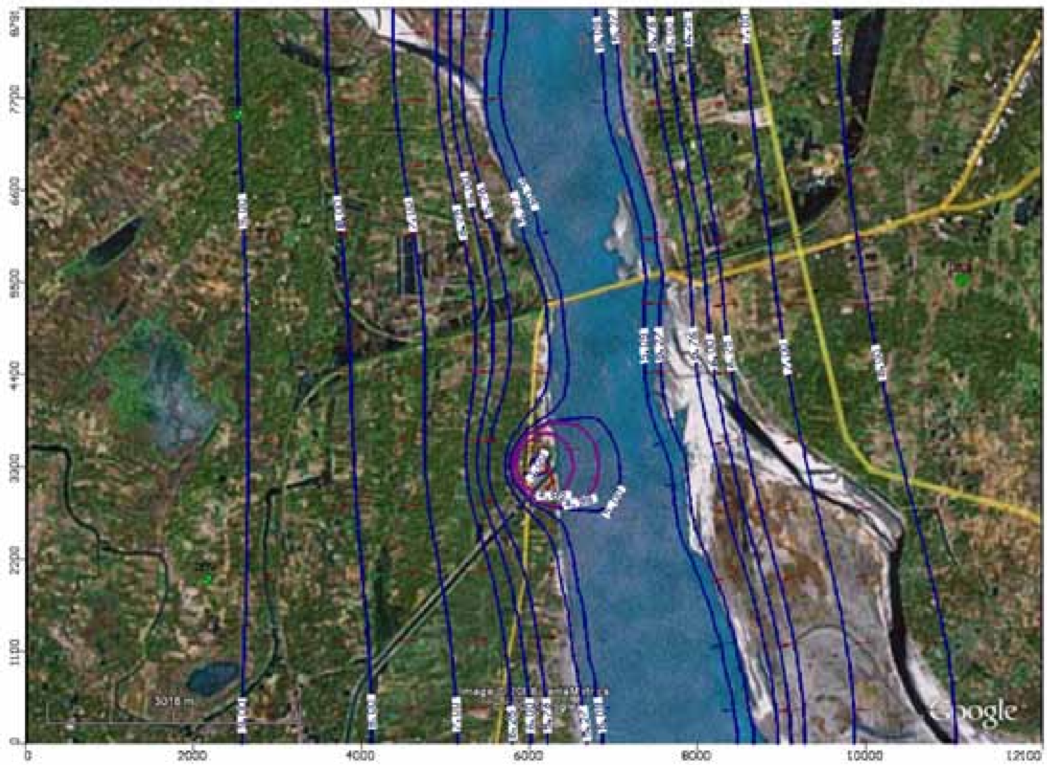


Figure I-4-6-8 Modeled dry season (May) water table contour map

4) findings from groundwater investigation

The preliminary study, which was done based on the invested hydraulical conditions of quifer, suggests that the natural aquifer condition in the study area may be suitable for supplying 31,200 m^3/day (=1,300m^3/hr x 24hr/day) of required makeup water for the cooling tower continuously without massive lowering of groundwater table and environmental degradations. Padma River contributes significantly in recharging the aquifer in each year.

The deep well layout study to minimize any impact on existing tube wells and the ground water study based on the above optimum layout were described in Section 4.7.4 Selection of Cooling System (2) Study on Water Intake for Cooling Systems.

Finally, determination of hydraulical conditions of aquifer based on the groundwater investigation result and whole process of groundwater study including modeling, input data/condition and output were reviewed by an expert in field of groundwater hydrology

(Ph. D.). The expert concluded that the above investigation and study could be acceptable. Detailed result of the groundwater investigation/study is shown in the Attachment 2 of Groundwater investigation report and Attachment 3 of Groundwater study report.

4.6.5 Site Environment

Environmental conditions such as ambient temperature, humidity, rainfall, wind direction and wind speed are necessary data for designing of the power plant. In the Study, such data were corrected through document research and were described in Sub-section 7.1.2.
Furthermore, in the Study, present air quality, noise and water quality was measured and it was confirmed that present environmental condition satisfied the environmental standards. Details are described in Sub-section 7.1.2.

4.7 Study on Selection of Combined Cycle Power Plant

4.7.1 Fuel Flexibility of Combined Cycle Power Plant

Generally CCPP is planned to utilize gas as fuel, however there are many CCPPs with diesel oil back up system considering emergency purpose in case of gas supply shut down. The Project has planned to utilize natural gas produced in Bangladesh as fuel however alternative fuel has to be evaluated because gas shortage is expected as described in Section 4.5.
Comparing the price ratio of heavy oil and diesel oil, heavy oil price in Bangladesh is regulated around a half of diesel oil price. Therefore the feasibility of gas / heavy oil (HO)-fired CCPP is evaluated at first and next the feasibility of gas / diesel oil (DO)-fired oil CCPP is evaluated.

(1) Evaluation of gas / heavy oil-fired CCPP

Based on the technical and economical evaluation, the gas / heavy oil-fired CCPP can be described as follows, as compared to the conventional thermal power plant:

- Technically possible, but required heavy maintenance.
- The plant efficiency is reduced to the level of the conventional thermal power plant and output is reduced about 17%.
- Not appropriate for base load plant because of low availability by required frequent shutdown for cleaning of turbine blade and inspection.
- Not economical even in case small percentage of fuel usage.

Therefore, it can be concluded that application of the gas / heavy oil-fired CCPP to this Bheramara CCPP is not recommendable.

(2) Evaluation of gas / diesel oil-fired CCPP

There are many CCPPs with diesel oil back up system because those can generate power even in case of gas supply shut down. In this section, it is also evaluated that the feasibility of continuous diesel oil fired by CCPP.
In conclution, the F-class CCPP is recommendable for the Bheramara CCPP Project through technical and economical evaluation and taking into account environmental aspect as summarized in Table I-4-7-1.

Table I-4-7-1 Summary of comparison of E class CCPP and F class CCPP

	F class CCPP	E class CCPP	Recommendation
Output @site condition	380 – 420 MW	360-530 MW (Only 2 OEMs offer over 450MW CCPP)	Competitive bidding is restricted by the minimum capacity requirement as 450 MW.
Efficiency (@ISO, in case of one-through condenser)	58％	52％	F class CCPP has 6 % higher efficiency.
Estimated EPC Cost	390 mil.USD （937USD/kW）	416mil.USD （869USD/kW）	E class CCPP’s unit price (USD/kW) is slightly lower.
Generation Cost （Unit Gas Price = 2.4USD/GJ）	3.66 cent/kWhr	4.05 cent/kWhr	F class CCPP is more economical.
CO_2 emission (per annual Power generation)	Base	Minus (-) 100,000 ton CO_2/yr	F class CCPP emits less CO_2.
Influence on Grid	Within allowable limit	Within allowable limit	Same level
Limitation by Transportation	GT weight 339～418 ton	GT weight 200～339 ton	Same level (Limitation of barge is 600 ton.)

4.7.2 Study on Shaft Configuration

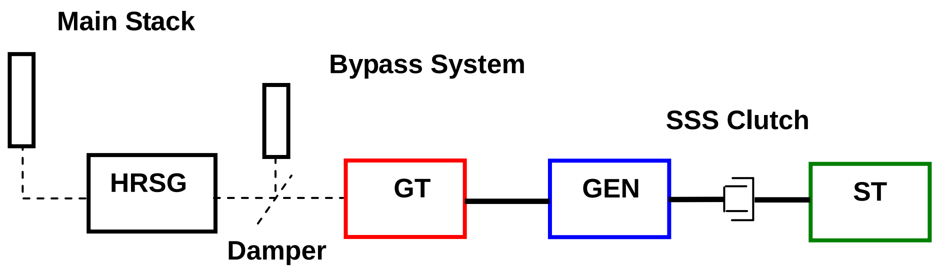
(1) Type of Shaft Configuration

Basically, there are two (2) types of shaft configurations. One is called single-shaft configuration where the gas turbine, a steam turbine and a generator are connected on the same shaft. The other is called multi-shaft configuration where the gas turbine/generator shaft and the steam turbine/generator are separate.

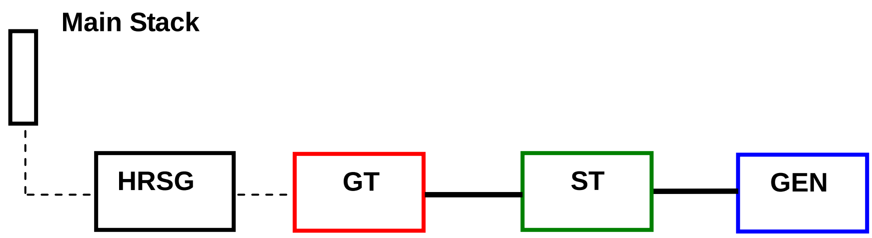
The single-shaft configuration is classified into two (2) types of configurations depending upon with and without a SSS clutch and a bypass system. In case of the former configuration, the power train is arranged in order of the gas turbine, the generator and the steam turbine. The SSS clutch is of auto-engagement and disengagement type and is located between the generator and the steam turbine. In case of the latter configuration, the power train is commonly arranged in order the gas turbine, the steam turbine and generator.

In case of the multi-shaft type, two (2) types of CCPP configurations with and without the bypass system could be considered. These four (4) types of CCPP configurations are as depicted below:

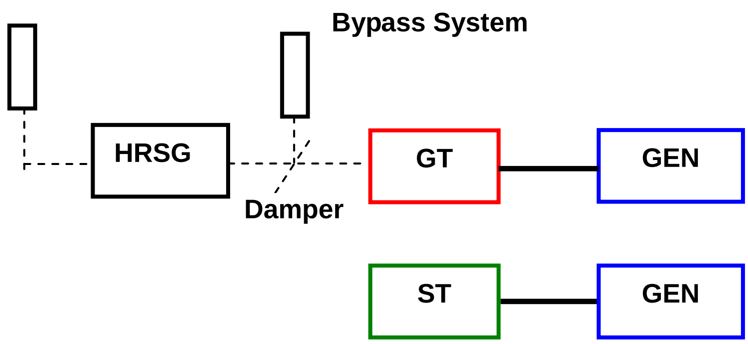
Single-Shaft CCPP with SSS Clutch and Bypass System

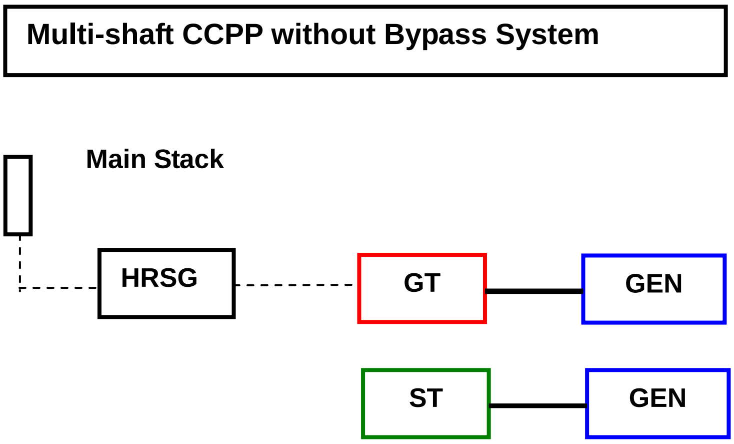


Single-Shaft CCPP without SSS Clutch



Multi-shaft CCPP with Bypass System





The comparison study among the four (4) types of shaft configurations is performed from the viewpoints of thermal efficiency, operational flexibility, operability, start-up steam and auxiliary power requirement, application experiences, operating reliability, maintainability, installation footprint area requirement, construction cost, generation cost and transportation. The comparison study results are summarized as tabulated in the next page.

(2) Study Summary and Recommendation

The study results described above is simply summarized as the table attached in the next page. The yellow colored cell shows that the shaft configuration of the cell is advantageous in the related comparison item. As shown in this table, each type of shaft configuration of CCPP has both merits and demerits. For example, if the first priority is given to the economy (thermal efficiency, construction cost, generation cost) of the project, the single-shaft CCPP without the clutch can be recommended, while the first priority is given to the operational flexibility (simple cycle operation) and operating reliability (hour basis), the multi-shaft CCPP with the bypass system can be recommended.

The single-shaft CCPP with the clutch and the bypass system is possessed of all merits of the economy and the operational flexibility and operating reliability although they are not always best in their comparison items. However, it is afraid that the fair competitive bidding could not be expected because of limitation of CCPP manufacturers of Alstom and Siemens having sufficient experience of the single-shaft CCPP with the SSS clutch.

This plant is to be constructed in the north-southern area of Bangladesh country to improve the power flow imbalance in the Bangladesh Network System. For the time being, this plant is scheduled to operate by only one unit. Therefore, any power shall not be developed from the plant if it drops after the existing superannuated and small power units are demolished. However, such situation must be avoided. For the purpose, the multi-shaft configuration CCPP with the bypass system should be recommended. This type of CCPP can cope with the steeply increasing power demand of Bangladesh because the phased construction is applicable.

As a conclusion, the multi-shaft CCPP with the bypass system shall be recommendable considering the significance of construction of this type of plant as stated above. It is another reason for recommendation of it that all CCPPs introduced into Bangladesh are of same type.

Comparison Item		Single-shaft CCPP		Multi-shaft CCPP	
		Without a SSS clutch	With a SSS clutch	With a bypass stack	Without a bypass stack
1. Thermal Efficiency		Base (100 %)	Δ 0.17 %	Δ 0.27 %	Δ 0.10 %
2. Operational Flexibility (Simple Cycle Operation)		Base (No)	More flexible (Yes)	More flexible (Yes)	Same (No)
3. Operability		Base	Same	Slightly complicated due to operation of more equipments	
4. Start-up Requirement	Steam	External auxiliary steam	Own steam	Own steam	External auxiliary steam
	Power for Starting device	App. 2.5 % of GT capa.	App. 2.0 % of GT capa.	App. 2.0 % of GT capa.	App. 2.0 % of GT capa.
5. Application Experiences		No difference (Both configurations have many experiences), however, many experiences with CCPP with SSS clutch are limited to two (2) manufacturers.			
6. Operating Reliability	Hour basis	Base (100 %)	+ 0.3 %	+ 0.5 %	Δ 0.5 %
	kWh basis	Base (100 %)	Δ 0.7 0%	Δ 0.76 %	Δ 0.60 %
7. Maintenance Cost		Base	Same	Slightly higher because of more equipments	
8. Footprint Area of Power Train		Base (100 %)	+ 15 %	+ 25 %	+ 10 %
9. Phased Construction		No	No	Yes	No
10. Construction Cost		Base (100 %)	+ 2.2 %	+ 6.1 %	+ 4.2 %
11. Power Generation Cost		Base (100 %)	+ 1.5 %	+ 2.7 %	+ 1.3 %
12. Inland Transportation		Base	Similar	Similar	Similar

4.7.3 Selection of Cooling System

The study on the selection of cooling system for the steam turbine condenser of this power plant was carried out with the following steps.

Step 1: Comparison study on the cooling system
Step 2: Comparison study on the intake system of cooling water
Step 3: Selection of the cooling system

In the step 1, three (3) types of cooling systems to be considered for this plant were studied from technical and economic points of view including the impact on environments.
In the step 2, the intake systems for the two (2) types of cooling systems where cooling or make-up water is required out of three (2) types were studied. As for the make-up water, the following two (2) types of methods were performed from the technical possibility point of view including the impact on environments.
In the step 3, the condenser cooling system optimal to this plant was chosen based on the study results of steps 1 and 2.

(1) Comparison Study of Condenser Cooling Systems

1) General

Three (3) types of cooling systems of a once-through cooling system, a forced draft cooling tower system and a forced draft air cooling system could be considered as the cooling system of the steam turbine condenser for the Project. The merits and demerits of the cooling system are variable depending upon the site ambient conditions, operating conditions and economic conditions such as an electric power sales price and a fuel cost. This study is carried out from technical and economical points of view for selection of the most suitable cooling system for the Project.

2) Technical Evaluation

a. Once-through cooling system

This system is the most common system to various kinds of power generation plants.

The condenser vacuum is estimated at 5.32 kPa and the steam turbine net power output could be largest among three (3) types of cooling systems. That means that the plant thermal efficiency is highest among them.

However, there must be any available cooling water source from which the necessary amount (some 30,000 m^3/hr including that for equipment lube oil systems) of water with suitable quality could be stably taken in to the condenser and be discharged to the water source. In case of this Project, Padma River could be considered as the water source since it is located comparably close to the candidate site of the Plant.

The routing of the intake and discharge channels and type of them between the river and the site shall be decided at the detailed design stage and a huge amount of civil works shall be required. During civil works for construction of the intake and discharge channels, significant consideration of impact on circumferential environments shall be specially paid from viewpoints of dust, noise, vibration and etc.

In case of this system, the thermal effluent as much as 30,000 m^3/hr shall be discharged to Padma River. The river temperature rise due to the thermal effluent may give any influent on the River.

As mentioned in the successive sub-section (2) [Study on Water Intake of Cooling Systems], however, it was founded that it was impossible to steadily intake the necessary amount of cooling water from the River. Therefore, specific studies about impacts on environments due to civil works and river temperature rise were not conducted.

b. Forced draft cooling tower system

This system is also common to the power generation plants to be built in the area where the water source with necessary amount of flow rate capacity is not available. The re-circulating cooling water flow rate of the cooling tower is estimated to be some 30,000 m^3/hr including the cooling water for equipment. The net power output of the steam turbine is large next to the once-through type cooling system.

In case of use of this type of cooling tower, some 4% of the re-circulating water flow rate must be made up to compensate the blow-down water and evaporation and water drift losses depending upon the design parameters of the tower. Therefore, the required make-up water flow rate the cooling tower can be calculated at 1,200 m^3/hr.

The make-up water of 1,300 m^3/hr in total including 1,200 m^3/hr for the cooling tower is necessary for the project. As the site survey results of the successive sub-section (2) [Study on Water Intake of Cooling Systems], the underground water was found to be available as the make-up water. In this case, any influence on the circumferential environments due to pumping-up of the water was concerned. However, it was confirmed that the pumping-up of the underground water for the long term through the plant lifetime would not give rise to any significant influence on circumferential environments.

Some 2 % (600 m^3/hr) of the circulating water for the cooling tower must be continuously blown down to the River. The water blown down from the cooling tower water reserve vessel is discharged to the Padoma River after proper mesh type filtration treatment. The temperature of the blown water (thermal effluent water) is designed at 39.8 ^oC, which meets the regulation of 40 ^oC of the Bangladesh. The flow rate of the blown water is approximately 0.025 % times the minimum river water (30 ^oC) flow rate at the dry season. Therefore, it is definitely envisaged that any influence on the environments by the blown water doesn’t happen.

As the noise simulation analysis results based on noise data of the main equipment consisting of the plant, the sound pressure levels on the border of the power station was found to be less than the prescribed value.

c. Forced draft air cooling system

This type of system has been used for the power generation plants which are built in areas where water sources are not available in the vicinity of plants as inland and desert areas. The net power output of the steam turbine will be the lowest among three (3) types of cooling systems.

The totally required footprint area for installation of the air cooling system is approximately 60 m by 75 m and the installation of it on the given site area is allowable.

The mechanical sounds from the axial air fans are supposed to be the noise source of this cooling system. The noise levels on the ground level around the similar size air cooling system in Japan was less than 85 dB(A). It was confirmed that the noise levels on the power station boundary is permissible from the noise simulation analysis results based on the noise source data of the plant including the noise source from the forced draft air cooling system.

3) Economic Evaluation

a. Loaded cost due to shortage of annual net sales power

The loaded cost is defined to be equal to the net present value (NPV) due to the shortage of the annual net sales power by the steam turbine with a certain cooling system against the steam turbine with the maximum annual net sales power. The loaded costs for the individual cooling system are calculated as shown below:

Type of Cooling System	Loaded Cost (MMUS$)
Once-through cooling system	±0.0
Forced draft cooling tower system	+ 7.6
Forced draft air cooling system	+ 11.2

As shown by above figures, the loaded costs for the cooling tower and air cooling systems are higher compared with those of the once-through type system. These large differences are derived from the differences of condenser vacuum pressure of the steam turbine depending upon the type of the cooling system.

b. Construction cost for condenser and cooling system

The construction cost for individual cooling system is estimated through the computer software referring the relevant cost of similar project. The closed component cooling system is not included in the estimation of the construction cost because its specification is deemed to be common to all types of cooling systems.

The costs of any civil works associated with the intake and discharge channels for once-through cooling system are tentatively estimated from the experience with similar plants for comparison of the cooling system.

The costs for the ground water pump-up system including boring cost of the well for make-up water of the cooling tower system are also tentatively imagined from the experience with similar plants for comparison of the cooling system.

The estimated costs are summarized as shown below:

MM US$

Description	Once-through	Cooling Tower	Air-cooled
Condenser and accessories	5.5	6.2	-
Circulating Water System	9.5	17.4	-
Cooling Tower	-		-
Air-cooled Condenser	-	-	31.7
Intake & Discharge Channel Civil works (assumed)	15.0	-	-
Groundwater Pump-up System including well drilling	-	1.0	-
Total	30.0	24.6	31.7

As shown in this table, the construction cost of the forced draft air cooling system is highest among the three (3) types of cooling systems.

c. Construction cost plus loaded cost

The construction cost plus loaded cost for three (3) types of cooling systems are as tabulated below from values estimated above.

Type of Cooling System	Construction and Loaded Costs (MMUS$)
Once-through cooling system	30.0
Forced draft cooling tower system	32.2
Forced draft air cooling system	42.9

As can be seen from above figures, the difference of economy between the once-through cooling and forced draft cooling tower systems is very small, while the forced draft air cooling system is far more uneconomic compared with any other two (2) types of cooling systems.

(2) Study on Water Intake for Cooling Systems

1) Once-through cooling system

Cooling water of approximately 40,000m^3/hr should be required for once-through cooling system.

Based on the survey data as mentioned in Section 4.6.5 Water source (1) Hydrological and morphological data of Padma River, it is concluded that water intake by open cut is impossible during dry (low-water) season due to the following reasons;

- heavy sand sedimentation along the right bank of the River
- top level of sedimentation is higher than the water level of the River
- water depth of Padma River (dry season) is very shallow
- cross section / level of the River bed is heavily fluctuated year by year

2) Forced draft cooling tower system

Total makeup water of 1,300 m^3/hr should be required. 1,200 m^3/hr is for forced draft cooling tower system, approximately 50 m^3/hr is for HRSG and approximately 50 m^3/hr is for injection water to reduce NOx in case of oil firing.

Based on the groundwater investigation/study as mentioned in Section 4.6.5 (2) Groundwater investigation, it is concluded that natural aquifer condition of the site is suitable for supplying 31,200m^3/day (=1,300m^3/hr x 24hr/day) continuously without massive lowering of groundwater table. Therefore, Deep Well is adopted as water intake for forced draft cooling tower system.

Well field with possible number of wells was designed as followings;

- capacity : 160m^3/hr/nos (160 x 12 = 1,920 m^3/hr = approx.1.5 x 1,300m^3/hr)
- quantity : 12nos
- distance : 140m

Figure I-4-7-1 shows well layout of the above.

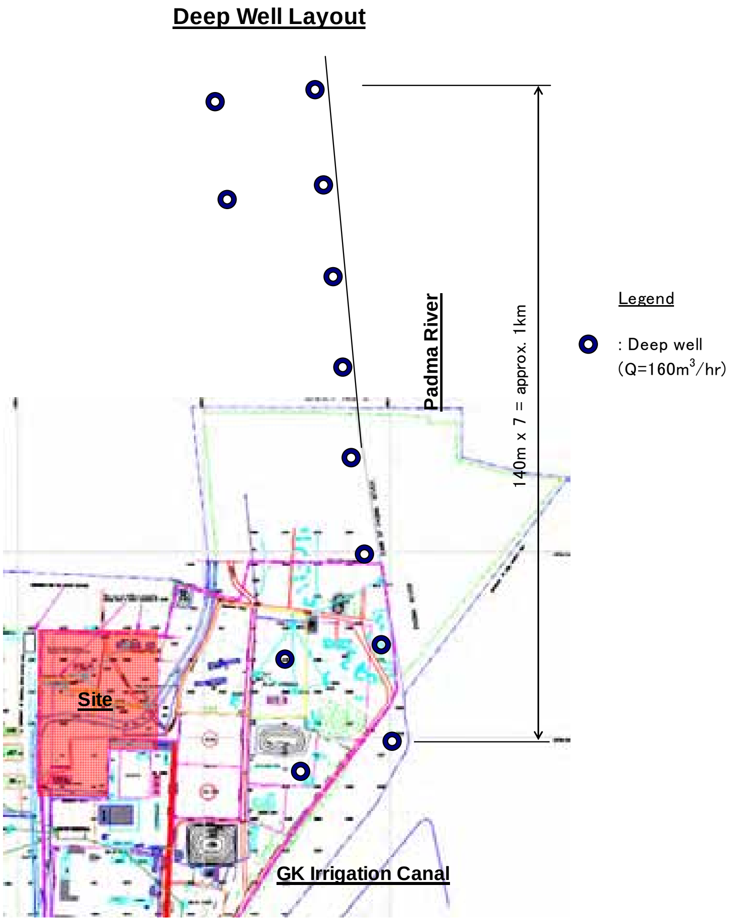


Figure I-4-7-1 Deep well layout

Hydrogeological parameter settings for the model is shown the Table I-4-7-2.

Table I-4-7-2 Hydrogeological parameter settings for the model

Layer	Lithology	Thickness (m)	Kx m/d	Ky m/d	Kz m/d	Ss (1/m)	Sy (%)	Effective porosity (%)	Total porosity (%)
1	Clay and silt	0-36	1	1	0.1	0.0001	0.03	0.06	0.5
2	Very fine to fine sand	5-51	10	10	1	0.0001	0.18	0.18	0.2
3	Medium to coarse sand and gravel	75 +	45	45	4.5	0.007	0.25	0.27	0.3

Explanation: Kx = Hydraulic conductivity in the x direction, Ky = Hydraulic conductivity in the y direction, Kz = Hydraulic conductivity in the z direction, Sy = Specific yield, Ss = Specific storage.

Simulation results and Impact on existing tubewells

Zoomed modeled dry season (May) water table contour map of the study area after 20

years of pumping is shown in the Figure I-4-7-2.
Within the area of contour in a concentric fashion going down from approximately EL+6.0m to EL+4.0m centering on the pumping point of the site, groundwater table has been declined from the present condition approximately maximum 2m. Based on this result, Figure I-4-7-3 gives impacted area on existing tubewells.

Figure I-4-7-2 Zoomed in modeled dry season (May) water table contour map

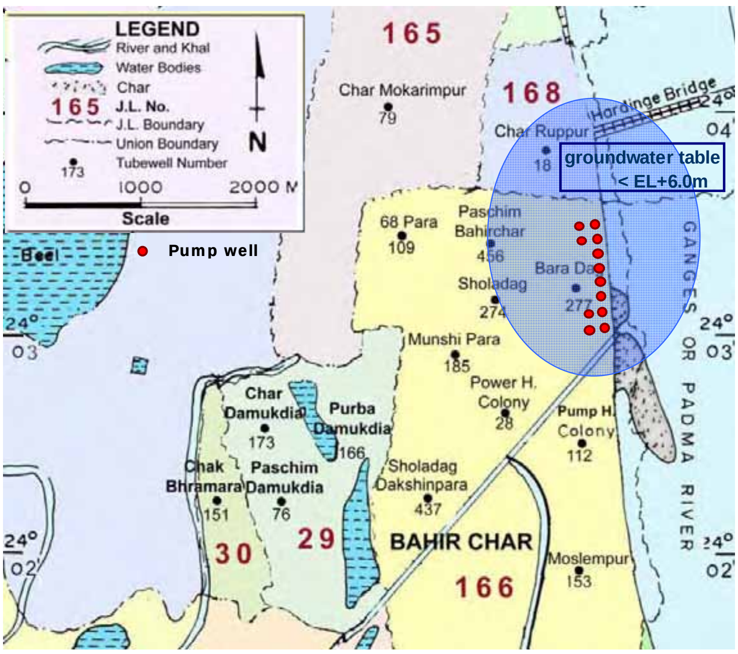


Figure I-4-7-3 Tubewells survey map with impacted area in dry season

As mentioned in Section 4.6.5 Water Source (2) Ground water Investigation, hand tubewell (HTWs) could operate only in suction limit of approximately 7.5m. Therefore, the above mentioned result of the study shows that HTWs in Char Ruppur Village, Bara Dag Village, Sholadag Village and Paschim Bahirchar Village might not suction groundwater in dry season.

On the other hand, shallow tubewells and deep tubewells have enough depth and would not be effected at all.

Table I-4-7-3 Impact on the existing tubewells

J.L. No.	Geo code	Locality	Area (km^2)	House Hold (nos)	Population (2001) (head)	HTWs (nos)	Water Bodies (nos)	Impact
30	213	**Chak Bheramara**	0.81	196	929	151	11	
165	307	**Char Mokarimpur**	4.04	122	492	79	13	
168	331	**Char Ruppur**	1.28	28	346	18	17	Y*
29	355	**Damukdia**	2.97	647	3,095	415	12	
		Char Damukdia		181	936	173	4	
		Purba Damukdia		365	1,705	166	5	
		Paschim Damukdia		101	454	76	3	
166	902	**Pashchim Bahirchar**	12.88	3,412	16,889	2,077	53	
		Powerhouse Coloney		175	767	28	1	
		Bara Dag		279	1,420	277	4	Y
		68 Para		141	694	109	3	
		Moslempur		444	2,218	153	3	
		Munshi Para		241	1,174	185	4	
		Sholadag Dakshinpara		552	2,716	437	8	
		Sholadag		551	2,712	274	9	Y
		Paschim Bahirchar		856	4,334	456	13	Y
		Pumphouse Coloney		70	353	112	6	
		Bengal Para		103	501	46	2	

* : Y means "Yes, may be effected"

Based on the above result, HTWs in said four (4) villages especially Bara Dag Village besides the pumping points should be monitored carefully during plant operation period especially in dry season. In case HTWs which could not suction would be found, following countermeasure should be applied by NWPGCL.

<u>Countermeasure</u>

Deep set hand tubewell (DSHTWs) which could suction approximately 30-37m and is wildly used in Bangladesh (Tara pump) should be applied with enough depth covering groundwater table in dry season.

Detailed result of the groundwater investigation/study is shown in the Attachment 2 of Groundwater investigation report and Attachment 3 of Groundwater study report.

(3) Selection of Cooling System

As selection of cooling system for this project, three possible candidates of Once-through cooling system, Forced draft cooling tower system and Forced draft air cooling system were investigated/studied.

As the results of investigation/study, it was found that Once-through cooling system could not be adopted for cooling system of this project because of the difficulty to secure required amount of cooling water throughout a year. Forced draft air cooling system was also shelved because of its disadvantages in plant performance and economical viewpoint.

On the other hand, Forced draft cooling tower system is approximately 5,000 kW less than Once-through cooling system in net power output, but almost same in economic efficiency. This system could continuously be secured enough amount of water by pumping groundwater through Deep well for makeup water without massive lowering of groundwater table. It is therefore concluded that Forced draft cooling tower system could be recommendable for the cooling system of this project. In this regard, however, some existing shallow wells around the site would possibly be disturbed, therefore, such existing wells should be carefully monitored during the site operation especially in dry season and be taken appropriate measures as deep set hand tubewell (DSHTWs) with enough depth to secure constant supply of adequate amount of groundwater if it required by NWPGCL.

4.8 Equipments and materials transportation

Power generation plants including steam cycle are normaly constructed at seacoast or rivercoast can easily supply the cooling water and directly transport heavy weight or large volume cargoes to site by ships.
The Bheramara site is located in the vicinity of the upstream of the Padma River. The water level of the Padma River in the vicinity of the Bheramara site is changing throughout the year and the water level change is maximum 10m. Accordingly, when the heavy weight equipments and materials (herein after heavy weight cargoes) required for the construction of the Bheramara site are to be brought into the Bheramara site from overseas countries, the EPC contractor may not be able to transport the heavy cargoes into the Bheramara site as planned. To solve this problem, we conducted the transportation survey and study including overland transportation for heavy weight cargoes in this survey.

4.8.1 Procurement of equipments and materials

Total transportaion weight including heavy weight cargoes is apploximately 30 thousand ton. The 10 thousand ton is equipments such as gas turbine, HRSG, steam turbine etc. and the 20 thousand ton is materials such as cement, aggregate, sand, rebar etc.
Equipments required for the construction of the Bheramara site are almost imported from overseas countries. Materials such as cement, aggregate, sand, rebar etc. can be procured in Bangladesh. Government of Bangladesh does not permit import of these materials can be procured within Bangladesh.

4.8.2 Heavy weight equipments transportation

Survey and study of heavy waight equipments transportation is required in the equipments and materials transportation. The heavy weight equipments required for the construction of the Bheramara site include a gas turbine as the main engine, steam turbine, HRSG, generator and transformer.

4.8.3 Transportation limit

Transportation limit in overland transportation is as indicated below.
Highway in Bangladesh are designed with 10 ton based on the axitial load of truck and trailer and bridges and culverts are designed with 35 ton per pier span or lane.
The axitial load less than 10 ton in overland transportation is required.
Overland transportation weight limit is restricted below 40 ton according to regulation of “Gazette Notification of Government Regulation regarding Carrying Capacity of Road” and road administrator opinion of “Letter of Superintending Engineer, Roads & Highway Department (RHD) on Carrying Capacity of Road”. Therefore Heavy weight cargoes over 40 ton are necessary to consider channel transportation.
If cargo weight is below 40 ton and cargo size is below width 2.5m×height 2.5m×length 6m or width 2.5m×height 2.5m×length 12m with precaution these cargoes is not necessary to obtain the permission of road administrator.

In case of existing Mymenshingh CCPP (Output 2 units×70MW, 2 units×35MW) heavy weight cargoes over 100 ton with permission of road administrator were transported from Kanchpur to Mymensingh by trailers. Mymensingh case means if the permission of road administrator is obtained heavy weight cargoes over 40 ton can be transported by trucks or trailers in this project.

4.8.4 Survey and study policy

In this project equipments below 40 ton are apploximately 5.5 thousand ton and over 40 ton are 4.5 thousand ton. Approximately equipments of 4.5 thousand ton will be transported by channel transportation.
In this study heavy weight cargoes over 40 ton of overland transportation weight limit were studied by channel transportation according to the regulation and road administrator opinion in section 4.8.3. Cargoes below 40 ton were studied by overland transportation from Mongla port to Bheramara site.

4.8.5 Selection of candidate transportation routes

Candidate transportation routes for cargoes transportation from overseas to Bheramara site shown in section 4.8.2 are as indicated below.

(1) First unloading port in Bangladesh

As first unloading port in Bangladesh representative Mongla port and Chittagong port were selected and the qualification was surveyed and studied.

1) Mongla port

The port facilities are sufficient to handle any cargo dispatched by ocean going vessls in all seasons but heavy weight cargoes over 100 ton shall be unloaded by cranes from ship to the barges in the outer anchorage.

2) Chittagong port

The heavy weight cargoes should be unloaded from ship on to the barges by cranes in the outer anchorage area considering the draft of large cargo ship. But in monsoon season, sea remains very rough condition and unloading from ship to barges is less possibility by rolling and pitching.
No equipments can be unloaded in the Chittagong port during monsoon season which rivers are very good for navigation.
Though the coast line near Chittagong port is safe for navigation in dry season, Padma river becomes dry and no heavy equipments can be transported by barge through Padma river.
Chittagong port is greatly crowded with ships except for January and February.

3) Selection result for first unloading port in Bangladesh

Mongla port was selected as first unloading port in Bangladesh which heavy weight cargoes can unload in all season and agreed by BPDB.

(2) Candidate transportation routes

3 candidate transportation routes from Mongla port as indicated below were selected and agreed by BPDB.

Route 1 : Channel transportaion :

Mongla port – River Ganges – River Padma – Bheramara site

Route 2 : Channel transportation and overland transportation
Mongla port – River Ganges – River Jamuna – Sirajganj site (channel)
Sirajgabj site – Bheramara site (overland transportation)

Route 3 : Overland transportation
Mongla port – Bheramara site

Candidate transportation routes for heavy weight cargoes is shown in Figure I-4-8-1.

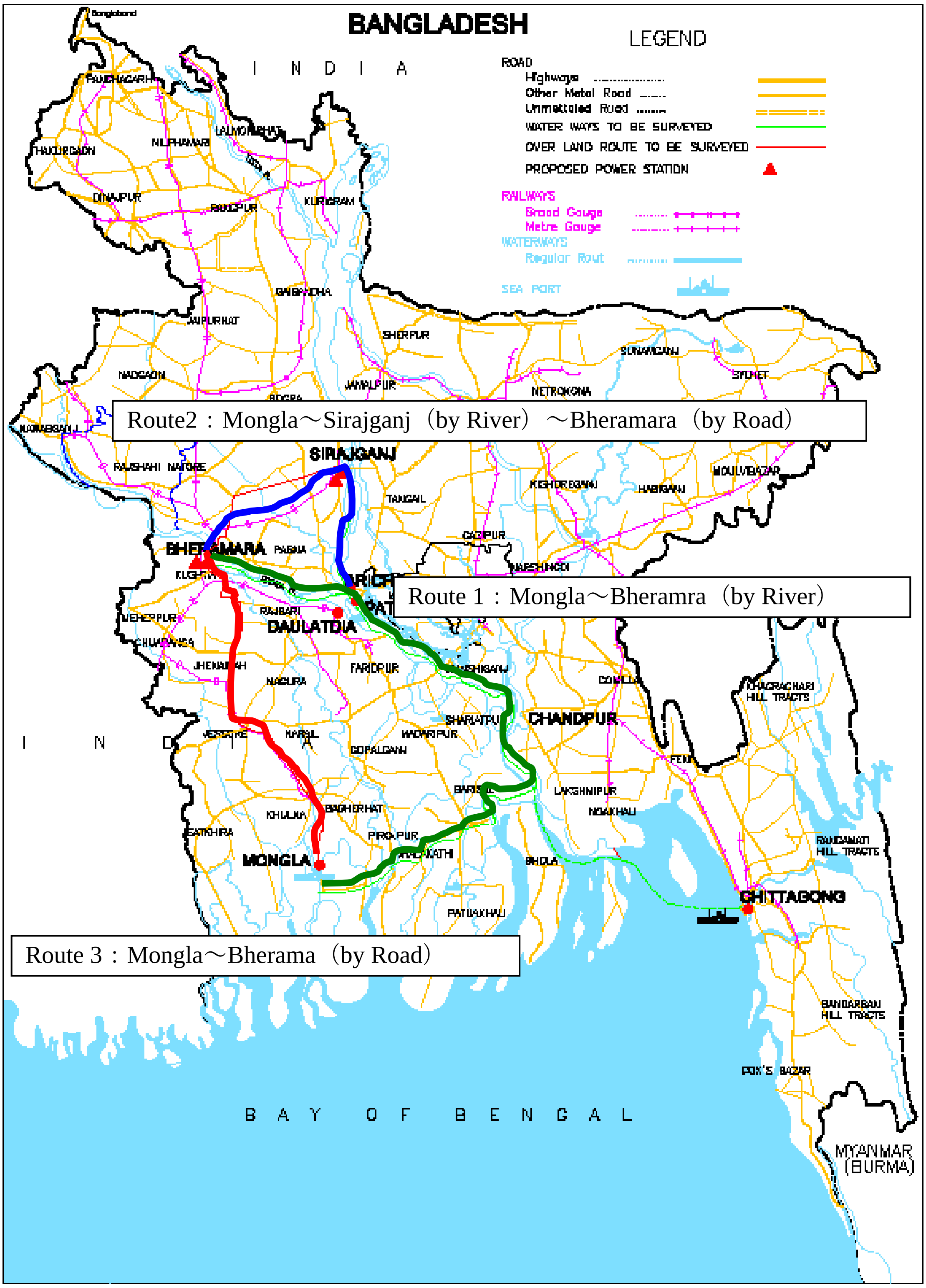


Figure I-4-8-1 Candidate transportation routes

4.8.6 Survey of candidate transportation routes

(1) Mongla port to Bheramara site (channel transportation)

This route goes upstream on Ganges river and Padma river from Mongla port to Bheramara site. These river have several km width and considerable degree of water quantity and high water level in monsoon season. On the other hand these river water level comes down in dry season as holms comes from river. Especially water depth of Padma river is sharrow and can not navigate through the year. Therefore channel transportation period can keep the applied barges draft in heavy weight equipments transportation shall be studied.

1) Channel survey results

Survey was conducted for channel depth, width and the condition from Mongla port to Bheramara site.

Total distance of this transportation route is apploximately 377 km.

The depth is over 4.5m at center of the river and it is enough depth for navigating barges with maximum capacity 600 ton and tag boats with draft 1.22 to 2m.

Though Gabkhan bridge as obstruction for navigation is at 89 km apart from Mongla port, there are no ploblem for channel transportation of heavy weight cargoes in this project because distance between Bridge bottom and barge deck is 8 m.

2) Available period for channel transportation

The Ganges river from Mongla port to Daulatdia can be used throughout the year as informed by Banglaesh Inland Water Transport Authority (BIWTA). Barges and tagboats with draft 1.5m – 2m. can navigate through the year. Applied biggest 600 ton barges draft is 1.22m and tagboats draft is 2m. Therefore channel transportation from Mongla port to Daulatdia was possible from July to September was clarified.

Water level falls too much in the dry period from termination of monsoon. Rivers particularly Padma river from Daultatdiaghat to Bheramara is sharrow. Deep channels are narrow and non continuous. Suitable time is during wet monsoon from July to September. This appears to be most suitable route.

The River water level data for past 30 years at 1 km down river of Harding bridge near Bheramara site received from BPDB shows river water level data from July to September is approximately same. Channel water depth from August to September is enough for barge transportation was clarified by comparison of these water level data and channel water level data.

River bed is unpredictable on account of rapid siltation on slight change in river flow. A dredger of adequate size and pilot service from IWTA will have to be arranged along the Ganges river route from Daultatdiaghat to Bheramara.

(2) Mongla port to Sirajganj site (channel transportation) ～Bheramara site (overland transportation)

Route survey from Daulatdia to Sirajganj was conducted for channel depth, width and the condition.

The river route from Mongla port up to Sirajganj is about 365 km long.

Route survey results from Mongla port to Daulatdia already has been mentioned in section 4.8.6 (1).

Jamuna river from Daulatdiaghat to Sirajganj can navigate from July to September.

River bed is unpredictable on account of rapid siltation on slight change in river flow. A dredger of adequate size and pilot service from IWTA will have to be arranged along the Jamuna river route from Daultatdia to Sirajganj.

The depth is over 4.8m at center of the river and it is enough depth for navigating applied biggest 600 ton barges with draft 1.22 to 2m.

The channel condition from Daulatdia to Sirajganj is same condition from Daulatdia to

Bheramara site on available period for channel transportation and can not navigate through the year, therefore this channel route from Daulatdia to Sirajganj has no merit was clarified.

(3) Mongla port to Bheramara site(overland transportation)
There is a two lane national highway from Mongla port to Bheramara.
Brief summary is as indicated below.

- Distance between Mongla port and Bheramara site is 226 km.
- Entire road is built of asphalt concrete. Road width is 4.5 m to 9.1 m and the either end width of shoulder is 0.61 m to 1.37 m.
- Road condition is good except for partly damaged road to 5 km from Mongla port and there are 128 turning points with 20 to 90 deg.
- There are 70 overhead obstructions in this road of which 69 are overhead power line, one over head dish line, height ranges from 3.5 m to 9.17 m.
- Height of one toll plaza is 14.57 m.
- There are nine railway crossing.
- There are 29 bridges and 75 culverts in this road. Longest bridge in this road is the Khan Jahan Ali Bridge over the river Rupsha near Khulna town. Khan Jahan Ali Bridge is 1.36 km long and 16.65 m. Khan Jahan Ali Bridge is a new bridge constructed with the assistance of JICA. Condition of other bridges and culverts except for two small culverts are good.
- There are two small culverts at 26 km and 28 km from Bheramara. Width of these two culverts is only 3.84 m.

These overhead obstructions, toll plaza, raiway crossing, bridges and culverts etc. can pass cargoes within transportation limitation without repair and renovation of roads, turning point, bridges, culverts except for two culverts, overhead walkway, signal and installation of bypassroad, traffic restriction.

(4) Comparison of transportation cost
Cargoes except for heavy weight cargoes were transpoted by overland transportation from Mongla port to Bheramara site.
Channel transportation period for route 2 via Sirajiganj was restricted within 3 months from July to September and the period is same as direct channel transportation route from Mongla port to Bheramara site as indicated in above item (3). The channel condition from Daulatdia to Sirajganj is same condition from Daulatdia to Bheramara site on available period for channel transportation and can not navigate through the year, therefore this channel route from Daulatdia to Sirajganj has no merit. The route from Mongla port to Bheramara site via Sirajganj site was dropped from cost evaluation.
Total transportaion cost of route1 and route 3 is respectively about 204 million Taka and 274 million Taka.
Route 3 does not include the repair and renovation cost for road, bridges and culverts, bypass road etc.
The transportation cost in route 1 is economic compared with route 3.

4.8.7 Recommended transportation route

Summary of the problems and countermeasures, cost are shown in Table I-4-8-1.
The problems and countermeasures, cost estimation for each transportation route shows route 1 could be recommended as transportation route for heavy weight cargoes.
In this recommendation all heavy weight cargoes shall be shipped to Bheramara site from July

to September by adequate numbers of barges and tagboats and also permanent jetty and storage yard for construction etc. at Bheramara site shall be prepared before heavy weight cargoes transportation starts.

Transportation route	Problems	Countermeasures	cost
Route 1 Heavy weight cargoes : Channel transportation from Mongla port to Bheramara site Note1:HRSG modules are transported by channel. Note2:Cargoes except for heavy weight cargoes are transported by overland transportation.	Necessary channel transportation period is 3 months. This period is same as available channel transportation period.	・Study of overland transportation for HRSG modules to reduce channel transportation risk. Channel transportation period will be reduced to 2 months can be expected. ・Study of overland transportation permission for Heavy weight cargoes over 40 ton.	low
Route 2 Heavy weight cargoes : Channel transportation from Mongla port to Sirajganj and Overland transportation from Mongla port to Bheramara site Note1:HRSG modules are transported by channel. Note2:Cargoes except for heavy weight cargoes are transported by overland transportation.	Channel transportation period is restricted within 3 months same as route 1 and route 2 can not navigate through the year, therefore this route has no merit	This route was dropped from cost evaluation.	
Route 3 All cargoes transportation : Overland transportation from Mongla port to Bheramara site	・Overland transportation for heavy weight cargoes	Careful planning with road administration authority etc. is necessary to obtain the permission of heavy weight cargoes transportation.	high

Note 1: Route 3 does not include repair and renovation cost for roads, bridges, culverts etc. required in overland transportation of heavy weight cargoes.

4.8.8 Heavy weight cargoes transportation method for maintenance

Periodic maintenance for gas turbine combusters and rotor vanes, the compressor rotor vanes are necessary. Transportation method for these parts shall be clarified after plant completion. The weight and size of these parts is within the limit of overland transportation. Usually these parts can be transported by trucks or trailers without permission of road administrator.

On the other hand gas turbine rotor is not need periodic maintenance but has possibility the maintenance or repair needs in duration of 30 years plant life. Channel transportation for this part will be possible from July to Septenber to be constructed jetty as permanent facility in

Bheramara site but limited from July to September.
In this project EPC contractor shall be study the overland transportation method with the permission of road administrator for the heavy weight cargoes such as existing Mymenshingh CCPP.
Careful planning including cargo weight and size transported, applied trailers, transportation routes and period, time, strength check of road, bridges and culverts, the reinforcement check, bypass route check etc. with road administrator and authorities concerned such as BIWTA is necessary to obtain the permission of heavy weight cargoes for overland transportation.

4.9 Project Implementation Schedule

Initially, though Bheramara combined-cycle power plant will be completed upon at the end of 2012 based on request from the Bangladesh side, the goal for putting into commercial operation of Bheramara CCPP will be the end of September in 2014 when is more realistic, and as soon as possible due to delay in gas supply.
The followings are assumed to be critical points to be considered in developing the project schedule.

(1) Heavy cargos having a weight of more than 40 tons are transported on channel Mongla port to Bheramara site. But, channel transportation is limited from July to September because water depth in Padma river is not enough to move barge loading such heavy cargo.
(2) In recent years, since global demand for F-type gas turbine is high, the plant's production lines of four major gas turbine manufactures (GE, Mitsubishi, Alstom, Siemens) are occupied, the required delivery period from design to FOB of gas turbines take about 25 months.

Project schedule is made taking into consideration the above issues and show in Table I-4-9-1 and Figure I-4-9-1.

1) JICA standard
Period when requires the selection of consultant and the manufacturers is JICA''s standard. In this case, since the gas turbine will be arrived at Mongla port on July or later after the FOB, through maritime transportation in Bangladesh, the gas turbine has to be waiting to transport on channel transportation for nine months. So, this is inefficient work.

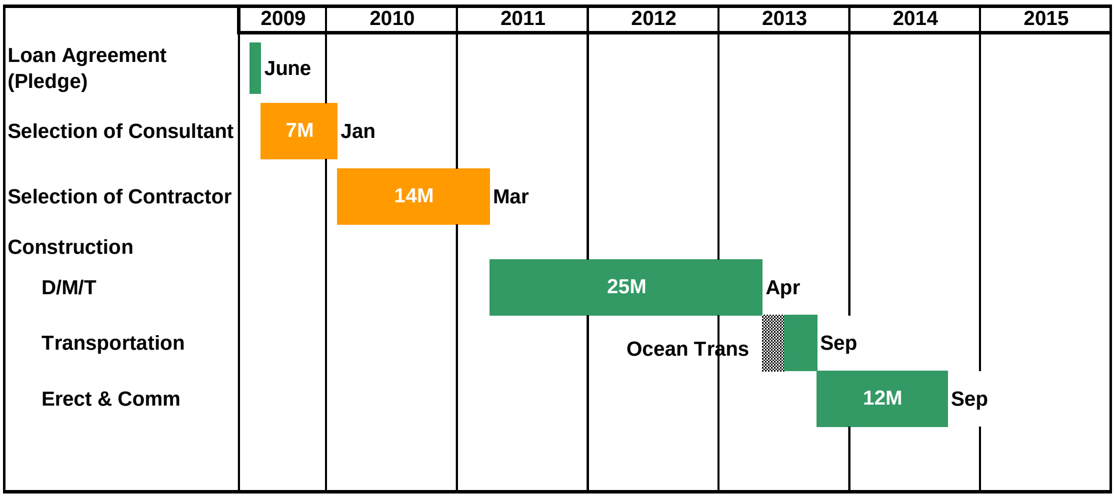
2) Recommended schedule
This schedule is made to shorten each one (1) month of the selection of consultants and manufacturers in order to arrive gas turbines and other heavy cargos at Mongla port before July.

Table I-4-9-1 Required Months from Selection of Consultant to the Completion of CCPP

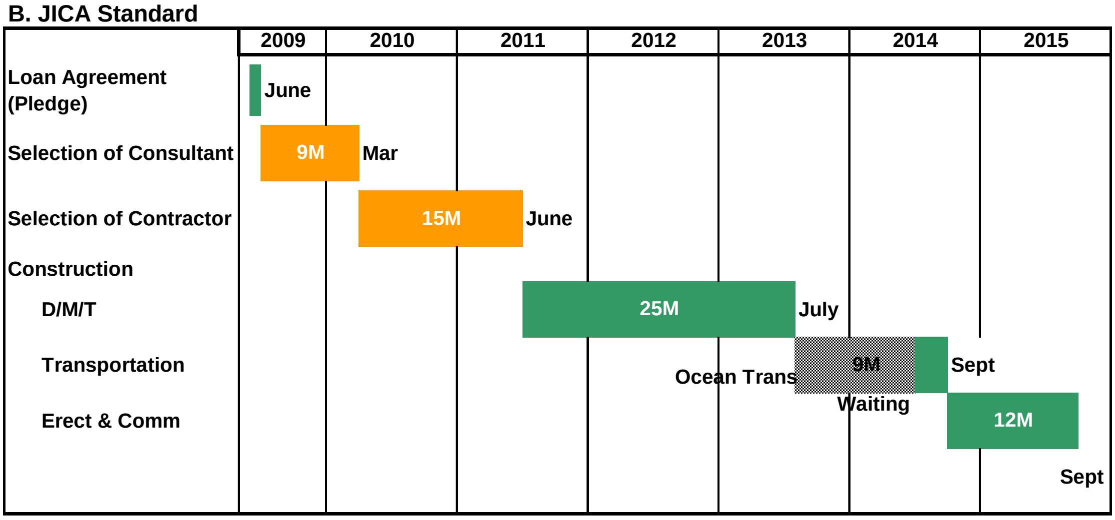
	Selection of Consultant	Selection of Contractor	Construction Period				
			*1	*2		*3	Total
				Wait	Trans		
JICA Standard	9M	15M	25M	9M	5 M	12 M	51M
Recommended	7M	14M	25M	0M	5 M	12 M	42M

Remarks：*1 Design and Manufacturing、*2 Transportation、*3 Erection and Commissioning

A. Recommended Schedule



B. JICA Standard



Remarks : D/M/T - Design, Manufacturing and Test

4.10 Outline of Long Term Service Agreement for Gas Turbine

In case of the maintenance of gas turbine, hot parts of it require periodical inspection / repair / replacement. Consequently gas turbine OEM, such as GE, offers the Long Term Service Agreement (LTSA) which covers such inspection / repair / replacement for certain period at a lump sum fee.

Bheramara CCPP will be NWPGCL's first F class CCPP. And NWPGCL is planning more efficient management of power plants by smaller organization than that of BPDB. Therefore LTSA is necessary technical support for stable operation of CCPP. LTSA is also preferable contract scheme from lenders position because LTSA contributes on both stable operation of the Plant and stable management of NWPGCL as mentioned above. Therefore it is recommended that LTSA is introduced as the scope of the Bheramra project.

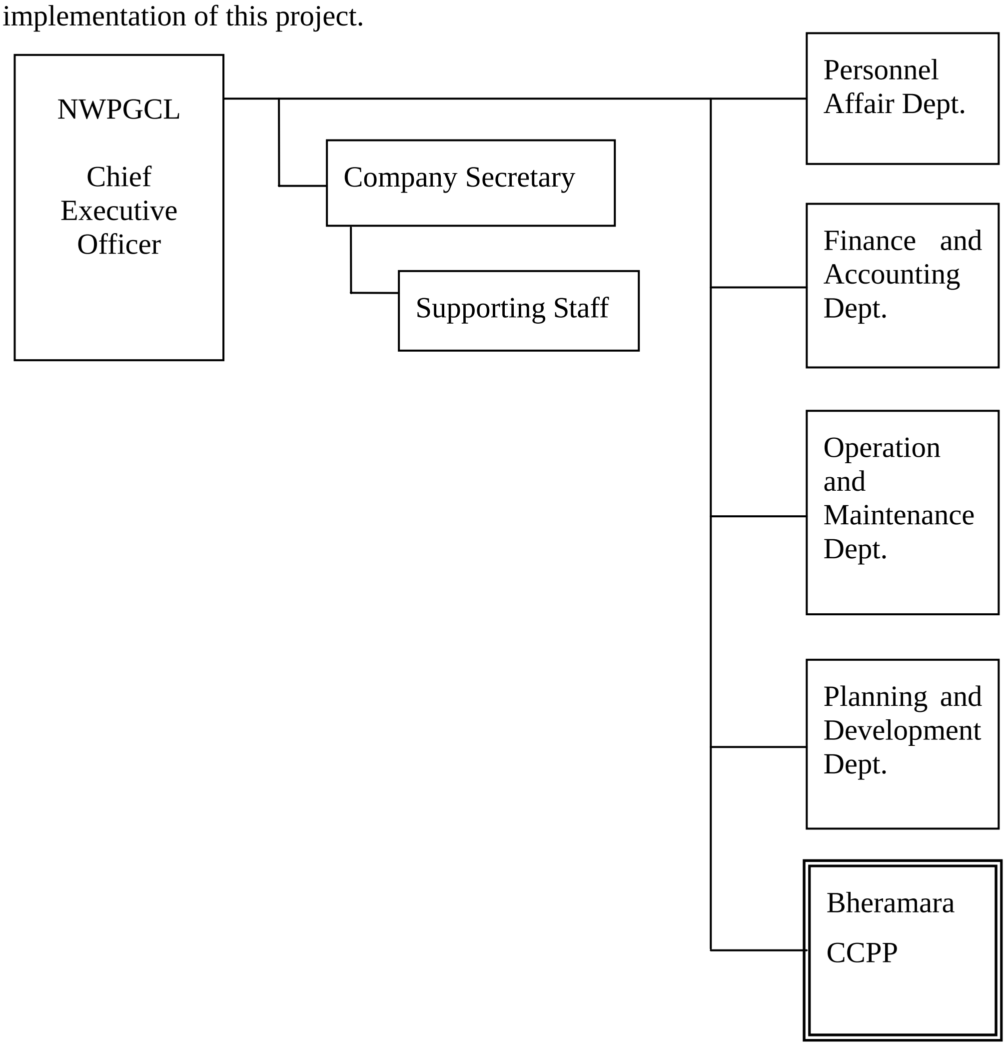
4.11 Project Implementation Organization

4.11.1 General

This section mentions an implementation organization which implement Bheramara CCPP project. It is recommendable that a Project Implementation Unit (hereinafter call as "PIU") will be established to manage and implement Bhearamara CCPP project as a department in North West Power Generation Company Limited (NWPGCL). And personnel and staffs belonged to PIU will shifted to be Bheramara CCPP or O&M department of NWPGCL.

(1) Establishment of Project Implementation Unit (PIU)

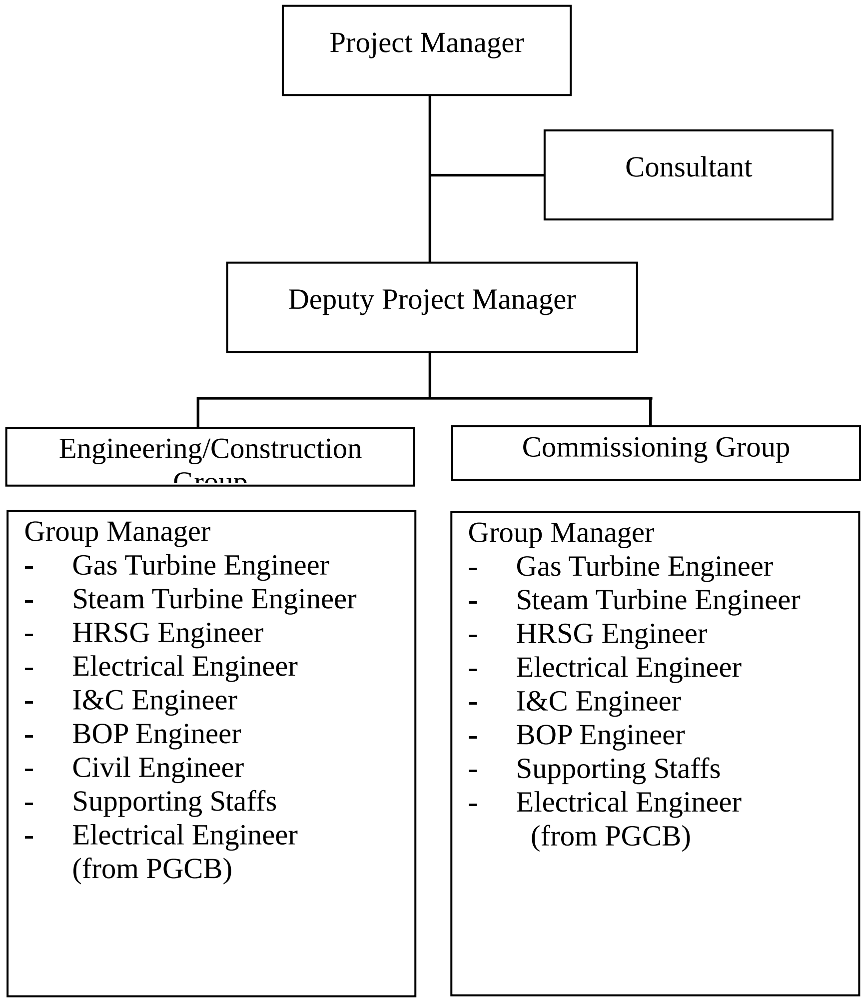
The organization of NWPGCL proposes the organization as shown in the below and installs Project Implementation Unit (PIU) in CEO's falling plumb down. PIU plays the central role of implementation of this project.



(2) Organization of PIU

PIU consists of Project Manager. Deputy Project Manager and 2 sections of Engineering/Construction Group and Commissioning Group, and a Consultant as an adviser. Taking the establishment of NWPGCL as an opportunity, it seems important to establish an organization which is slims to take a quick and flexible action and handover a right certain degree (for example, Project Manager has a right to purchase goods under 1 Mil.US$) to Project Manager in PIU.

1) Organization of PIU



4.12 Conclusion

As a result of having examined a technical feasibility of the construction plan, that is, power demand forecast, beneficial effect, power supply development program, a power system plan, a fuel supply plan, the site situation, examination of generation facilities basics method, erection and transportation of equipment and materials, the implementation organization, a project schedule, a gas turbine long term service agreement, it is almost judged that a construction plan of a Bheramara CCPP project is almost justified. But a trend of gas supply should be carefully monitored in future.