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

Preparatory Survey on Chittagong Area Coal Fired Power Plant Development Project in Bangladesh

Final Report
on
Power Plant / Port / Transmission Line / Access Road / Execution Survey of Natural Condition

Book 1
For Publishing

March 2015

Japan International Cooperation Agency (JICA)
Tokyo Electric Power Services Co., LTD
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Abbreviations

Abbreviations	Words
A/C	Account
ADB	Asian Development Bank
ADP	Annual Development Programme
AE	Assistant Engineer
AGM	Assistant General Manager
APSCL	Ashganj Power Station Company Limited
ASME	American Society of Mechanical Engineer
ATM	Automated Teller Machine
BAS	Bangladesh Accounting Standard
BDT	Bangladesh Taka
BERC	Bangladesh Energy Regulatory Commission
BFRS	Bangladesh Financial Reporting Standards
BIOM	Bangladesh Institute of Management
B-MCR	Boiler Maximum Continuous Rating
BOD	Board of Directors
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
BREE	The Bureau of Resources and Energy Economics, a research body of the commonwealth of Australia
BTCL	Bangladesh Telecommunications Company Limited
BWPDA	Bangladesh Water and Power Development Authority
CAS	Country Assistance Strategy
CE	Chief Engineer
CEO	Chief Executive Officer
C&F	Cost and Freight
CFO	Chief Finance Officer
CFPP	Coal Fired Power Plant
CHCO	Chief Human Capital Officer
C&I	Control and Instrumentation
CIF	Cost Insurance and Freight
CMA	Certified Management Accountant
C/O	Commercial Operation
CO2	Carbon Dioxide
COD	Commercial Operation Date
COO	Chief Operating Officer
C/P	Counter Part
CPA	Certified Public Accountant
CPF	Contributory Provident Fund
CPGCBL	Coal Power Generation Company Bangladesh Limited
CPS	Country Partnership Strategy
CZPDCL	Central Zone Power Distribution Company Limited
D/D	Detail Design
D/E	Debt/Equity
DESA	Dhaka Electric Supply Authority
DESCO	Dhaka Electricity Supply Company
DFID	Department for International Development
DGM	Deputy General Manager
D/L	Distribution Line
DM	Deputy Manager
DOE	Department of Environment
DOS	Department of Shipping
DPDC	Dhaka Power Distribution Company
DPP	Development Project Proforma
DSCR	Debt Service Coverage Ratio

DSL	Debt Service Liability
DW	Dead Weight Tonnage
Dy	Deputy
E/A	Executing Agency
ECA	Export Credit Agency
ECA	Environmental Critical Area
ECNEC	Executive Committee of National Economic Council
ECO	Economizer
ECR	Economical Continuous Rating
EE	Executive Engineer
EGCB	Electricity Generation Company of Bangladesh
EIA	Environmental Impact Assessment
EIRR	Economical Internal Rate of Return
EPC	Engineering, Procurement and Construction Contract
ERD	Economic Relations Division
F&A	Finance and Accounting
FBCCI	Federation of Bangladesh Chambers of Commerce and Industry
FCD	Financial Closing Date
F&I	Freight and Insurance
FIRR	Financial Internal Rate of Return
FOB	Free On Board
F/S	Feasibility Study
FSA	Fuel Supply Agreement
FY	Fiscal Year
GDP	Gross Domestic Product
GM	General Manager
GOB	Government of Bangladesh
GPF	Gratuity Provident Fund
GTCL	Gas Transmission Company Limited
GW	Giga-watt
HHV	Higher Heating Value
HO	Head Office
HFO	Heavy Fuel Oil
HMS	Human Machine System
HQ	Headquarters
hr	hour
HRD	Human Resource Development
HRM	Human Resource Management
HSD	High Speed Diesel
HT	High Tension
IAS	International Accounting Standards
IASB	International Accounting Standard Board
I&C	Instrumentation and Control
ICAB	Institute of Chartered Accountants of Bangladesh
ICMAB	Institute of Cost and Management Accountants of Bangladesh
ICT	Information and Communication Technology
IDA	International Development Agency
IDB	Islamic Development Bank
IDC	Interest During Construction
IDCOL	Infrastructure Development Company Limited
IEE	Initial Environmental Examination
IFRS	International Financial Reporting Standards
IOL	Inventory of Losses
IPO	Initial Public Offering
IPP	Independent Power Producers
IR	Investor Relations
IRR-E	Internal Rate of Return on Equity

ISO	International Standard Organization
IT	Information Technology
IUCN	International Union for Conservation of Nature
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
JPY	Japanese Yen
JV	Joint Venture
kA	kilo ampere
KEM	Key Executive Manager
KfW	Kreditanstalt für Wiederaufbau
kg	kilogram
KPI	Key Performance Indicator
kW	kilo-watt
kWh	kilo-watt hour
LA	Loan Agreement
LAO	the Land Acquisition Officer
L/C	Letter of Credit
LHV	Lower Heating Value
LLCR	Loan Life Coverage Ratio
LNG	Liquefied Natural Gas
LT	Low Tension
MCR	Maximum Continuous Rating
MD	Managing Director
MDG	Millennium Development Goal
MGT	Management
MIS	Management Information System
MMkcal	Million kilo calorie
MOC	Ministry of Communication
MOE	Ministry of Environment and Forestry Affairs
MOF	Ministry of Finance
MOS	Ministry of Shipping
M/P	Master Plan
MPa	Mega Pascal
MPEMR	Ministry of Power, Energy & Mineral Resources
MT	magnetic particle flaw detection test
MT	Metric Ton
MTC	Maintenance
MW	Mega Watt
MWh	Mega Watt Hour
N/A	Not Applicable
NDT	Nondestructive Testing
NGO	Non-Governmental Organization
NLDC	National Load Dispatch Center
NOx	Nitrogen Oxide
NPV	Net Present Value
NTPC	National Thermal Power Corporation
NWPGCL	North West Power Generation Company Limited
NWZPDCL	North West Zone Power Distribution Company Ltd.
OA	Office Automation
ODA	Official Development Assistance
OECD	The Organization for Economic Co-operation and Development
OJT	On the Job Training
O&M	Operation and Maintenance
OPEC	Organization of the Petroleum Exporting Countries
OPGW	Optical Ground Wire
PBS	Palli Bidyut Samity

PC	Personal Computer
P&D	Planning and Design
PD	Power Division
PDCA	Plan, Do, Check, Action
PDH	Plesiosynchronous Digital Hierarchy
PEC	Project Evaluation Committee
PED	Project Effective Date
Petrobangla	Bangladesh Oil, Gas and Mineral Corporation
PGCB	Power Grid Company of Bangladesh
PLC	Public Limited Company
PLCR	Project Life Coverage Ratio
PLF	Plant Load Factor
PPA	Power Purchase Agreement
PR	Public Relations
P/S	Power Station
PT	Penetrant Flaw Detection Test
PTC	Private Trading Company
PWHT	Post Weld Heat Test
QC	Quality Control
QRPP	Quick Rental Power Producer
RAP	Resettlement Action Plan
REB	Rural Electrification Board
RHD	Roads and Highways Department
ROA	Return on Asset
ROE	Return on Equity
RPCL	Rural Power Company Limited
RPP	Rental Power Producer
SA	Supporting Agency
SARI	South Asia Regional Initiative
SC	Super Critical
SCADA	Supervisory Control And Data Acquisition
SBU	Strategic Business Unit
SDE	Sub Divisional Engineer
SDH	Synchronous Digital Hierarchy
SE	Superintending Engineer
SEC	Securities Exchange Commission
SIA	Social Impact Assessment
SIPP	Small Independent Power Producers
SLA	Subsidiary Loan Agreement
SOx	Sulfur Oxide
S/S	Substation
ST	Steam Turbine
STBA	Alloy Seamless Tube For Heat Exchangers and Boilers
STM	Synchronous Transport Module
Sub-C	Sub-Critical
SUMP	Suzuki's Universal Microstructure Printing method
SUS	Stainless Used Steel
SZPDCL	South Zone Power Distribution Company Limited
TBM-KY	Tool Box Meeting – Kiken Yochi (Risk Prediction)
T&D	Transmission and Distribution
TIG	Tungsten Inert Gas
Tk	Taka
T/L	Transmission Line
TMT	Top Management Team
TOFD	Time of Flight Diffraction Technique
TOR	Terms of Reference
TPP	Technical Assistance Project Proposal

TPS	Thermal Power Station
TQM	Total Quality Management
UK	United Kingdom
UN	United Nations
U.S.	United States
USA	United States of America
USAID	United States Agency for International Development
USC	Ultra Super Critical
USD	United States Dollar
US$	United States Dollar
UT	ultrasonic flaw detection test
VAT	Value Added Tax
VPN	Virtual Private Network
WACC	Weighted Average Cost of Capital
WB	World Bank
WZPDCL	West Zone Power Distribution Company Limited
XEN	Executive Engineer

Chapter 1

Preface

Chapter 1 Preface

1.1 Background of the Study

Currently, Bangladesh mainly uses gas-fired power generation utilizing domestic natural gas as its major sources, and the future development plan for new power generation still focuses on domestic natural gas as a main energy resource.

However, since the current domestic demand has increased rapidly and the production or currently available (proven + probable) domestic natural gas will face depletion in the near future, it is not realistic to establish a policy that depends too heavily on domestic natural gas for the development of a new long-term power generation plan.

In order to develop a policy of power source diversification in the Power sector, the GOB requested support from the Japanese government in terms of establishing the PSMP2010 which covers the strategy to expand coal-fired power generation focusing on not only domestic coal but also imported coal procurement.

In this situation, JICA implemented "The Study for Master Plan on Coal Power Development (PSMP2010)", which started in September 2009 and finished in February 2011. The study covered the strategy to expand coal-fired power generation focusing on utilizing imported coal and developing domestic coal.

As a result of the study, various measures for power source diversification, focusing on the expansion of coal usage in order to secure stable power supply in Bangladesh were proposed. By 2030, the measures targeted optimum power development planning, power system planning and the identification of potential sites for the coal-fired power station based on power sources diversification.

Based on the results of the PSMP2010, the Government of Bangladesh (GOB) has implemented a study of coal-fired power development, and in 2011, the GOB requested the Japanese government to conduct a study to inquire into the possibility of receiving support from Japan for imported coal power development. JICA implemented "Data Collection Survey on Coal Power Master Plan Follow-up (Follow-up Survey)", which started in December 2011 and finished in March 2012. In this Follow-up Survey, the detailed study including the selection of candidate sites was conducted.

By reflecting the results of the Follow-up Survey, GOB and JICA has signed the MOM regarding the implementation of "The Preparatory Survey on the Chittagong Area Coal Fired Power Plant Development Project" on March 2012.

1.2 Objective and Duration of the Study

1.2.1 Objective of the study

The Study is conducted for the investigation required for the examination to carry out the Chittagong coal-fired power plant construction project as a yen loan project.

Chittagong coal fired power plant is on the verge of starting future coal power development which was formulated by PSMP2010, and would be the first large-sized imported coal-fired high efficiency power plant of its kind in Bangladesh. During conducting this Study, full concern was given to this position.

1.2.2 Scope of the study

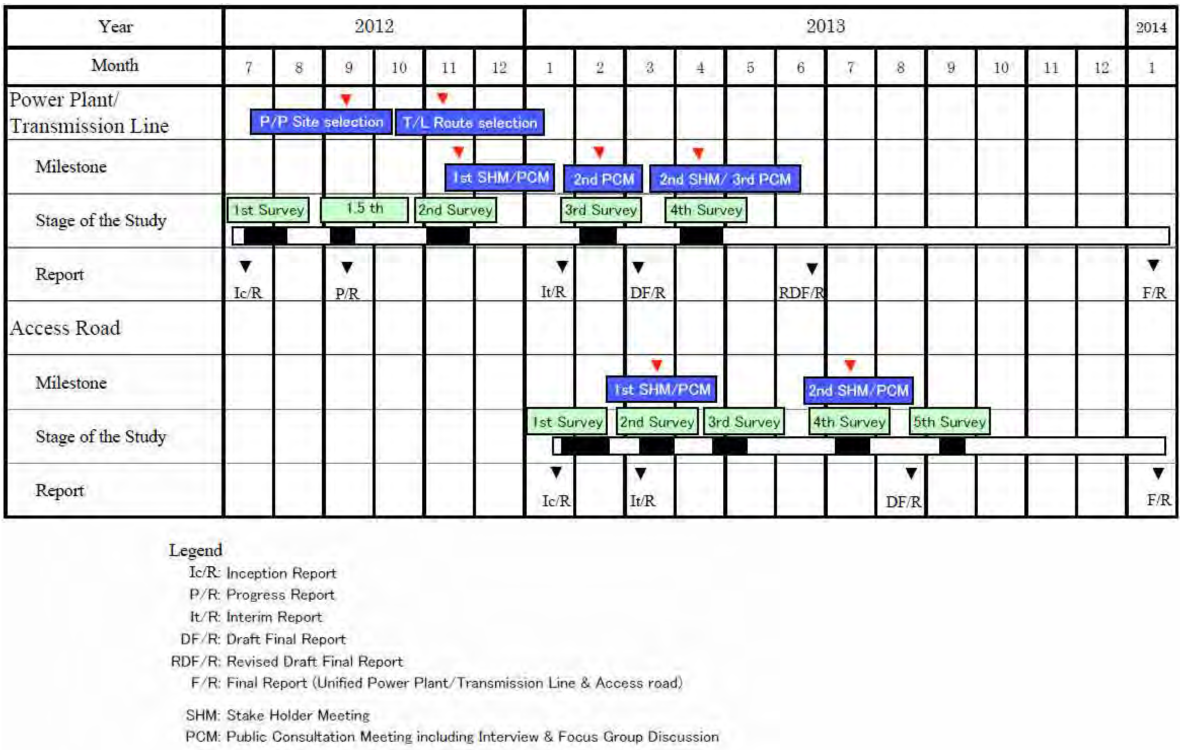
The following is the scope of the study;

- Confirmation of the background of the Project
- Preliminary design and the selection of optimum plan
- Investigation of natural condition
- Outline of the Project
- Study of fuel supply plan
- Power system analysis
- Designing of the facility
- Construction method
- Project schedule
- Formulation of consulting services implementation plan
- Organization of the implementation and O&M
- Environment and social study
- Cost estimation
- Donor comparison
- Formulation of the Project implementation plan
- Evaluation of the Project
- Support for DPP reporting

1.2.3 Duration of the study

The following table shows the overall schedule of the Study.

Table 1.2-1 Implementation Schedule of the Study



1.3 Assignment of the Study Team

Expert list and its role of work are as follows:

- Team Leader/ Power Plant System Planning A — Shigeru SAITO
- Deputy Team Leader/ Power Plant System Planning B — Yoichiro KUBOTA
- Power Plant Construction Planning — Shinji OUCHI
- Implementation Plan and Estimation — Sachio KOSAKA
- Civil — Mitsuaki SHIMADA
- Mechanical — Hideki ASAYAMA
- Electrical and I&C — Yoshihide KANAI
- Port Planning — Mitsunobu ABE
- Port Engineering — Ryo KONDO
- Power System Analysis — Atsushi YUIHARA
- Transmission — Satoshi KOBAYASHI
- Substation — Tomio ICHIKAWA

- Fuel Supply Planning Hajime ENDO
- Fuel Transportation Planning Genshiro KANO
- Operation & Maintenance Management A Kiyoshi KATAOKA
- Operation & Maintenance Management B Mayo YONEYAMA
- Human Resource Administration Keiichi FUJITANI
- Economy and Financial Analysis Yasuhisa KURODA
- Organization Structure Noboru SEKI
- Project Operation Atsumasa SAKAI
- Environmental A Tadashi NAKAMURA
- Environmental B Shigeki WADA
- Environmental Impact Evaluation Norihiko FUKAZAWA
- Fauna &Flora Kenzo UTSUGI
- Environmental & Social Consideration Tadashi MIYAGI
- Social Consideration Junko FUJIWARA

<Access Road Unit>

- Access Route Selection/Road /Foundation Kiyoshi WATANABE
- Road Planning Toshiyuki KOBAYASHI
- Road Construction Plan/Cost Estimate Takeo MOGAMI
- Natural Condition (Foundation/Geology/Hydrology) Yoshiyuki AKAGAWA
- Bridge/Structure Design Makoto IIDA
- Environmental & Social (Land Acquisition and Resettlement Action Plan Osamu NAKAZAWA
- Environmental & Social 8Social Survey and Ecosystem Jiro OTSUBO
- Environmental & Social (EIA) Kazuhiro YOSHIDA
- Economic Analysis Hiroaki YAMAGISHI

Chapter 2

Basic Concept of the Project

Chapter 2 Basic Concept of the Project

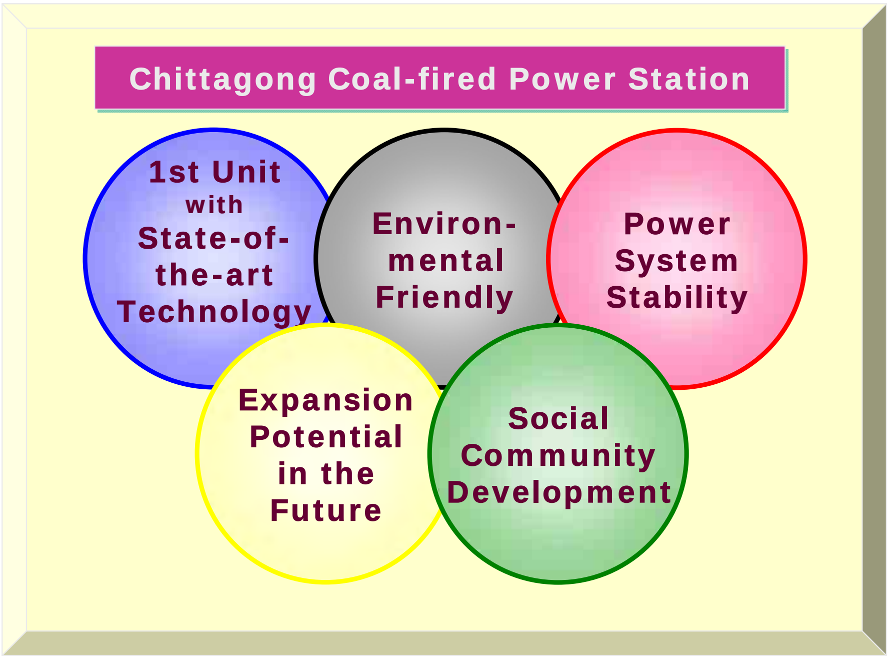
2.1 Configuration of the Basic Concept

The project includes first experience items for Bangladesh such as large size high efficiency coal-fired power plant, coal import and deep sea port development. In addition, it is the first step for future development.

Concerning the importance of the Project in Bangladesh, in this study, the following 5 items are configured as “Basic Concept”, and the study was conducted in order to achieve them.

- 1st Unit with State-of-art Technology
- Environmental Friendly
- Power System Stability
- Expansion Potential in the Future
- Social Community Development

The following figure is a visual breakdown of the basic concepts.



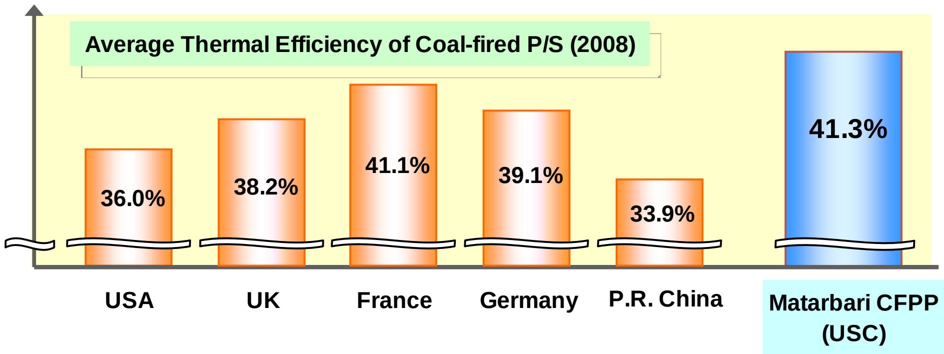
(Source: JICA Study Team)

Figure 2.1-1 Image of Basic Concepts

2.1.1 1st unit with state-of-the-art technology

This would be the first large scale coal-fired power plant in Bangladesh, and GOB is planning to continue developing a similar power plant based on the power development plan of PSMP2010. Concerning this situation, a facility with high performance and high reliability would be applied to the Project, and the facility would lead to the improvement of the technical capabilities of Bangladesh through the construction, operations and maintenance of the facility for the purpose of the progress in their own skill for development, operations and maintenance.

For the generation facility, the Ultra Super Critical (USC) technology with the steam of 600°C class would be applied, which is the state-of-the-art and the highest performance in the current reliable commercial base coal-fired power plant. As shown in the following, the efficiency of the USC facility is high compared with major countries, the base-up of the efficiency of Bangladesh could be expected by becoming widely used.



(Source : JICA Study Team base on "International Comparison of Fossil Power Efficiency and CO2 Intensity)

Figure 2.1-2 Comparison of Thermal Efficiency

As shown in the following table, there are many installations and operational records of a 600°C class USC coal-fired power plant in the world, mainly in Japan, especially Japan has more than 15 years of operating experience, it means that there is a technically proven and highly reliable facility. Even in countries which have no experience like Bangladesh, a high performance operation could be expected.

Table 2.1-1 Track Record of USC Coal Fired Power Plant in Japan

Company	Unit Name	Capacity (MW)	Main Steam Press (MPa)	Main Steam Temp. (℃)	RH Steam Temp. (℃)	Date in Operation	Boiler Manufac-turer	Turbine Manufuc-turer	Generato r Manufuc turer
Chugoku	Misumi #1	1,000	24.5	600	600	Jun-1998	MHI	MHI	MELCO
Tohoku	Haramachi #2	1,000	24.1	600	600	Jul-1998	BHK	Hitachi	Hitachi
J-POWER	Tachibanawan #1	1,050	25.0	600	610	Jul-2000	IHI	TSB/GE	GE
J-POWER	Tachibanawan #2	1,050	25.0	600	610	Dec-2000	BHK	MHI	MELCO
J-POWER	Isogo #1	600	25.0	600	610	Apr-2002	IHI	Fuji/Siemens	Fuji
Hokkaido	Tomato-Atsuma #4	700	25.0	600	600	Jun-2002	IHI	Hitachi	Hitachi
Tokyo	Hitachinaka #1	1,000	24.5	600	600	Dec-2003	BHK	Hitachi	Hitachi
Tokyo	Hirono #5	600	24.5	600	600	Jul-2004	MHI	MHI	MELCO
J-POWER	Isogo #2	600	25.0	600	620	Jul-2009	IHI	Hitachi	Hitachi
Tokyo	Hitachinaka #2	1,000	24.5	600	600	Dec-2013	BHK	Hitachi	Hitachi
Tokyo	Hirono #6	600	24.5	600	600	Dec-2013	MHI	MHI	MELCO

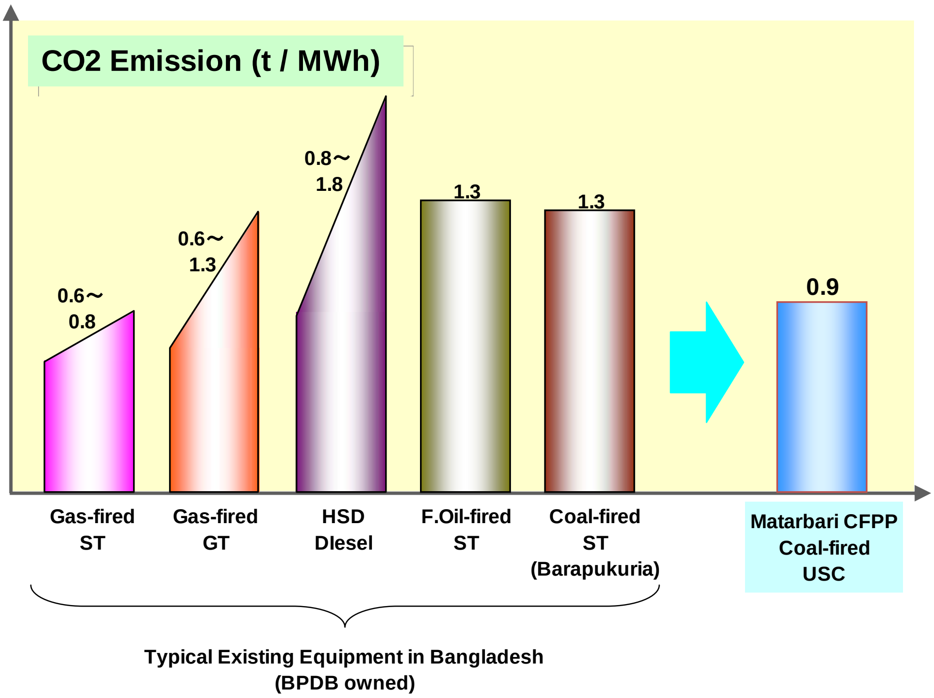
MHI: Mitsubishi Heavy Industries ltd
MELCO: Mitsubishi Electric Corporation
BHK: Babcock-Hitachi K.K.
TSB: Toshiba Corporation
GE: General Electric Company
(source: JICA Study Team based on the information from each manufacturer)

In the study of the organization structure, the personnel positioning and job allocation of the construction office or power station is studied with the concept that the Bangladeshi staff and engineer could improve their own technical skill through the construction, operation and maintenance of the power plant, and effective personnel training could be conducted.

2.1.2 Environmental friendly

Generally, from an environmental perspective, a coal-fired power plant is at a disadvantage compared with other fuels. However, by applying advanced facilities with a comparable environmental performance with a natural gas-fired power plant is to be expected. For the Project, such advanced facilities are applied.

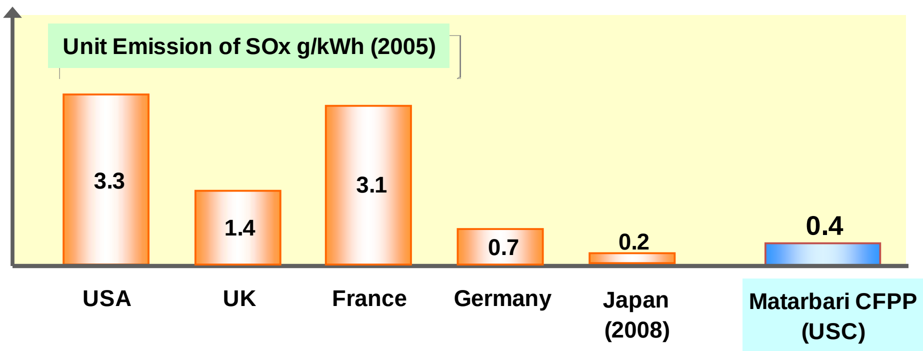
First, regarding CO_2 emissions, since high efficiency could be achieved by applying a 600°C class USC facility, it leads to fuel conservation, as a result unit CO_2 emissions could be reduced. The following figure shows a comparison of CO_2 emissions with existing thermal power plants in Bangladesh. It is clear that for that aspect of CO_2 emissions, the facility applied to the Project has a similar level of performance with the plant using other fuels even though it uses coal which emits more CO_2 than other fuels.



(Source: JICA Study Team based on BPDB Annual Report)

Figure 2.1-3 Comparison of CO_2 Emission

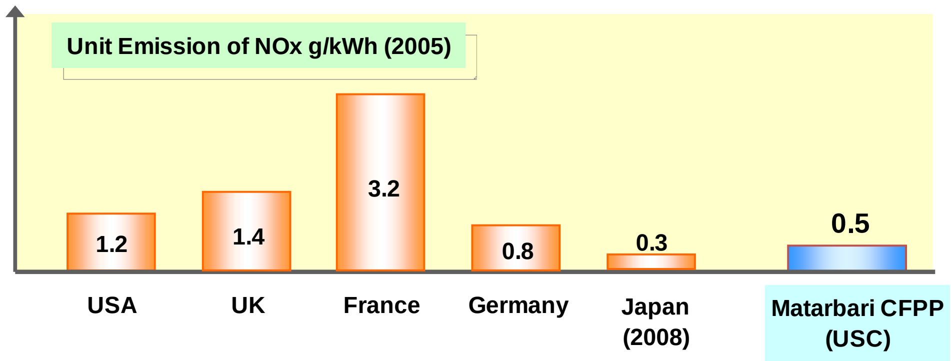
Regarding SOx which is one of the air pollutants, there is the case of coal firing an amount of emissions more than other fuels. However, the application of a high performance fuel desulfurization system leads to the considerable reduction of emissions. As for the following figure, the system leads to the lowest level of SOx emissions in the world. (assumed 1% of the sulfur content rate in coal, and 95% of the desulfurization ratio).



(Source: JICA Study Team based on OECD Environmental Data Compendium)

Figure 2.1-4 Comparison of SOx Emission

Regarding NOx which is also one of the air pollutants, by applying technologies for NOx reduction such as the Low NOx burner and the improvement of firing, it could also be reduced to a lower level in the world.



(Source: JICA Study Team based on OECD Environmental Data Compendium)

Figure 2.1-5 Comparison of NOx Emission

Other methods for the surrounding environment are applied such as sea water desalination in order to prevent ground subsidence by using a deep well.

And because the power plant will be located where many cyclones had passed, the design is concerned not to be damaged by cyclones such as a storm surge barrier and shore protection.

2.1.3 Power system stability

Due to fuel procurement sustainability, the coal-fired power plant should be in the important position of a base load power source. Concern should be given to a role in the power system.

First, the unit capacity is determined with the concept to minimize the impact to the whole power system in the case of a sudden outage

Furthermore, in order to supply stable power as a base load power source, concerning the situation of world coal market, the design is considered to be able to use a wide range type of coal. The risk of fuel supply would be minimized by easy procurement of coal. Furthermore, regarding the design of the coal stock yard, an easy mixture of various coal types is considered.

2.1.4 Future potential expansion

The site of the Project is nearby the deep sea area which is the handful place in Bangladesh. In the Project, a deep sea port is developed where a large-sized coal ship could enter directly.

In PSMP2010, this site is considered for not only large scale power station expansion, but also to develop a “coal center” which delivers coal to each coal-fired power plant around the country in the future.

This is the first experience for Bangladesh to develop such a large size deep sea port. It is a revolutionary development for Bangladesh. In the future, there is the possibility of the development of a multi sector such as a commercial port.

Given this potential, as the layout and design of the Project, it is fully considered not to prevent this future development.

2.1.5 Social community development

Generally, the development of power plants is the trigger to develop surrounding areas. The town is formulated around the power station, the residence are for the staff of the power plant that is developed. In addition, job opportunities for surrounding residents' increases. This development leads to economic progress. For example, the number of staff will be expected about 3,000 during construction period and about 320 after start of commercial operation. The size of population including the families of the staffs and the shops will be expected around 2,000. By preparing the residence for these staff, it will lead to the development of the town with the increase of job opportunity. And in the future, if a cement factory will be set for coal ash utilization, another development would be expected. In this study, the plot plan and access way etc. was considered not to prevent from increasing such development. For example, the buildings or water intake/discharge channels in the power plant are located by considering not to prevent from future expansion, the access road is designed not only for the construction of the power plant but also for the access from the surrounding large towns.

Chapter 3

Current Situation of Bangladesh and Necessity, Justification of the Project

Chapter 3 Current Situation of Bangladesh and Necessity, Justification of the Project

3.1 Outline of Bangladesh

3.1.1 Topography and population

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

Soil in Bangladesh is fertilized by nutrients carried by floods originating from the three major rivers, which helps with the growth of major agricultural products such as rice, jute and tea. Fishing and fishery farms in rivers and ponds across the country are thriving. On the other hand, heavy rain and river water inflow from upstream countries often causes wide-spread floods during the rainy season, resulting in flooding of approximately one third of the whole country at peak time causing considerable grief to the people in Bangladesh and much damage to the country's physical landscape. In a recent instance, the worst flood in Bangladesh history occurred in 1998, which submerged two-thirds of the country.

The land area of Bangladesh is 147,500 square kilo meters. The population in Bangladesh is regarded to be as high as 142.319 million[1], thus the population density is very high, around 1,000 people per square kilometer. The mean annual growth rate of the population is 1.39%, the same degree of India's.

In terms of the ethnic population, more than 98% of the Bangladeshi population is Bengali, with some minority Buddhist groups, e.g. Chakuma and other ethnic groups, who live in Chittagong Hill Tracts near Myanmar border. The official language is Bengali and the literacy rate of adults (15 years and older) reaches 56% (2011). As for religion, the majority is Muslim (89.7%), and the rest are comprised of Hindu (9.2%), Buddhists (0.7%) and Christians (0.3%).[2]

1 March 2011, Bureau of statistic in Bangladesh
2 Bangladesh Census 2001, Japanese Ministry of Foreign Affairs home page

3.1.2 Climate

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

Major characteristic of Bangladesh natural environment is that 80% of land area is located in alluvial plain, which major rivers, Ganges River (Padma in Bengali), the Brahmaputra River (Jamuna in Bengali) and the Meghna River, form. Along with the rain fall in Bangladesh naturally, 80% of river flow comes from the rain fall in other countries, such as India and Nepal, and domestic rain fall is attributed only 20% of total river flow. A large amount of rain fall water from upstream countries of major rivers causes flood damage in large area of Bangladesh every year.

Natural phenomena such as flood, cyclone, tornado and bore, hit Bangladesh almost every year, which causes not only transient damage but also secondary damage to the country such as deforestation, soil deterioration, land erosion, and so on.[3]

3.1.3 Political system and government structure

In 1947, Bangladesh once became independent from United Kingdom’s colonial occupation together with present Pakistan in the form of East Pakistan when India became independent from UK. Afterward, in 1971, East Pakistan became independent again from Pakistan in the form of Bangladesh due to 1,800km long distance divided country to East and West, different languages, and other many contradictions.

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

[3] The Preparatory Study for Project for the Study for Master Plan on Coal Power Development in People’s Republic of Bangladesh

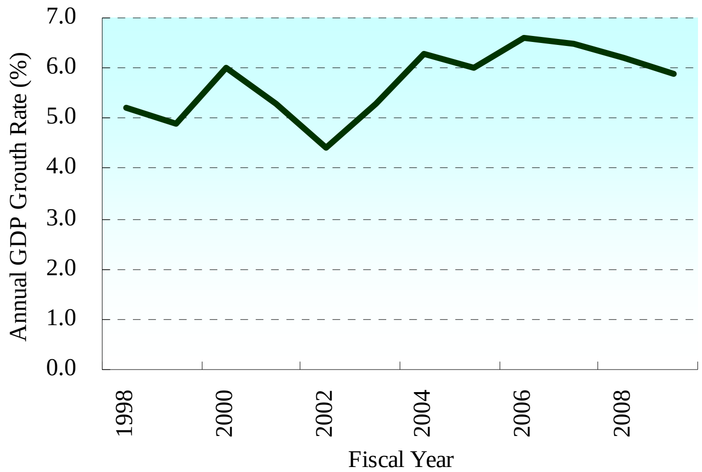
Her Excellency Sheikh Hasina, is the Prime Minister of the People's Republic of Bangladesh since January 2009. She is the head of the government.[4]

3.2 Macro Economy of Bangladesh

3.2.1 Economic overview

(1) Economic overview

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



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

Figure 3.2-1 Nominal Annual GDP Growth Rate of Bangladesh

The World Bank estimates[5] that Bangladesh will join middle-income countries in or relatively soon after 2016, though the country is presently categorized as low-income nation. In fact, the nominal GDP per capita as of 2007 has doubled since 1975, soon after the country's independence year. According to the World Bank's report, the country's poverty rate has decreased to below 20 % in the 1990s. Its unemployment rate has also decreased from 30% to 4%. Table 3.2-1 reveals the major indicators of the country's macro economy

4 JETRO homepage and others
5 Bangladesh: Strategy for Sustained Growth, World Bank, 2007

Table 3.2-1 Major Macro Economy Indicator[6]

Fiscal year	2006/07	2007/08	2008/09	2009/10	2010/11
National account	**(Incremental rate to the previous year except notification)**				
GDP(Nominal: billion Taka)	4,725	5,458	6,148	6,943	7875
Real GDP growth rate	6.4	6.2	5.7	6.3	6.7
Average inflation (CPI)	7.2	9.9	6.7	7.3	8.8
Saving/ Investment	**% of GDP**				
Savings	25.9	25.1	27.2	28.1	25.6
Investment	24.5	24.2	24.4	24.4	24.7
Saving-investment balance	1.4	0.9	2.8	3.7	0.9
Foreign account	**Billion US$**				
Export	12.1	14.2	15.6	16.2	23.0
Import	-15.5	-19.5	-20.3	-21.4	-30.3
Current balance	1.0	0.7	2.5	3.7	0.9
Foreign exchange reserves	5.1	6.1	7.4	10.1	10.0
International debt balance(% of GDP)	29.1	25.6	24.1		
Import coverage (month)	2.7	3.1	3.6	3.4	2.9

(Source: IMF, "Bangladesh: Staff Report for the 2011 Article V Consultation" November 2011)

(2) Economic growth

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

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

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

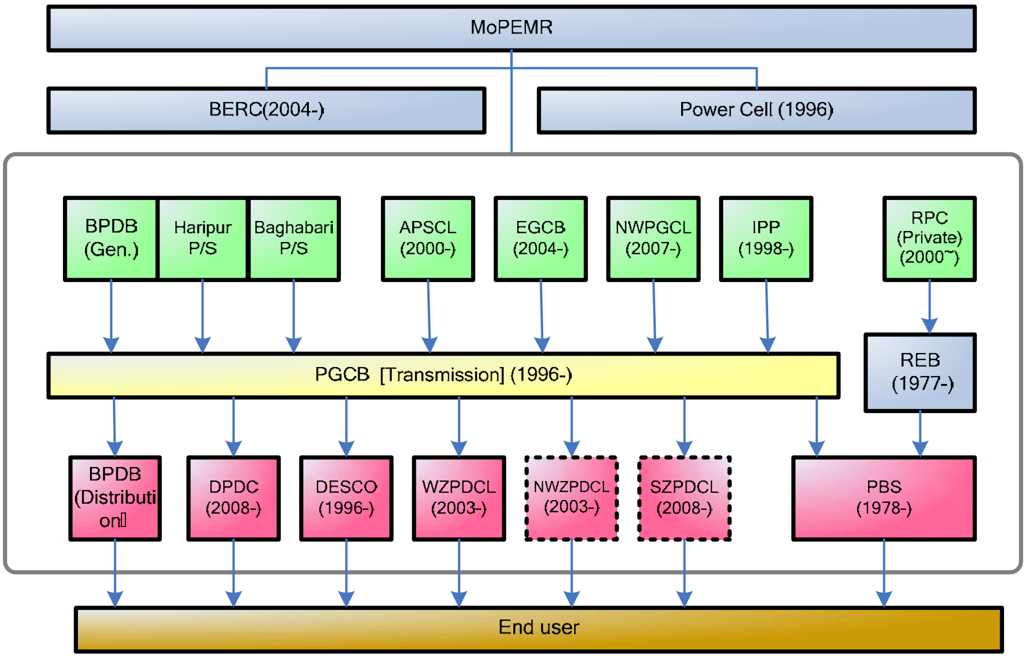
Hence, it has been pointed out that such an immature economic infrastructure has kept private enterprises away from more investment in the country, and this fact has resulted in national savings in order to maintain a constant share of the total GDP, compared to national investment to lose its share.

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

3.3 Brief of Power Sector in Bangladesh

3.3.1 Organization of power sector in Bangladesh

The following figure shows the structure of power sector in Bangladesh.



Notes: ———► : Flow of Power

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

Figure 3.3-1 Structure of the Power Sector in Bangladesh

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

For BPDB power generation department, the Haripur power plant was changed to the Strategic business Unit (BSU)[7] and the Ashuganj power plant was changed to the subsidiary based on the "Vision Statement/Policy Statement (January, 2001)." And then, the Baghabari power plant was changed to the BSU, EGCB who owns Siddirganj Power Station (210MW), and NWPGCL who developed Khulna Power Station (150MW) and Sirajganj Power Station (150MW), and will develop Bheramara Power Station (360MW) were split up from BPDB based on the "Vision Statement/Policy Statement" and "3-Year Roadmap (2006)"

3.3.2 Current situation of power sector

(1) Chronic power shortage

The following table shows the electricity consumption per capita of Bangladesh and other surrounding countries. Compared with those countries, Bangladesh's is small in the world.

Table 3.3-1 Electricity Consumption per Capita

Country	Electricity Consumption Per Capita (kWh/capita)
Malaysia	3,672
China	2,631
Thailand	2,072
India	596
Pakistan	452
Sri Lanka	415
Bhutan	262
Bangladesh	228

(Source: IEA, Energy Balances of Non-OECD Countries, 2011; US CIA, The World Factbook 2011)

The electrification rate of Bangladesh is 47% in terms of population. (National census in 2009)

Chronic power shortages are a problem in Bangladesh. There was an incident once when 30% of the total demand during peak hour was not supplied as shown in the following figure.

The World Bank report[8] estimates that the productivity of the average enterprise falls by 10% as the number of blackouts per year increases by 1%.

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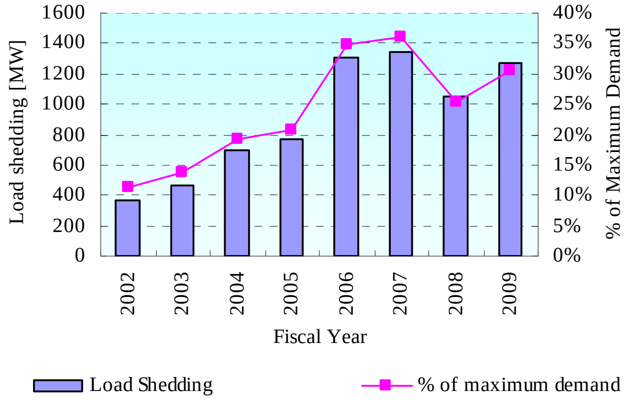
[7] SBU (Strategic Business Unit) is a form of the organization which BPDB still owns but transfer the authority to some extent.

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



(Source: BPDB Annual Report 2008-2009)

Figure 3.3-2 Annual Load Shedding/Restriction [MW]

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

On the other hand, BPDB regards the power shortage as the most important issue. However, the process of securing a stable supply is not without its mishaps. In order to secure a stable power supply within a short period of time, there is no choice but to depend on rental power which saves on the time required to build a power station. However, the unit costs are very high. These increased power purchase costs have put BPDB in a very tight financial situation. Most of the generation facilities under BPDB are being operated continuously without any planned shutdowns for maintenance or overhaul. Unceasing operations at maximum capacity minus periodical maintenance eventually causes a breakdown. Once the facility breaks down, the power plants are forced to shut down for a long time and the repair costs are tremendous. Power supply stability worsens resulting in what is termed a "Negative Spiral".

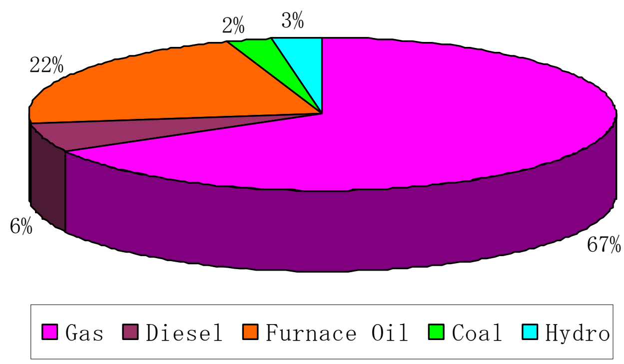
According to a report by the World Bank in 2003[9], around 70% of the interviewed enterprises answered that electricity supply is the obstacle blocking potential investments,

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

largely exceeding the amount of the whole south Asian region, 40%. Taking into account that the other investment environments are superior to that of middle-income countries such as China and India[10], it is expected that any industry which requires stable power supply would experience a lasting leap upwards once the power shortage issue is resolved. In fact, it is said that the reason Japanese investment in Bangladesh is not progressing as steadily as hoped for in spite of high interest in Bangladesh as an overseas production base is the unstable power supply. Simply put, stable power supply benefits not just the nation of Bangladesh but will also serve to attract Japanese enterprises.

(2) Risk of natural gas

70% of all generation facility in Bangladesh is natural gas-fired thermal power facilities.



(Source: BPDB Annual Report 2011-2012)

Figure 3.3-3 Power Source in Bangladesh

Natural gas consumption in Bangladesh is approximately 650BCF (Petrobangla Website, 2009). According to PSMP2010, the estimated amount of natural gas reserves was approximately 20TCF. Considering the demand increase, it is said that the amount of gas production will reach approximately 1,500BCF at its peak in 2017. In the future, there is the risk that natural gas supplies will be insufficient for power generation because it is needed not only for power generation but also for the residential/commercial sector. Sole dependence on natural gas to achieve a stable power supply is a dangerous proposition.

Countermeasure

As mentioned above, there are risks such as the possibility of a chronic power shortage and an over-dependence on natural gas. In order to deal with these risks, the most important and urgent issue is to work towards “the diversification of energy resources by cheaper power development with an ensured supply of energy”.

[10] Doing Business, World Bank

3.4 Donor Activities and Performance of Implemented Projects

3.4.1 Donor activities

Donors providing significant scale in financing as well as in technical assistance are recognized at; Asian Development Bank and World Bank, while there exist other donors including the Kuwait Fund, the Russian Federation, KfW and others extending sporadic assistance in providing loans or technical assistance. The following are the notable activities carried out by those donors for the power sector in Bangladesh;

(1) Asian Development Bank (ADB)

ADB's Country Partnership Strategy (hereinafter referred to as "CPS")[11] stipulates its policy of emphasizing; (i) continuation of the policy, legal and regulatory reforms to create an enabling business environment for the private sector; (ii) implementation of power transmission interconnections with India; (iii) investment in new power generation facilities and rehabilitation of old power plants for improved efficiency; (iv) increased investment in clean energy; (v) transmission network strengthening for expected generation capacity additions. ADB aims at achieving; (i) access to electricity increased from 47% of the households in 2009 to 65% in 2015; and (ii) per capita consumption of electricity increased from 170 kWh in 2010 to 390 kWh in 2015. ADB's major activities for the power sector in the power sector are as follows;

[11] ADB, "Country Partnership Strategy: 2011-15", October 2011

Table 3.4-1 ADB's Activities

Calendar Year	Project	Type	Amount (US$ million)	Executing Agency
2000-02	Meghnaghat Power	Loan	70	AES Meghnaghat Ltd.
2001-08	West Zone Power System Development	Loan	60	MPEMR, PGCB, REB
2001-10	West Zone Power System Development	Loan	186	BPDB, PGCB, REB
2001	Corporatization of West Zone Distribution Operations of BPDB	Tech Assist.		MPEMR
2002-04	Corporatization of DESA	Tech Assist.		MPEMR
2003-05	Power Sector Dev. Program (Program Loan)	Loan	100	MPEMR
2003-10	Power Sector Dev. Program (Project Loan)	Loan	186	BPDB, PGCB, EGCB
2005	Corporatization of BPDB	Tech Assist.		BPDB
2006	Promotion of Private Sector Participation in the Power Sector	Tech Assist.		Power Div.
2007-12	Sustainable Power Sector Dev. Program (Project Loan)	Loan	400	MPEMR, BPDB, NWPGCL, PGCB, DPDC(DESA), DESCO
2007-12	Sustainable Power Sector Dev. Program (Program Loan)	Loan	60	MOF, Power Div.
2007	Tendering Process for Independent Power Producer (IPP)	Tech. Assist.		Power Cell
2010-(cont)	Bangladesh – India Electrical Grid Interconnection Project	Loan	100	PGCB
2012	Power System Efficiency Improvement Project	Loan	300	Power Div. APSCL, BPDB
Total			1,462	

(note) A number of preparatory studies for the loan stipulated above have been provided but are omitted here.
(source: ADB, website)

The table above enumerates the major power sector projects to which ADB extended assistance. Prior to what appears in the above table, ADB is known to have continuously provided financial as well as technical assistance. During the period of 1973 through 1999, 14 loans had been granted for the aggregate amount of US$ 783 million and 17 cases of technical assistance. Out of the projects listed in the above table; the (i) West Zone Power System Development extended assistance to the creation of WZPDCL, creation and operationalization of the new regulatory authority, augmentation of transmission and distribution lines and substations; (ii) the Power Sector Development Program has dealt with the promotion of sector reform through the financial stabilization of PGCB, DESCO, BPDB and DESA by settlement of outstanding dues of the governmental bodies besides conducting the Study for Power System Master Plan Update 2006. The Program has provided financing for Siddirganj 2 X 120 MW power plant; (iii) Sustainable Power Sector Development Program has financed the new clean-fuel based generation plants; Sirajganj 150 MW peaking power plant and Khulna 150 MW peaking power plant and the improvement of efficiency in transmission and distribution; and (iv) the Power System Efficiency Improvement Project has addressed the replacement of old power stations at APSCL with an efficient combined cycle plant (450 MW), conversion of a less efficient plant at Siddirganj to a combined cycle plant (318 MW), construction of 400 kV and 230 kV transmission lines (332 km), etc.; whereas for the other projects, the title of the projects reflects the contents of the projects.

The specific generation projects assisted by ADB include the ones stipulated above and Meghnaghat IPP Power listed in the above table. The ADB’s assistance to generation projects for the development of implementation capability has been financed through allocation of a part of the loan funds in the loan agreements. ADB has no practice of extending technical assistance grants for developing the institutional capability of the executing institutions. The capacity building program has included such components as; overseas training, procurement assistance, etc.

All in all including the projects implemented prior to the above table, the entities assisted by ADB includes almost all of the public entities in the power sector, including MPEMR (Power Division and Power Cell), BERC, BPDB, PGCB, APSCL, EGCB, NWPGCL, REB, WZPDCL (a part of BPDB’s operation), DESA, DPDC, DESCO, South Zone Power Distribution Company Ltd. (SZPDCL, a part of BPDB’s operation). ADB’s projects in the pipeline includes the conversion of the simple cycle power plant into the combined cycle ones which ADB intends to implement by co-working with other development partners.

With regard to the probability of ADB extending financial assistances for the development of coal-fired power generation plants, ADB is expressing less inclination for financing by stating that there exist many hurdles of safeguard that have been established within its organization and are hard to be cleared[12].

[12] Interview conducted at ADB under the Master Plan Study in 2010-11

(2) World Bank (WB)

In the Country Assistance Strategy 2011-15[13], World Bank sees that the peak power deficit is more than 2,000 MW. In the absence of investment, the deficit is expected to more than double in the next ten years. As a strategic priority for the government, transformative investments in the energy sector will be the prime focus for World Bank during the CAS period. World Bank's support will be three-pronged. First, the Bank will adopt a pragmatic approach to domestic generation and transmission that will combine support for sector reforms with large scale investments. Second, the Bank will encourage integration with regional electricity networks through strategic investments. Third, the Bank will scale up the IDA funded Rural Electrification and Renewable Energy Development Program. World Bank is presenting its major activities for the power sector as follows;

Table 3.4-2 World Bank's Activities

Calendar Year	Project	Type	Amount (US$ million)	Executing Agency
2000-01	Haripur Power Project	Loan	61	AES Corp
2002-08	Rural Electrification and Renewable Energy Development Project	Loan	191	REB, IDCOL
2004	Power Sector Development Technical Assistance Project	TA Loan	16	Power Div. BERC
2008-09	Power Sector Development Policy Credit	Loan	120	MOF, MPEMR
2008-(cont)	Siddirganj Peaking Power Project	Loan	350	EGCB, PGCB, GTCL
2009-(cont)	Additional Financing for Rural Electrification and Renewable Energy Dev. Project	Loan	130	REB, IDCOL
2011-(cont)	Additional Financing II for Rural Electrification and Renewable Energy Dev. Project	Loan	172	IDCOL
Total			1,040	

(note) A number of preparatory studies for the loan stipulated above have been provided but are omitted here.
(source: World Bank, website)

Out of the projects listed in the above table; (i) Rural Electrification and the Renewable Energy Development Project were committed in 2002 and two additional cases of financing were committed in recent years addressed the assistance to REB for expansion of its outreach, capacity of rural grids and the promotion of the solar home systems in remote rural areas through the financing to be provided by the Infrastructure Development Company Ltd. (hereinafter referred to as "IDCOL"); (ii) Power Sector Development Technical Assistance Project has extended technical assistance with the objectives of the creation of effective capacity at MPEMR and BERC including the

[13] World Bank, "Country Assistance Strategy 2011-2015", July 2010

Study for Financial Restructuring and the Recovery Plan and the preparation for at least two well structured power sector investment projects; and the (iii) Power Sector Development Policy Credit has supported the promotion of the private sector participation in power generation, full operationalization of BERC, registration of SZPDCL, power sector financial restructuring, etc.

The specific generation projects assisted by WB include Haripur IPP Power, Siddiranj Peaking Power Project, Bibiyana I and Bibiyana II Project. The extended capacity building program has included primarily the procurement assistance, including preparation of bidding documents, evaluation, contract negotiation, etc.

The entities assisted by World Bank include MPEMR (Power Division), BERC, BPDB, EGCB, PGCB, REB, IDCOL, SZPDCL (a part of BPDB's operation).

With regard to the probability of WB extending financial assistances for the development of coal-fired power generation plants, WB is expressing less inclination for financing by stating that there exist the following six pre-conditions that have been established within its organization and are hard to be cleared[14].

<Six Pre-conditions (from Box 1 of "Energy Strategy Approach Paper" (Oct. 2009, World Bank))>

1) There is a demonstrated developmental impact of the project including improving overall energy security, reducing power shortage, or increasing access for the poor.
2) Assistance is being provided to identify and prepare low-carbon projects.
3) Energy sources are optimized, looking at the possibility of meeting the country's needs through energy efficiency (both supply and demand) and conservation.
4) After full consideration of viable alternatives to the least-cost (including environmental externalities) options and when the additional financing from donors for their incremental cost is not available.
5) Coal projects will be designed to use the best appropriate available technology to allow for high efficiency and, therefore, lower GHG emissions intensity.
6) An approach to incorporate environmental externalities in project analysis will be developed.

[14] Interview conducted at ADB under the Master Plan Study in 2010-11

(3) Other Donors

According to the World Bank's document called "Bangladesh Donor Mapping" attached to the Bank's Country Assistance Strategy Paper[15], donors focusing on the power sector are identified by World Bank as; World Bank, ADB, Japan, Germany, Korea, UN, USA, while France is acknowledged as "phasing in" while the UK is "phasing out" whereas some participation is observed at Norway.

Meanwhile, ADB reports the external loan assistance received by Bangladesh during 1972 through 2005 as; (i) multilateral agencies including ADB, WB, Islamic Development Bank and OPEC for the aggregate amount of US$ 2,150 million; (ii) bilateral agencies including France, Germany, Japan, Kuwait, People's Republic of China, Russia, Saudi Arabia, UK, USA for the aggregate amount of US$ 2,119 million.[16]

Aside from the reports made by World Bank and ADB as above, the following is the cases of projects that have been broadcasted by the donors as the results of their assistance;

Table 3.4-3 Projects Assisted by Other Donors

Donor	Calendar Year	Project	Type	Amount	Executing Agency
Kuwait Fund	2000-	Greater Chittagong Power Transmission and Distribution Development Project	Loan	US$ 42 million	
	2007-(cont)	Greater Chittagong Power Transmission and Distribution Development Project Ph-III	Loan	US$ 14 million	
	2011-(cont)	Shikalbaha 225 MW Combined Cycle Power Plant	Loan	US$ 51 million	BPDB
KfW	2002-(cont)	Promotion of Renewable Energy	Loan	Euro 16.5 million	
Russian Federation		(used to assist Ghorasal TPS 950 MW & Siddirganj TPS 210 MW)			
USAID		SARI for/Energy			
People's Republic of China		Barapukuria Coal Thermal Power Station 250 MW	Loan	US$ 210 million (*1)	BPDB

(note) *1: Contract amount released by the contractor, China National Machinery Import and Export Company.
(source: Websites of respective donors)

15 World Bank, "Country Assistance Strategy 2011-2015", July 2010
16 ADB, "Sustainable Power Sector Development Program", June 2007

The table above reveals the activities of some of the donors other than the major three. Among those, the Kuwait Fund is shown to have financed two sizable projects of a transmission line in the Greater Chittagong area and the combined cycle power plant of 225 MW at Shikalbaha[17].

Germany focuses on the energy sector, in particular, energy efficiency and renewable energies. The German Financial Cooperation attaches particular importance to the sustainability and supports institutional reforms in the priority areas of cooperation. KfW is supporting GOB's strategy by promoting the local, off-grid use of renewable energies (solar home system, biogas) in rural areas. KfW is making commitment to the effect that it will increase its efforts in this priority area of cooperation in the years to come[18].

The Russian Federation announces through its website that Russia maintains a strong tie with Bangladesh as it is responsible for financing two large thermal power plants of Ghorasal and Siddirganj throughout its history. The website keeps mentioning that Russia is ready to further strengthen its relations with Bangladesh and is considering not only the modernization of existing plants but also the introduction of new technologies based on the use of other sources than gas for energy[19].

Unlike the other donors, USAID concentrates in providing assistance in a knowledge based cooperation, distancing itself away from involvement in the infrastructure development. Through the South Asia Regional Initiative for Energy (hereinafter referred to as "SARI"), USAID continues to extend intelligent assistance to the power sector. The SARI Energy program promotes energy security in South Asia by focusing on the following three areas: (i) cross border energy trade, (ii) energy market formation, and (iii) regional clean energy development. It has initiated the cross border trade of electricity with India that has culminated in signing bilateral agreements with the government of India and is under way in its implementation phase.

China has been extending assistance for the development of Barapukuria Coal Mines and its associated construction of a 2 X 125 MW coal-based thermal power plant. The coal mine is said to have started its commercial operations several years ago, the construction of the power plant appears to have taken longer than expected. The plant is

[17] Kuwait Fund for Arab Economic Development, website
[18] KfW, website
[19] Embassy of the Russian Federation in Bangladesh, website

reported to have been officially delivered to BPDB in May 2012[20]. China is reported to be in negotiation with the government of Bangladesh for the expansion of the coal mine and the power plant.

Finally, a remark ought to be made with regards to the UK. DFID, the donor window of UK is releasing its official strategy under the "Operational Plan 2011-2015" dated April 2011 to the effect that DFID will concentrate its efforts on supporting the achievement of the MDGs, creating wealth in poor countries, strengthening their governance and security and tackling climate change while making it clear that, through strategic reprioritization, DFID is graduating from large scale infrastructure projects[21].

3.4.2 Performance of power entities and implemented projects

The external assistance received for the power sector can be rearranged into the segments of the power sector where the assistance has been directed. The segments include; (i) sector reform, (ii) regulatory control, (iii) generation, (iv) transmission, (v) distribution, (vi) off-grid, (vii) others. The following are the typical issues that remain entangled at the power entities despite the efforts that have been made under the assistance provided by the external donors;

(1) Sector reform

The power sector reform is defined by the government as being comprised of the following principal components[22];

(i) Segregation of power generation, transmission, and distribution functions into separate services and creation of the BPDB holding company as an apex body where generation;
(ii) Corporatization and commercialization of emerging power sector entities;
(iii) Effective regulation under BERC for power and gas;
(iv) Private sector participation and private-public partnership in the power sector;
(v) Financial restructuring and recovery plan for the sector;
(vi) Introduction of the cost reflective tariff for financial viability of the utilities and promoting efficient use of electricity;
(vii) Development of demand side management including energy efficiency measures to conserve energy;

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[20] China National Machinery Import and Export Company, website
[21] DFID, website
[22] Power Division, MPEMR, "3-Year Road Map for Power Sector Reform (2008-10)", May 2008

(viii) Creation of an appropriate framework and institution to facilitate the development of alternative/ renewable energy resources;
(ix) Utilization of captive power potential through an appropriate policy framework; and
(x) Capacity building and human resource development (hereinafter referred to as "HRD") for sector entities and corporatized bodies.

Out of the components listed above, the (i) segregation of power generation, transmission and distribution have been assisted by a large number of projects of different donors including such projects financed by ADB: West Zone Power System Development Project (2001), Power Sector Development Project (2003), Sustainable Power Sector Development Program (2007), Power System Efficiency Improvement Project (2012); the ones financed by World Bank: Rural Electrification and Renewable Energy Development Project (2002, 2009, 2011) and Power Sector Development Policy Credit (2008), etc. The (ii) corporatization and commercialization has been typically attended by ADB's Corporatization of BPDB (2005) and the Corporatization of DESA (2002), etc. The (iii) effective regulation by BERC has been the target of many donors for assistance. ADB extended assistance to BERC through the projects of Support for the Energy Regulatory Authority (1998) and the Power Sector Development Program (2003) whereas World Bank assisted through the Power Sector Development Technical Assistance Project (2004) and the Power Sector Development Policy Credit (2008), etc. In addition, USAID is known to have provided financial assistance to BERC for operationalization.

The (iv) private sector participation has also been the targets of assistance from different donors. The assistance to the segment is typically represented by ADB's Promotion of Private Sector Participation in the Power Sector (2006) and the Tendering Process for Independent Power Producers (2007) besides the provision of financial support directed to the Meghnaghat Power Project (IPP) in 2000. World Bank is also recognized in its extending of financial support to an IPP, Haripur Power Project in 2000. The (v) financial restructuring and recovery was assisted by World Bank's Power Sector Development Technical Assistance Project (2004). The (vi) introduction of the cost reflective tariff is the task BERC is assigned with and assistance provided for the creation and operationalization of BERC has been attending the subject. The (vii) demand side management and energy efficiency measures have been covered by projects such as; ADB's Sustainable Power Sector Development Program (2007), World Bank's Rural Electrification and Renewable Energy Development Project (2009) and

JICA's Total Quality Management and Power Distribution (1999). The (viii) development of renewable energies is also assisted by a sizable number of donors. The leading donor and project for the subject include World Bank's Rural Electrification and Renewable Energy Development Project (2002, 2009, 2011) and KfW's Promotion of Renewable Energy (2002), etc. The (x) capacity building at the sector entities is the issues handled repeatedly by many of the donors for extending various assistance. A typical and continuing example of the capacity building is found in JICA's Total Quality Management and Distribution Project (1999-09).

Despite the strenuous efforts made by the power sector entities under the assistance provided by the donors, there remain a number of critically important issues that need to be straightened out, including but not limited to, (i) clarification and establishment of the functions and player of the single buyer, (ii) clarification and demarcation of the transmission lines and business between BPDB and PGCB, (iii) unbundling and corporatization of NWPDCL, SZPDCL and CZPDCL, (iv) rationalization and efficiency improvement at BPDB, etc.

(2) Regulatory control

The Bangladesh Energy Regulatory Commission Act was enacted in 2003. BERC has been established and made functional to regulate the electricity, gas and petroleum sector. The establishment and operationalization of BERC has been assisted by donors as mentioned above. With respect to the tariff, the power pricing framework has been approved by the government, in accordance with BERC's efforts to rationalize the tariff. BERC's tariff rationalization efforts have been confronted with public backlash and pressure from the government to contain the abrupt hike of the tariff. The introduction by the government of the RPPs and QRPPs has caused chaos in regulating the tariff at BERC.

Based on the government policy and commitment to rationalize the tariff, rapid revisions of electricity tariffs are observed to be under way. The latest revision of the tariff made by BERC as of September 1, 2012 has brought the bulk tariff to Tk 4.70/kWh in the third revision of the year. The level achieved covers at least the average power supply cost at BPDB of Tk 4.20/kWh but is not sure if it covers sufficiently the present average supply cost. The continuation of the efforts needs to be carried onward to achieve a rational tariff system.

(3) Generation

BPDB has spun off Ashuganj Power Station in establishing APSCL in 2003. There had been protracted delays in the implementation of the unbundling as a PPA had not been signed for a long while. The company had to operate under a provisional PPA and tariff under which APSCL had to undergo a shaky financial arrangement with BPDB for temporary funding for its financial shortfall. As has been analyzed earlier, the company has inherited some legacy from pre-reform BPDB in which APSCL's account receivable days recorded as 124 days and a large amount of the debt service liabilities. APSCL is constructing new plants; a 225 MW combined cycle power plant under the export credit agency (hereinafter referred to as "ECA") backed the project financing; a 450 MW combined cycle power plant also with ECA financing; a 450 MW combined cycle power plant with financing from ADB and the Islamic Development Bank (IDB). Besides, the company completed a 53 MW gas engine power plant with its own financing in the amount of US$ 41 million which went into commercial operations in April 2011.

EGCB was incorporated in 1996 under the name of Meghnaghat Power Company Ltd. and was later renamed to Electricity Generation Company of Bangladesh Limited. The company has been constructing three major plants; (i) Siddirganj 2 X 120 MW Peaking Power Plant financed by ADB which has been completed and started commercial operations in February 2012, (ii) Haripur 360 MW Combined Cycle Power Plant financed by JICA is expected to be completed in July 2013, (iii) Siddirganj 335 MW Combined Cycle Power Plant financed by World Bank is scheduled to be completed by June 2015. It appears that the company has been created with a clear balance sheet without inheriting significant legacy from BPDB.

NWPGCL was incorporated in 2007. The company's construction of Bheramara 360 MW Combined Cycle Power Plant financed by JICA is underway. The company has been created with a clean balance sheet and therefore retains no succeeding legacy from BPDB.

In addition, BPDB has also been a direct recipient of financial assistance for generation. BPDB has extended financial assistance by ADB's Sustainable Power Sector Development Program (2007) for the construction of the Sirajganj 150 MW peaking power plant and the Khulna 150 MW peaking power plant.

It is regrettable that during the past decade, decisions had not been made or have been extraordinary slow for making and/or implementing investments. Delays have been reported in the various phases of the project cycle including the bidding announcement, bid evaluation, contract negotiation, execution of contracts, etc. The indecisiveness and delay has caused an insurmountable shortage in the supply of power. The government had to cope with the deadly situation by means of introducing the RPPs and QRPPs. Now, the government has to struggle to exit from the electricity supply system depending on the RPPs and QRPPs into an economically justifiable one.

In addition, the generation entities of EGCB and APSCL are demonstrating their experiences of; (i) transfer of debt service liabilities when accepting the existing plants from BPDB, (ii) delayed execution of contractual agreements, and (iii) slow payment of the electricity bill by BPDB and a resultant high level of account receivables, etc. CPGCBL has many sources to learn lessons which the Study Team hopes CPGCBL will take full advantage of learning and absorbing.

(4) Transmission

PGCB was created in 1996. All the transmission assets including the load dispatch center have been transferred from BPDB to PGCB. PGCB off-loaded 25% of its shares to the public through the capital market. PGCB has received assistance from a large number of donors and projects including; JICA’s Grid Substations and Associated Distribution (2006); ADB’s West Zone Power System Development (2001), Power Sector Development Project (2003), Sustainable Power Sector Development Program (2007) and World Bank’s Siddirganj Peaking Power Project (2008), etc. PGCB appears to have relatively good financial condition with a reasonable equity ratio, satisfactory current ratio, account receivable collection, earning power, debt service coverage and is considered to be a good forerunner of sector reform.

(5) Distribution

DESA was spun off from BPDB in 1991. Its performance has fallen considerably short of expectations as its governance and operating procedures were basically the same as BPDB. Accordingly, DESCO was created in 1996 to take over some of the service areas in Dhaka from DESA. The new company, wholly owned by DESA, started operations in 1998 after the transfer of the Mirpur service area followed by the transfer of Gulshan, Baridhara and Tongi areas. DESCO off-loaded 25% of its shares to the public through the capital market in 2006. The West Zone Power Distribution System of BPDB has been corporatized as WZPDCL in 2003.

The segment has received a significant amount of financial and technical assistance from the donors. Included among such are; JICA's Central Zone Power Development Project (2009), Rural Electrification Upgrading Project (2010); ADB's West Zone Power System Development (2001), Corporatization of West Zone Distribution Operation of BPDB (2001), Corporatization of DESA (2002), Sustainable Power Sector Development Program (2007); and World Bank's Rural Electrification and Renewable Energy Development Project (2000, 2009, 2011), etc.

Despite the efforts made by the government, the distribution entities and assistance by the donors, there still remain many issues to be addressed and problems to disentangle. The corporatization of the distribution system appears to remain stalled for a considerable span of time without significant progress. MPEMR has instituted the management contract system based on Key Performance Indicators with each of the power entities under which MPEMR and each of the power entities set the targets bilaterally in operating efficiency to be achieved annually with incentive/penalty. The system has contributed to improving the efficiency gradually at each of the power entities but its effect is limited within the power entities while little impact has been felt on the holistic level of the sector. There is an acute need for the power sector to address the issues of operating efficiency through adoption of appropriate measures covering the whole sector as well as the individual power entities.

3.5 Brief of "The Master Plan on Coal Power Development (PSMP2010)"

As mentioned above, it is absolutely necessary to solve the chronic power shortage for the future economic growth of Bangladesh. In order to achieve this, the positive development of the base load power source is especially necessary. As mentioned above, in order that Bangladesh secure a stable power supply for future power demand growth by not relying on domestic natural gas, the power development master plan towards 2030 was formulated in PSMP2010. This Project is positioned at the start of future coal power development in Bangladesh based on the master plan. The following shows a brief of PSMP2010.

3.5.1 Power demand forecast

In Bangladesh, increased economic growth and power demand is to be expected. A long-term demand forecast by 2030 which was committed to in PSMP2010 is shown in the following table.

Table 3.5-1 Long Term Demand Forecast by 2030

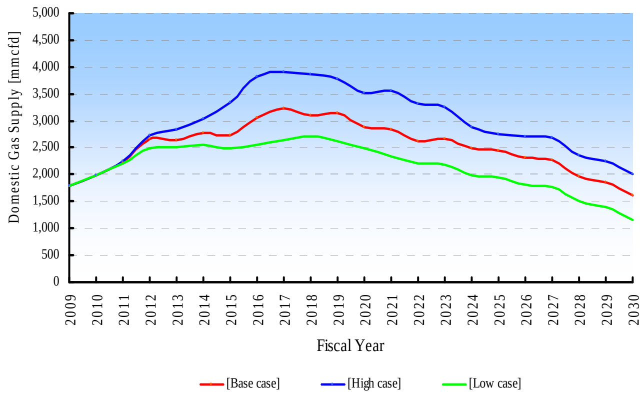
FY	Peak Demand [MW]
2013	8,349
2014	9,268
2015	10,283
2016	11,405
2017	12,644
2018	14,014
2019	15,527
2020	17,304
2021	18,838
2022	20,443
2023	21,993
2024	23,581
2025	25,199
2026	26,838
2027	28,487
2028	30,134
2029	31,873
2030	33,708

(Source: BPDB Website)

3.5.2 Energy balance and power development scenario

Currently, Bangladesh relies on domestic natural gas as the main primary energy, and more than 80% of the power supply consists of gas-fired power plants. However, in considering a future power development plan to meet economic and power demand growth, it is not wise to rely on a single energy source such as the current situation. Risk reduction via energy diversification should be considered. Under these situations, a Study for PSMP2010 was started.

Recently, the depletion risk of domestic natural gas was pointed out. According to the gas production scenario which was formulated in PSMP2010, after 2012 as a peak (3,907 mmcfd as High Case) it is assumed that the production will decrease.

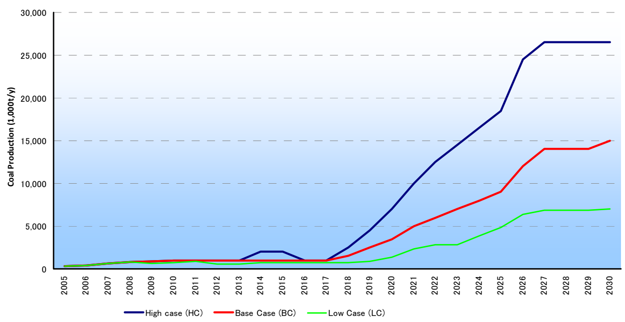


(Source: PSMP2010)

Figure 3.5-1 Domestic Natural Gas Production Scenario on PSMP2010

Bangladesh is considering importing LNG for the purpose of strengthening the availability of natural gas. However, the world LNG market is primarily occupied by a large amount of import countries such as Japan, South Korea, and Taiwan, so it is difficult for new upcoming countries to join the market to achieve stable procurement. To achieve a stable supply, a capital investment for the construction of an LNG terminal etc. would be needed. Furthermore, given that the current domestic gas price is controlled at a low level, the application of LNG will lead to a gas price increase. For the above reasons, the import of LNG has its limitations. Considering this situation, the amount of natural gas-fired power plants is about 1/4 of the total capacity in 2030.

Regarding coal, if the domestic coal in the northwest side of the country is to be developed, the amount of production is expected to be 26.5 million t/year in 2030 according to the High Case scenario, which could cover about 1/4 of the total power capacity.



(Source: PSMP2010)

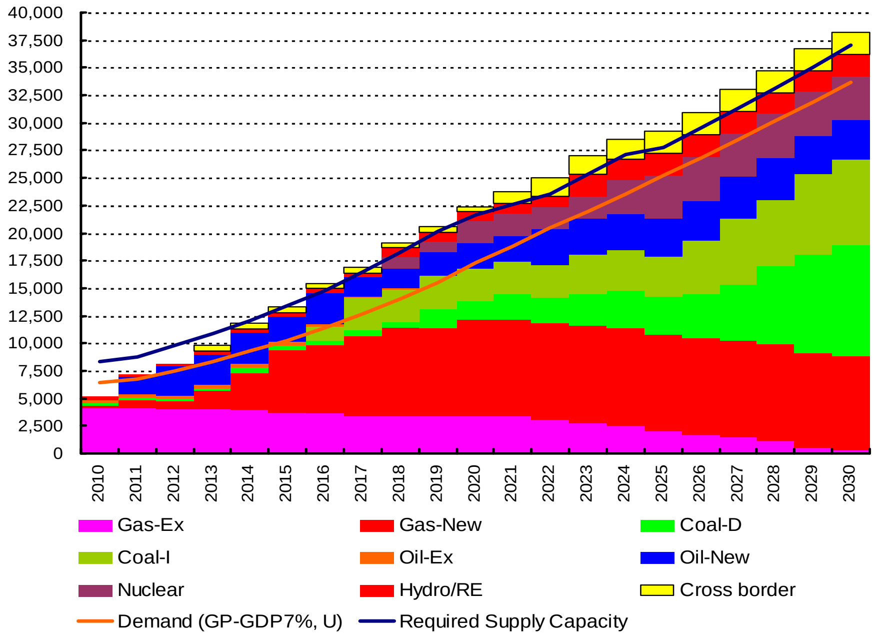
Figure 3.5-2 Domestic Coal Production Scenario on PSMP2010

In Bangladesh, other domestic energy could not be secured as the base. It is estimated that the total amount of hydropower, renewable energy, cross border trading etc. will be about 1/4 of the total amount in 2030. This means that the remaining 1/4 of total amount should be relied on the imported energy sources for the generation.

As import energy sources, there are LNG, oil and coal. As mentioned above, LNG has certain limitations. Currently oil is being imported. However, given price instability and the location eccentricity of production (need to rely on the Middle-East), it is not wise to rely on oil by spreading the amount of imports. On the other hand, with regards to import coal,

- It is not a problem for new upcoming countries to join the world market on the condition to spread the acceptable type of coal (it is different from the LNG case).
- The location of production is not eccentric, stable procurement is possible via risk diversification.
- The price is stable for a long time, which is different from oil and LNG.
- A large amount of reserves compared with oil and natural gas.

For the above reasons, coal is suitable for the base energy in Bangladesh. Based on this estimation, a power development scenario with 1/4 of the total amount in 2030 would be by import coal with an amount of approximately 25 million t/year.



(Source: PSMP2010)

Figure 3.5-3 Power Development Planning in PSMP2010 (Government Policy Scenario)

3.5.3 Coal power development plan

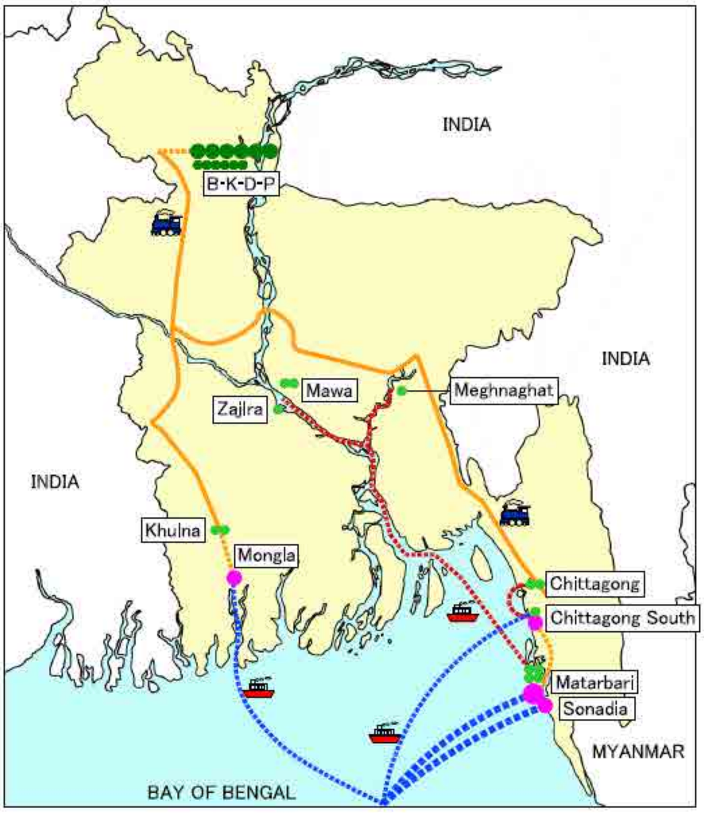
According to the above power development scenario, a specific coal power development plan was formulated.

Regarding domestic coal, given that there is strict resistance from the residents towards the development, a solution to social issues would be needed. GOB should formulate a Coal Policy and promote appropriate development with which all of the people could agree under strong leadership. In consideration of these situations, it is assumed that it will take time for domestic coal development progress.

On the other hand, import coal could be considered soon. However, in considering coal imports, the problem is that it is almost shallow around the Bay of Bengal. To achieve efficient coal imports, the direct approach of large scale coal ships should be necessary. However, there is only a small area in the southeast of Bangladesh with a deep sea. Therefore, at an early stage, a power station with a deep sea port should be developed at the site in the south east area, after that the site will be developed into a “coal center”, and the coal transportation system from the coal center will be formulated. This system will make the stable coal supply.

In the PSMP2010 power development scenario, operations of the first imported coal fired power plant are slated to start in 2016. However, it is impossible to build a port that can dock large-scale vessels until 2016. Therefore, until the completion of a large-scale port and coal center by 2020, it is planned to have the coal transportation vessels anchor offshore and from there, small-size barges will shuttle coal to the power plants. However, the Matarbari Coal Fired Power Station is not scheduled to begin operations until 2023. Given this extended period of time, it is possible to develop a port that would be able to accommodate large-scale vessels. This would allow the vessels to dock directly and thus it would be unnecessary to have the vessels anchor offshore. That is why this project is the first step of coal-fired power development in Bangladesh. In the future, by developing an import coal power station in other areas (inland areas) and establishing a coal center, the power station can serve as a hub of coal supply.

In addition, the Deep Sea Port Project, whose implementation was planned to take place at Sonadia Island by the Ministry of Shipping in Bangladesh, is not progressing as this island has been designated as an Environmental Critical Area. To sum up, the port being developed by this project would be the first Deep Sea Port in Bangladesh. Once completed, this port has the possibility to contribute to not only coal imports but also the large-scale commercial development of the Matarbari area.



(Source: PSMP2010)

Figure 3.5-4 Import Coal Transportation and Supply Plan on PSMP2010

3.6 Energy Option (Necessity of Coal)

In this Study, based on the results of PSMP2010, with an update of the latest situation, the energy option for Bangladesh will be studied again.

3.6.1 Energy balance

The following table shows the energy balance of Bangladesh in 2009. As the primary energy for electricity, natural gas comprises around 90% of the total.

Table 3.6-1 Energy Balance of Bangladesh (2009)

(Unit: TOE)

Year 2009 Supply and Consumption	Coal & Peat	Crude Oil	Petroleum Products	Gas	Nuclear	Hydro	Geotherm. Solar etc.	Biofuels & waste	Electricity	Heat	Total
Production	500	70		15321		133		8813			24838
Imports	400	867	3859								5126
Exports			-148								-148
Intl..Marine bunkers			-35								-35
Intl. Aviation bunkers			-192								-192
Stock changes	-271	140	141								10
TPES	628	1077	3626	15321	0	133	0	8813	0	0	29599
Electricity and CHP plants	-219		-655	-8226		-133			3256		-5978
Petroleum refinaries		-1077	1071								-6
Other transformation	-9		-64	-251					-157		-480
TFC	400	0	3978	6845	0	0	0	8813	3099	0	23135
Industy Sector	400		286	2444					1742		4872
Transport Sector			1901	727							2628
Others Sectors			1477	1919				8813	1357		13566
Non-Energy Use			315	1754							2069
Electricity Generated (GWh)	638 (1.69%)		1832 (4.84%)	33840 (89.38%)		1552 (4.1%)					37862 -100%

(Source: IEA Statistics, Energy Balances of Non-OECD Countries (2011))

3.6.2 Comparison of energy option for generation

(1) Energy option

As an energy option, the LNG for supporting natural gas availability, shale gas, oil, nuclear, hydropower, renewable energy, domestic coal and import coal could be considered.

Regarding hydropower, given that there is no more potential for large scale hydropower in Bangladesh, it could not be a main energy source.

Regarding nuclear, given the safety matters presently under discussion in the world, there is no room to consider this as a new main energy source.

Regarding renewable energy (wind, photovoltaic, biomass etc.), it should be considered as a complementary energy source. It is difficult to be a main energy source because the potential for economical development is low and it cannot be a large scale stable energy source.

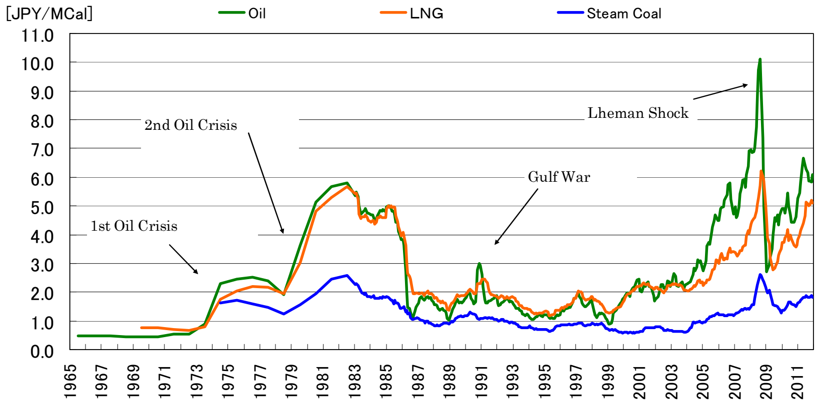
In consideration of the above, for the other sources which are fuel, the following is the comparison. In this comparison, shale gas is equal to LNG because it would change to LNG during transport.

(2) Comparison of fuel

1) Price Stability

First, the price stability is compared.

The following figure shows the price trend.



(Source: The Institute of Energy Economics, Japan)

Figure 3.6-1 Trend of Fuel Price for Thermal Power Generation

In reviewing the trend over the past 40 years, the prices of oil and LNG were fluctuating due to changing world conditions, on the contrary, the price of coal is low and stable, it means that coal has a price advantage.

2) Supply Flexibility

As mentioned above, the production points of oil are disproportionately located especially in the Middle East. That means that the risk of stable procurement is big. The production points of LNG are also limited, even though the trading of shale gas will be started, it does not mean that there are no limitations. On the other hand, coal is produced everywhere, it means the risk of the location of coal production is the lowest.

Regarding a reserve, according to the BP Statistical Review 2011, oil is 46.2 years, natural gas is 58.6 years, and coal is 118 years. It means coal is expected to be a long term supply.

Recently, in Japan, the utilization of sludge from sewage farms and timber from forest thinning as biomass fuel is promoted. These are solid fuel so that these could be used in the coal-fired power plants. It means that other solid fuel from biomass could also be used for the coal-fired power plant. It also contributes to fuel supply flexibility. If solid fuel from waste is produced utilizing Bangladesh’s biomass technology, it would be possible to utilize biomass fuel besides coal for thermal power plants.

3) Easiness of Market Entry

The world LNG market is already occupied by a large number of import countries such as Japan, South Korea, and Taiwan, so it is difficult for new upcoming countries such as Bangladesh to join the market to procure stably. Even if shale gas is in the trading stage, it is assumed to be in the LNG market. In the case of coal, even though it is difficult to procure some part of high quality coal, it is easy to procure by spreading an acceptable type of coal.

4) Facility Investment

For every fuel, transportation by large ships is needed for stable procurement, the development of a large port is needed. For the operation, the storage and transportation facility (coal stock and transportation facility for coal, oil tanks (and refinery facility) for oil, tanks and vaporizers for LNG) is needed. Generally, the cost of an LNG facility is higher than the coal facility or oil facility.

5) Environment Load

Unit CO_2 emissions are natural gas > oil > coal. Natural gas has almost no sulfur while coal has sulfur. From the perspective of an environment load, coal has its disadvantages.

6) Other condition

Besides the power sector, there is a great demand for imported natural gas and oil in the residential/commercial sector. Natural gas and oil cannot always serve as stable energy resources. On the other hand, imported coal is used only for power generation and contributes to a stable power supply.

As a summary of the above, from various points of views, coal has its advantages except as an environment load. It means that, as the future stable energy for Bangladesh, it would be the best solution to apply coal by considering countermeasures to reduce environmental load.

Table 3.6-2 Comparison of Fuel Option for Thermal Power Generation for Bangladesh

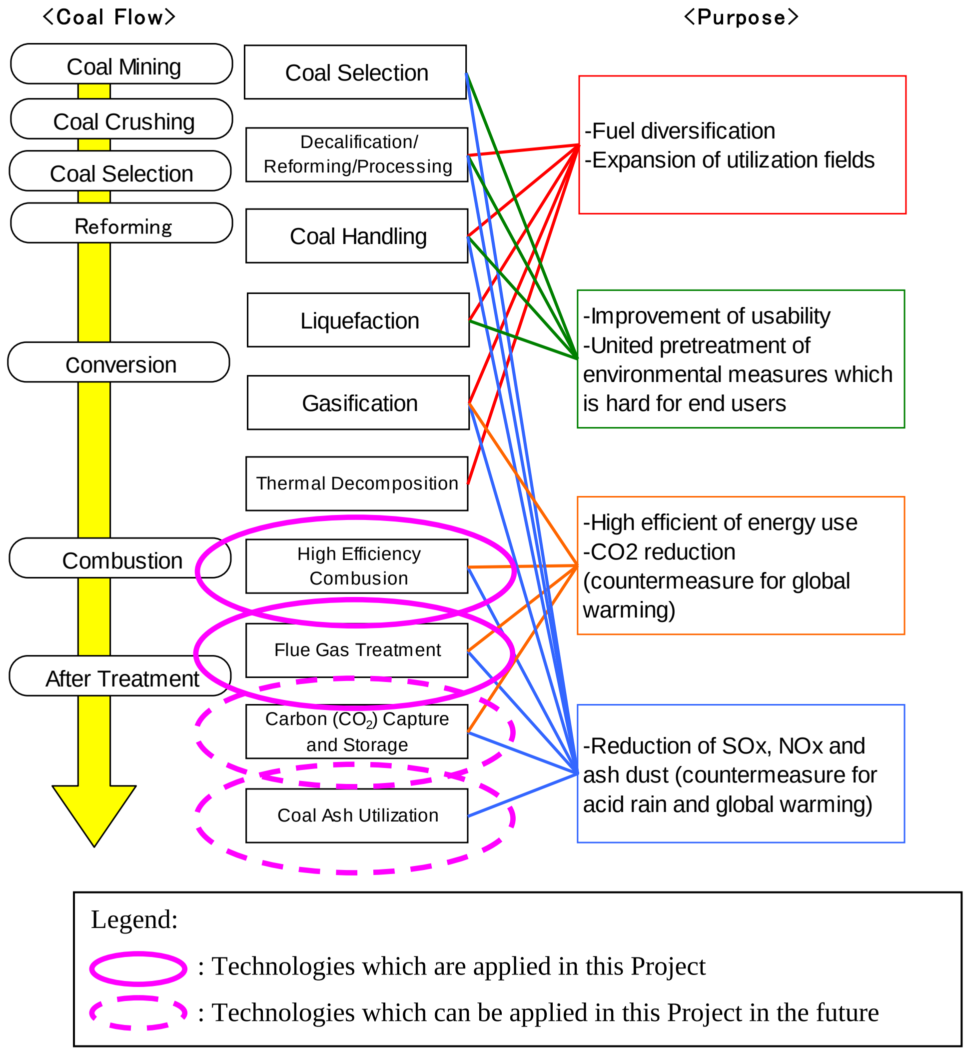
	Natural Gas (LNG, Shale Gas)	Oil	Coal
Price Stability	Fluctuate per the world situation. (dominantly synchronized with oil prices) No experience in importing Shale Gas	Fluctuate per the world situation.	Stable. Cheaper than LNG
Supply Flexibility	Production area is limited. Reserve 58.6 years Currently shale gas is in the USA	Production area is limited to the Middle East Reserve 46.2 years	Everywhere Reserve 118 years Solid biomass fuel can be accepted.
Easiness of Market Entry	Difficult to join	Possible to extend current imports	Easy to join
Facility Investment	Large port Storage (tank) vaporizer	Large port Storage (tank) (Refinery)	Large port Coal storage and transportation facility
Environment Load	Low (Low CO2 emissions No sulfur)	Middle (Middle CO2 emissions Little sulfur (depends on production area)	High (High CO2 emissions Sulfur (depends on production area)
CO_2 Emission Factor(*1)	56.1 t-CO_2/TJ (58% for Coal)	73.3 t-CO_2/TJ (76% for Coal)	96.1 t-CO_2/TJ (100)
Others	High demand in the residential/commercial sectors	High demand in the residential/commercial sectors	Only for the power sector

(*1): 2006 IPCC Guidelines for National Greenhouse Gas Inventories
(Source: JICA Study Team)

3.6.3 Environmental load reducing measures on using coal

(1) Clean Coal Technology

Since coal is expected to continue to be the main energy in the world, technology to achieve environment load reduction is important. The environment load reduction means to reduce the emission of pollutants, Clean Coal Technology including production reduction technology, capture technology, utilization technology etc. is developed and utilized. The following figure shows the clean coal technology. Even for the technology which is still in the experimentation stage, development is underway. Among them, the contents surrounded with a solid line are applied in this project, and the contents surrounded with a dotted line are applied in this project in future.



(Source: JICA Study Team based on "Tokoton Yasashii Sekitan no Hon")

Figure 3.6-2 System Chart of Clean Coal Technology (CCT) and Application for the Project

(2) Applied Technology to the Project

1) Application of High Efficiency Power Plants

As mentioned above, the installation of high efficiency facilities using high temperature and high pressure condition leads to reduced fuel consumption, and then the unit emission ratio of CO_2 would be reduced.

2) Application of High Performance Flue Gas Treatment System

Also as mentioned above, through the high performance flue gas treatment system, the air pollutants would be removed. So that, the exhaust gas from the stacks would be as clean as that from gas-fired facilities.

3) Proper Treatment of Ash (Coal Ash Utilization)

By securing enough space for coal ash disposal in the site and proper treatment with the anti-scattering measures should be conducted. This area could be used as space for the new facilities in the next step.

In the future, the beneficial utilization of ash should be studied, and a large portion of ash should be utilized in a beneficial way.

The following shows the example of beneficial utilization of ash in Japan;

- Material for Cement

  Ash could be used as an alternative material of clay for cement which needs about 240 kg for 1 ton of cement. The maximum mixture ratio to clay is around 20%.

- Admixture for Concrete

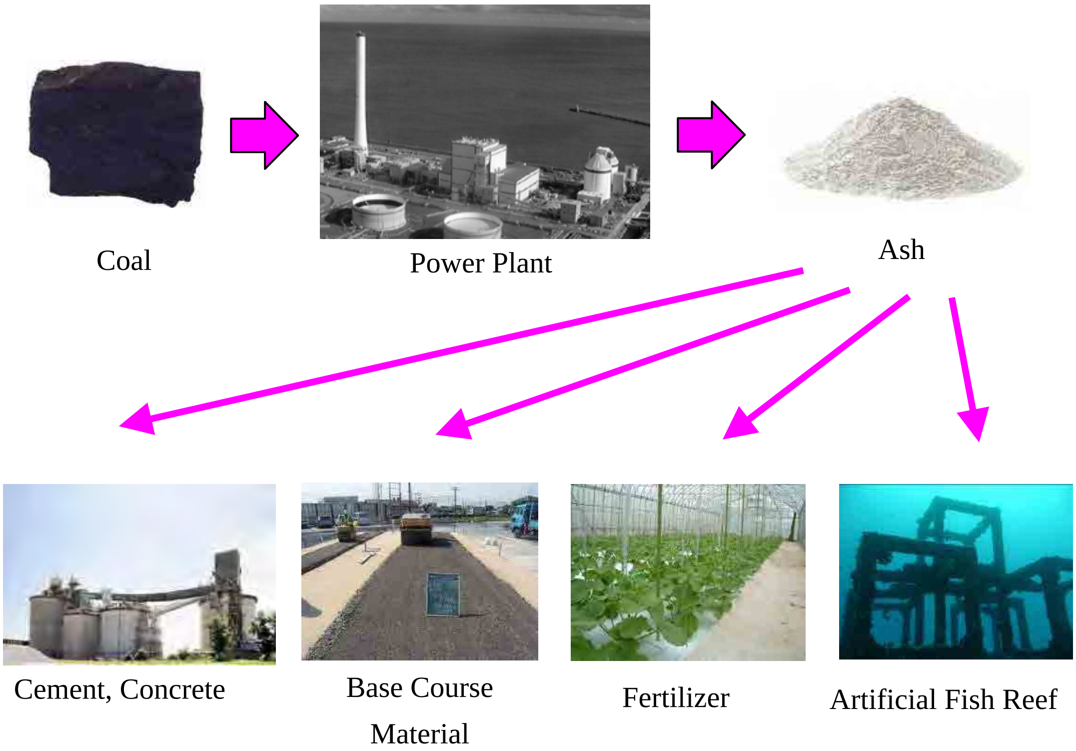
  It is used for concrete for dams etc. Heat generation during calcification would be decreased and crack would be inhibited

- Material for Road

  Used as the base course material using powder and/or granular material

- Fertilizer and soil conditioner
- Artificial Fish Reef

  Usage of solidified material with ash



(Source: JICA Study Team)

Figure 3.6-3 Beneficial Utilization of Ash

The application of ash utilization for cement has been studied as follows.

Bangladesh has a high need for basic infrastructure, housing and services. Therefore, further robust growth in cement consumption is anticipated. Bangladesh's domestic cement consumption has grown at an average rate of 10-12% over the last five years. In 2010, consumption registered an impressive rise of 31.8% equivalent to approximately 14 million t/year due to construction of Padma Bridge, housing projects and other infrastructure. The capital Dhaka in the central region and Chittagong in the south-east are the main consumption hubs in Bangladesh and together account for 75% of demand.

On the other hand, in terms of production and technology, Bangladesh has almost zero limestone deposits which is a necessary material for cement production. Therefore, the cement industry totally depends on imported raw materials including key supplies of clinker. Since an integrated production system that entails importing limestone and cement production in a domestic factory does not pay off due to the high cost of materials, most factories applies only a milling and mixture procedure, using imported clinkers which is one of the semi-finished products in the cement production procedures. As of May 2013, only one cement factory in Chhatak (Northern Bangladesh) implemented an integrated production system, which is a joint venture factory between Lafarge and Cementos Molins and produces 1.3 million t/year. The other factories are milling factories. The production in Bangladesh is not meeting demand. A portion of the needed cement materials is imported. As of 2009, the amount of imported clinkers was 8 million t/year, and imported cement was 0.8 million t/ year. The process of cement made from cement clinker necessitates the import of various materials. The slag is imported at a rate of 0.85 million t/year, and fly ash at a rate of 1.04 million t/year. Especially nowadays, the cost to import fly ash from India is very high. Hence, Bangladesh has few coal-fired power plants.

Bangladesh's demand for new infrastructure and residential projects is huge, and the demand for cement is forecasted to increase. If domestic production capacity is not increased and steps taken to ensure steady procurement of the necessary materials, the necessity of cement imports will increase.

Under such a situation, if a large-scale coal-fired power plant begins operations in the future and coal ash is used for cement material, the amount of importing fly ash can be decreased, resulting in reduced costs. In general, there are two measures to utilize fly ash for cement materials. One is using it as an alternative to clay and another is using it as fly ash cement whose temperature at the point of coagulation is low. In Bangladesh, in terms of cost, the former idea is difficult to develop. However, the latter is possible (in fact, importing fly ash corresponds with the latter measure. At Matarbari Coal Fired Power Plant, it is estimated that the amount of fly ash produced from two units of 600MW is approximately 0.1-0.5 million t/year after operations started in 2023. With such fly ash, it is possible to produce the cement amount of 0.3-1.5 million t/year. If the cement factory is built near the power plant, it would be logically more effective to utilize all fly ash for cement materials.

4) Waste Water Treatment Facility

High performance water treatment facility would be applied, not only waste water from generation facilities, but also from flue gas treatment facilities, and coal-stained water from coal stock yard etc, all of waste water should be treated and the quality should be kept within the restricted levels.

5) Environment Monitoring

After applying the above environmental load-reducing measures, environment monitoring would be conducted in the surrounding areas for immediate action in case of an emergency.

(3) Record of clean coal technology in Japan

In Japan, in the past coal was mainly used as fuel for power plants, after 1950 many coal-fired power plants were developed. At the same time, pollution problems stemming from NOx, SOx, ash became obvious. The use of oil became popular instead of coal. However, an oil shock occurred and the risk of relying on oil became apparent. To achieve energy diversification, the import of LNG also began. However, the price of LNG and oil is linked, so that coal was restarted to use for the next stage of energy diversification.

For the restart of coal, to reduce the environmental load was the strict condition, for this reason, environmental technology was developed in Japan. As a result, currently the performance of an environment facility in a Japanese coal-fired power plant is high, and comparable with other fuels. For example, as mentioned above, regarding NOx and SOx emissions, Japan is of a lower level in the world. As mentioned, in Japan, social demands leads to technological development, then, the Japanese environment facility has high performance. A table in Chapter 2 shows the record of a coal-fired power plant in Japan, all of those plants have environmental facilities.

For reference, the following figure shows a typical coal-fired power plant in Japan.

(Source: Hitachinaka Thermal Power Station, TEPCO)

Figure 3.6-4 Example of Coal Fired Power Plant in Japan

3.6.4 Justification of using import coal

A vein of coal was found in the north west part of Bangladesh and one coal mine (Barapukuria) and power station (2 x 125MW) is in service, and it is clear that there is the potential to develop good quality coal in Bangladesh. There are plans to increase the production of the Barapukuria coal mine from the current 1 million t/year to 1.5 million t/y within 2013.In Barapukuria Power Station, there is an expansion plan of #3 (250MW) and is expected to start operations in 2017. The development costs of the Barapukuria coal mine was about 255 million USD for current 1 million t/year scale. The actual coal price in 2011 was 85.5 USD/t for the Barapukuria Power Station and 100USD/t for a private company. It means that there is a possibility that the price is cheaper than imported coal even if transportation costs are taken into consideration.

However, regarding the possibility to use domestic coal for the Project which is the first large-scale coal fired power plant in Bangladesh,

- Given environmental and residential issues, the current government does not issue out any permits allowing for development except for the extension of Barapukuria (only for the extension of Barapukuria power station).
- Even if development is permitted, it would take at least 10 years (3 years for the EIA, 2 years for the F/S of the underground mining and the contractor selection process, and 5 years for the development of underground mining) until the start of coal production to develop a new coal mine. So that the supply to power plants would not be not possible for a long period of time. (With regard to the EIA for the coal mine, a hydrogeology investigation, for which data collection will take a long time, is needed; the impact area for open mining is considerable, and a ground subsidence assessment is important for underground mining. For the above reasons, it would take longer than the power plants.)

Given the above reasons, it is impossible to create a domestic coal plan to apply to the Project which is expected to start commercial operation after 10 years (over 3 million tonnes per year of coal will be used).

Currently, GOB is preparing to formulate a “Coal Policy” in order to position coal as one of the key resources for solving the problem of energy supply in the future. However, although the draft of the Coal Policy was completed in 2009, GOB could not put it into practice due to public sentiment, and it is not yet formulated at this moment.

And, even if the domestic coal is developed in the future, the estimated amount of domestic coal is expected to be insufficient to cover the shortage of power demand in the future. In any case, it is necessary to import coal in order to meet power demand in the future. Regarding imported coal, once the measure to secure from the market is put into place, Bangladesh could begin preparations immediately.

The above-mentioned reasons prove that the Project needs import coal.

3.7 Unit Capacity

It is important to determine the unit capacity during the development of the new power station. Generally, equipment with bigger unit size has the advantage of scale so that the construction costs can be decreased. However such equipment has a big impact to the whole of the power grid in case it stops due to trouble. Therefore, the optimum unit capacity should be determined via a comparison of the related items taking in account the stability of the power grid.

For a decision of the unit capacity of this project, the following 3 candidate types would be compared.

Table 3.7-1 Case for Comparison

	Case 1	Case 2	Case 3
Unit Capacity	300MW	600MW	800MW
Steam conditions	16.6MPa	24.1MPa	24.1MPa
	566℃/566℃	566℃/566℃	566℃/566℃
Unit construction costs	1,690USD/kW	1,600USD/kW	1,500USD/kW
Efficiency (LHV)	42.0%	43.8%	43.8%
Auxiliary power ratio	7.0%	7.0%	7.0%
Forced outage rate	8%	8%	8%

* Forced outage rate = (Annual forced outage time) / (8760 hour – Annual planned outage time)

(Source: JICA Study Team)

For the above, one candidate would be selected by comparing the following five points. The “Economy” and the “Possibility of a system collapse” are given special consideration.

- Economy
- Possibility of a system collapse
- Reliability level
- Environment (CO_2)
- Operations and maintenance

Generally, for the comparison of a newly installed generation facility, the economy is the important point. However, in this case, as mentioned later, the unit capacity is the issue of having an impact for the stability of the whole power system, so the possibility of a system collapse is also an important point.. Therefore, these 2 points should be made compared weighing their respective areas of importance.

3.7.1 Economy

On the condition that the annual plant factor is determined to be 80% which means base load operations, the generation cost for each case is calculated as follows. The coal price in 2020 (2.2USD/Mcal) in the scenario in PSMP2010 is adopted

Table 3.7-2 Generating Cost (Sending end)

(Unit: USC/kWh)

	300MW	600MW	800MW
Fixed cost	1.6	1.5	1.4
Fuel cost	4.8	4.6	4.6
Total	6.5	6.2	6.1

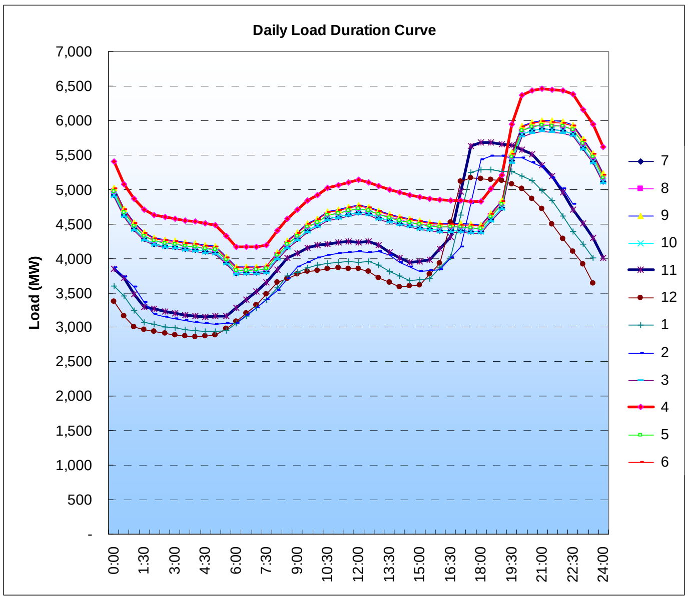
(Source: JICA Study Team)

Compared with the 300MW unit, both the 600MW unit and 800MW unit is economical because the unit costs of construction are low and the thermal efficiency is high so that the generation costs are low. There is no significant difference between the 600MW unit and 800MW unit because both of them are USC facility, but the construction cost is a little cheap in case of 800MW. Only from the economical point of view, the larger unit has more advantage.

3.7.2 Possibility of a system collapse

On the power grid, in case that a generator stops by accident, the total supply capacity in the grid will decrease instantaneously, and that causes a temporary frequency drop. The system frequency of Bangladesh is 50Hz. Generally, if the frequency drops to less than 48.5Hz with the amount of drop exceeding 1.5Hz, it may cause serious damage to other normal generators, so that the system would issued an automatic command to stop other normal generators when a drop in frequency is detected. If the amount of the frequency drop is large, or it takes a long time to recover the frequency, there is the possibility that a generator outage with an accident will cause the outage of other normal generators one after another, and finally result in a system collapse (all system stop). In order to prevent the risk, the Bangladesh Grid Code (Nov.2010) states that “The Generator shall ensure that each Generating Unit is capable of generating at full rated power output within the frequency range of 48.5 - 51.5 Hz, +/- 10% rated voltage and power factor 0.8 lagging to 0.95 leading.” This means that the generator has to maintain the frequency range under 1.5Hz.

The frequency drop is proportional to the amount of dropped supply. In the general power grid, in a case where the amount of 10% of the whole supply capacity drops, the frequency would drop by 1 Hz. Therefore, the limitation of the unit capacity in the grid in order to not cause a system collapse could be roughly calculated from the size of the grid.



(Source: PSMP2010)

Figure 3.7-1 Daily Load Curve (2010)

The above figure shows the daily load curve in Bangladesh which was studied in PSMP2010. During the high load period in the summer season, a rotational outage (load shedding) actually occurs due to the shortage of power supply, so that the estimated load curve based on the curve in the winter was applied in this part. According to this curve, the maximum demand of the year is assumed to be 6,454MW while the minimum demand of the year is 2,866MW, the ratio is 1:0.444.

According to the demand forecast in the PSMP2010, the maximum demand in 2020 by the GDP 7% scenario which is lower than the government policy scenario which is determined as the base case in the study, is 13,244MW. Because it was assumed that the load factor towards 2020 would not change (60%) and the load curve would change in a similar fashion, the minimum load in 2020 is assumed to be 5,827MW which is 44.4% of 13,244MW. In addition there are 2,190 hours (1/4 of one year) with a load less than 7,000MW which is 1/2 of the maximum demand.

The coal-fired power plant which would be studied in this study would be operated as a base load because the fuel costs are cheap, so that it could be operated at maximum capacity during such a low demand period. It means that the impact of the outage during a low demand period is bigger than during a high demand, so that the comparison during low demand is important. When the total demand is around 7,000MW, if an 800MW unit stops by accident, it causes more than a 1.2Hz frequency drop, it means that it is easy to drop under 48.5Hz depending on the frequency before the accident (there is a possibility that the frequency before the accident had already dropped) and cause a system collapse. Therefore, the adoption of an over 800MW unit is not to be suggested for this grid. In the case of under 600MW, the frequency drop with such an accident is less that 1.0Hz even at minimum demand, the possibility of this causing a system collapse is lower.

In the study of future demand and power development, one case where the power development could not be implemented on schedule should be studied. Even in such a case, steady demand growth would be favorable so that the low demand would increase, as a result the conditions for the study of the unit capacity would be the same as above. Therefore, there is no problem in choosing 600MW. On the other hand, there is also a possibility that the demand growth itself would be lower than the forecast. In that case, it is true that there is a possibility of a system collapse even with 600MW. However, the risk could be hedged by partial load operations during the dangerous period. In case of general thermal power plants, the thermal efficiency during partial load operations is lower than full load operations. By comparison of partial load operations between 600MW and 800MW, 600MW would be better than 800MW.

Currently, Bangladesh’s power grid is isolated with no interconnection between other countries, actually there is a plan to establish a connection between Bangladesh and India. This plan would adopt a DC connection. This DC interconnection would have no impact to the size of the whole supply capacity of the Bangladesh system, hence, there would be no impact to the frequency drop prevention.

3.7.3 Reliability level

There is no difference between the forced outage ratios of each unit (8%). If the unit capacity is large, the influence to the grid is significant in the case of a generator outage with an accident. On the other hand, if the unit capacity is small, a large number of units are needed for a certain capacity, so that the probability that all units are in good operation becomes low.

In order to compare the reliability, the same capacity should be determined for all cases by changing the number of units. In this case, the total capacity is determined to be 2,400MW which is the greatest common denominator of 300, 600 and 800, and then the reliability is calculated. As the level of reliability, an evaluation is conducted by using LOLE (Loss of Load Expectation) as the base of demand and power supply configuration in 2020 from PSMP2010.

Table 3.7-3 Reliability Level

	300MW 8 units	600MW 4 units	800MW 3 units
LOLE (hours/year)	34.6	43.0	49.3

(Source: JICA Study Team)

As shown in the above table, LOLE with a lower unit capacity is lower. It means that the level of reliability is a little higher in the case of using small capacity units. However there is no significant difference because the reserve margin is over 10% in each case.

3.7.4 Environment (CO_2)

During the comparison of CO_2 emissions, the capacity should be determined to be the same. The following table shows the CO_2 emissions calculation result for every 2,400MW under the condition that the annual plant factor is 80%

Table 3.7-4 CO_2 Emission

	300MW 8 units	600MW 4 units	800MW 3 units
CO_2 emission (kton-CO_2)	14,167	13,584	13,584
	Base	- 583	- 583
Unit CO_2 emission (ton-CO_2/MWh)	0.906	0.868	0.868

(Source: JICA Study Team)

The CO_2 emissions are lower in the case of 600MW and 800MW due to high thermal efficiency, which can reduce the amount of 583 kton per year.

3.7.5 Operation and maintenance

Currently, the size of the existing biggest steam turbine unit in Bangladesh is 210MW and steam conditions are 545degrees/545degrees/14MPa. There are 7 units totaling 210MW in Ghorasal, Rauzan and Siddhirgonj. The oldest one started commercial operations in 1987, so that there is abundant experience in operations technology and the maintenance of such a size of steam turbine equipment.

Given that the level of steam conditions is almost the same and the material of the boiler tube etc. is at the same level, the operations and maintenance for a 300MW unit is capable at the current technical level of Bangladesh. On the other hand, in the case of 600MW or 800MW units, because the steam pressure and temperature is higher and an advanced type of material is used for the high temperature part of the boiler tubes, a very high level of maintenance technology would be needed. In order to solve this issue, engineer training is needed.

3.7.6 Overall evaluation

For each point, the comparison is conducted above. As mentioned above, in this comparison, the economy and possibility of a system collapse should be weighed. Regarding the economy, 600MW or 800MW should be chosen because of the size and difference of type, and regarding possibility of a system collapse, the risk of 800MW is higher than 600MW. Considering that the level of the economy is almost the same, in this comparison, 600MW should be chosen by weighing the risk of a system collapse.

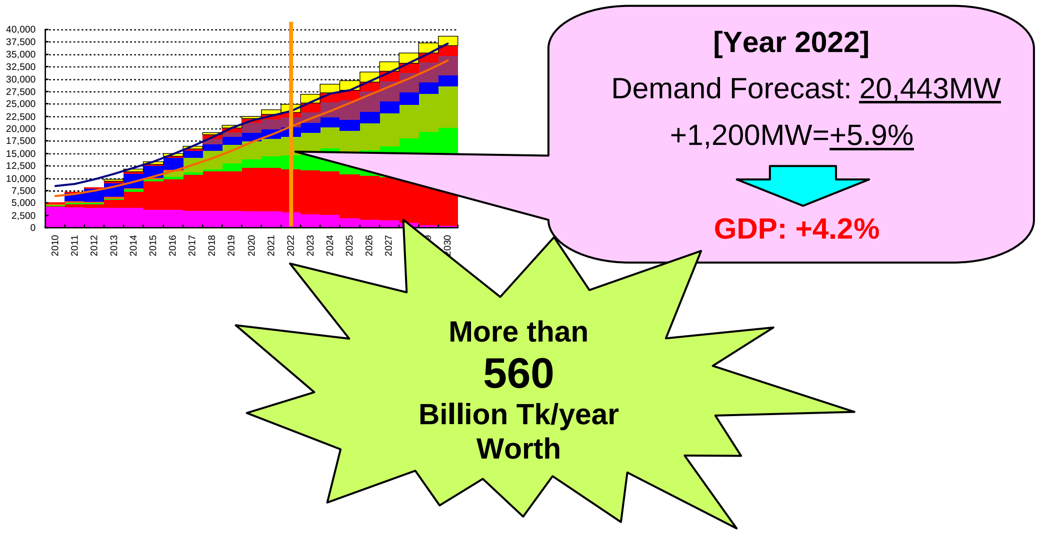
It is true that the larger the size, the more economical it is. Therefore, in the future, in case demand increases, the possibility of a system collapse could become lower. So in the future, the adoption of an 800MW unit or a 1,000MW unit could be considered.

3.8 Economic Effect Brought by the Project

By implementing this project, not only will power supply be increased in Bangladesh, but other various associated effects can also be expected. Many type of economic effects could be estimated, the following shows some simple examples.

3.8.1 Impact to GDP

As mentioned above, the target of the elasticity of the power demand to the GDP is 1.4. Here “the elasticity” refers to the ratio between the electric energy consumption growth ratio (power demand growth ratio) and the economic growth ratio (GDP growth ratio). Suppose that the GDP growth is 5%, the GDP in 2022 when the project starts commercial operations would be Tk 13,468.9 billion. If the power demand at that time is 20,443MW, which is the same as the forecast, and if the increase of the 2 x 600MW = 1,200MW demand occurs via the newly started power plant (actually a part of the capacity is not an increase because some rental power plant would stop operations instead), the demand growth ratio is equal to about 1,200 / 20,443=5.9%. In case the elasticity is 1.4 at that time, it is equivalent to about 4.2% of GDP growth. It means that, the impact of the project to the GDP would be about Tk 13,468.9 billion * 4.2%=Tk 565.6 billion.

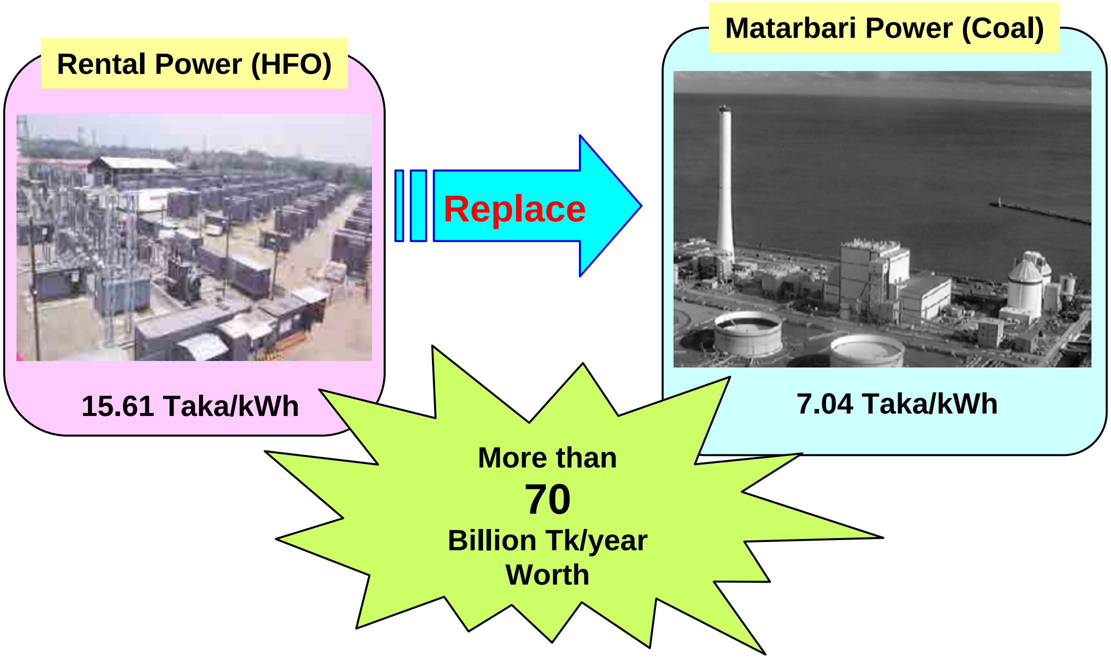


Source: JICA Study Team

Figure 3.8-1 Image of Impact to GNP

3.8.2 Impact to the power sector's finances

Currently, in order to mitigate power shortage, the power sector relies on rental power facilities even though the unit costs are high. In that situation, by installing a large scale coal-fired power plant whose generation costs are low, rental power facilities could be decreased so that total generation costs would be reduced. It means that, from a BPDB side, because the unit price of procurement is low, the procurement costs become low. For example, as an objective for comparison, the HFO-fired rental power plant with the same size (1,200MW) is concerned. According to Chapter 11, the current cost (procurement costs of BPDB) of the HFO-fired rental power plant is Taka 15.61 /kWh, while the price of the Project is Taka 7.04 /kWh. It means there is a difference of Taka 8.57/kWh in the procurement costs. By using 80% of the plant factor (annual power amount is 1,200MW * 24hours * 365days * 80% = 8,409GWh）, as a result, it could be said that, the procurement costs of BPDB will decrease to more than Taka 70 billion /year.



(Source: JICA Study Team)

Figure 3.8-2 Image of Impact to Finance of Power Sector

3.8.3 Effects to the community people

Generally, via the development of the power station, the residential area would be formed around the power station, as a result, this would bring about the emergence of economic activities would. In addition, for the citizens of the surrounding area (those who currently earn their living by salt fields and cultivation of shrimp), new business opportunities in and around the power station would come up and leads to an increase in the standard of living. Furthermore, via the preparation of access roads, the traffic between the surrounding areas or between the big cities would become active, commodity distribution would also become active, and an increase in economic activity could also be expected.

For example, as a simple calculation, around 3,000 workers are in the site during the construction period, they go shopping in the surrounding area at the rate of about 100 Taka/person every day. In that case, the expected economic effects would be Tk 500 million over a period of 5 years, Tk 1,000 million for a 10-year period.

In addition, as it has a large scale of port which is the first experience for Bangladesh, it could lead to the development of other sectors, it means that it has the potential to trigger economic development of Bangladesh.

Chapter 4

Selection of the Suitable Site

Chapter 4 Selection of the Suitable Site

4.1 Study Areas

The study areas are Cox Bazaar district, Chittagong district, zone for transmission line, Chittagong city in Bangladesh and coal producing countries. A and B of the aerial photograph of Figure 4.1-1 are the main study areas.

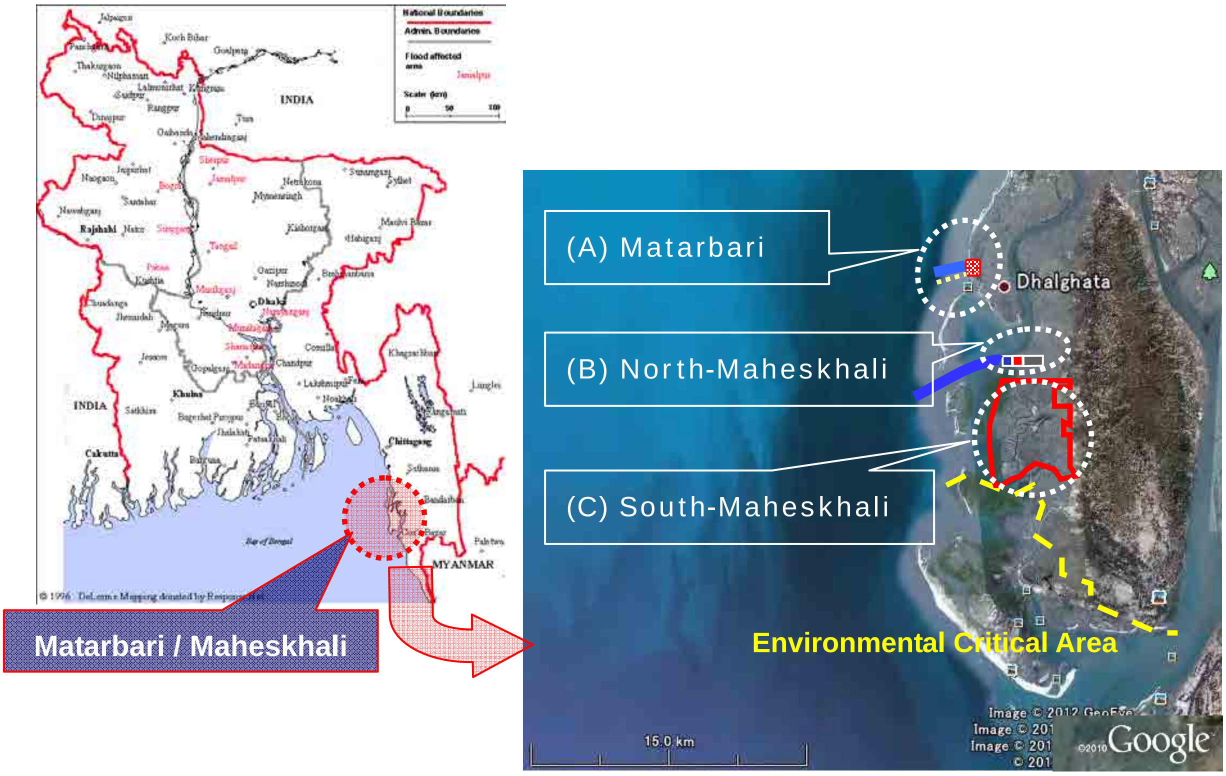


Figure 4.1-1 The Study Areas

4.2 Site Location

As the result of the Follow-up Survey, two candidate sites were selected and surveyed. As a first step of the Study, one candidate site should be selected for further detail study. The candidate sites which were selected on the Follow-up Survey were as follows.

According to the result of the Follow-up Survey, Matarbari has an advantage from the viewpoint of environmental issue. After the Follow-up Study, GOB and JICA signed the Minutes of Discussion which says that, Matarbari site would be considered on a priority basis over North-Maheskhali but in-depth examination and further consideration will be required. As the first step of the Study, the confirmation of the suitability of the candidate site is conducted by detail including site survey and numerical simulation etc.

4.3 Design Conditions

4.3.1 Flow chart of the study

The flow of the Study is shown in Figure 4.3-1.

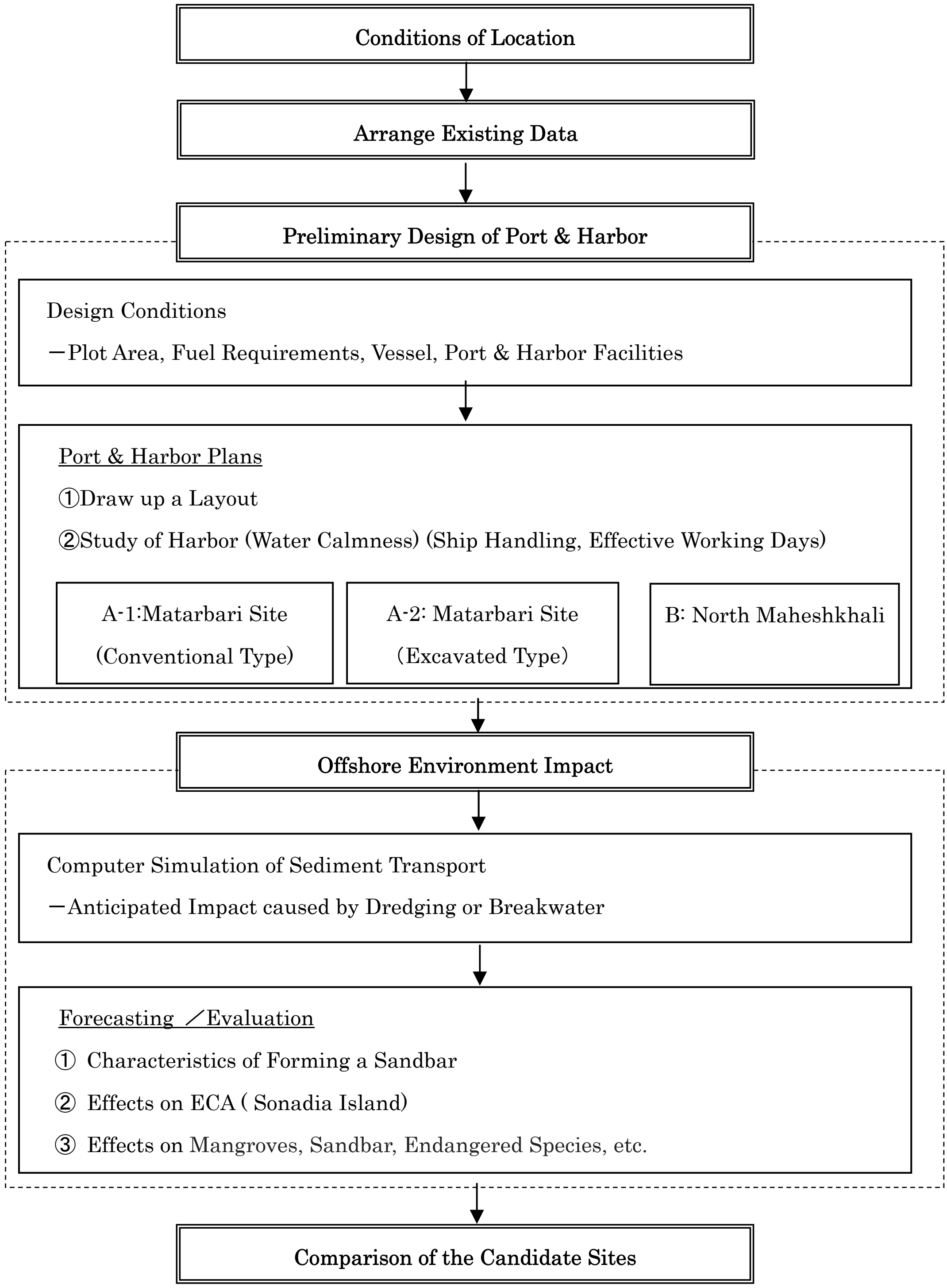


Figure 4.3-1 Flow Chart of the Study

4.3.2 Environmental situation

(1) General

The JICA Study Team will carry out a field investigation of the environmental situation after determining the candidate site.

In relation to the preliminary designs, we have collected existing data / information on the environmental situation in order to study a selection of the suitable site.

As will be seen in the next section, we analyzed the calmness of the harbor and calculated the rate of sediment transport carried out based on this data / information.

The information and volumes, etc., we collected from the subject areas are described in this section.

- Water depth of sea area
- Wave height of deep water
- Tidal Current
- Meteorological data (Wind, Rainfall, Temperature, Humidity)
- Cyclonic Storm Surge

(2) Oceanographic Conditions

1) Water Depth

The water depth as charted by the hydrographic chart applies to the sea area of the candidate site. The hydrographic chart is shown in the next page.

(m)

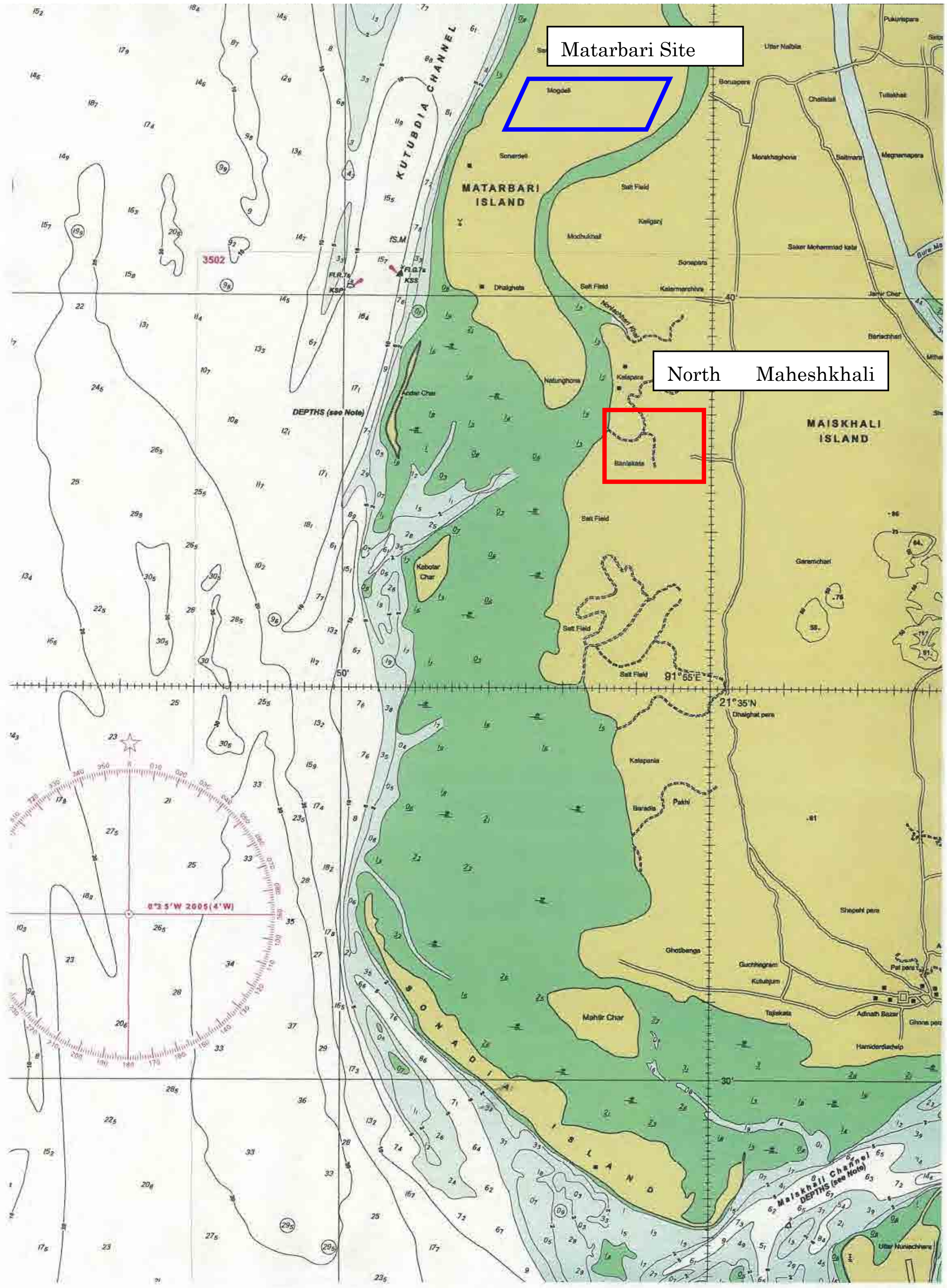


Figure 4.3-2 Hydrographic Chart (Candidate Area)

2) Ordinary Deep water Waves

(i) Outline of Estimated Global Wave Database

An estimated global wave database has been calculated using the Wave Estimation Model "JWA3G" developed by the Japan Weather Association, based on the objectively analyzed sea surface wind values of the European Center for Medium-Range Weather Forecasts (ECMWF) as input conditions.

Model JWA3G is the most advanced model for estimating irregular waves approaching from various directions based on the spectral method

(ii) Deep water Waves Data

- Period : 2006.1.1～2010.12.31
- Extraction Point : Long. 91°30' E, Long. 20°30' N
- Time Interval : 1 hour
- Data Elements : Significant wave height、period and direction

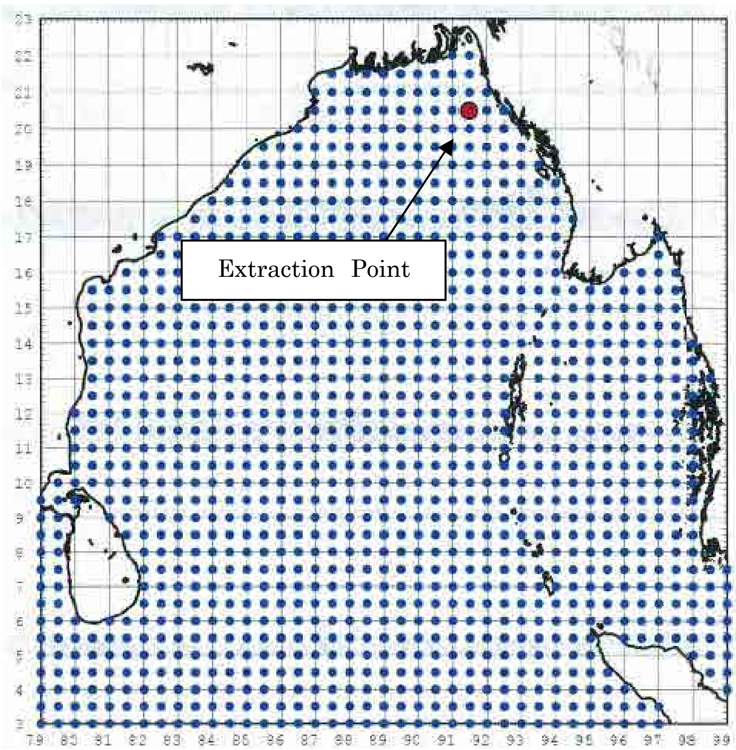
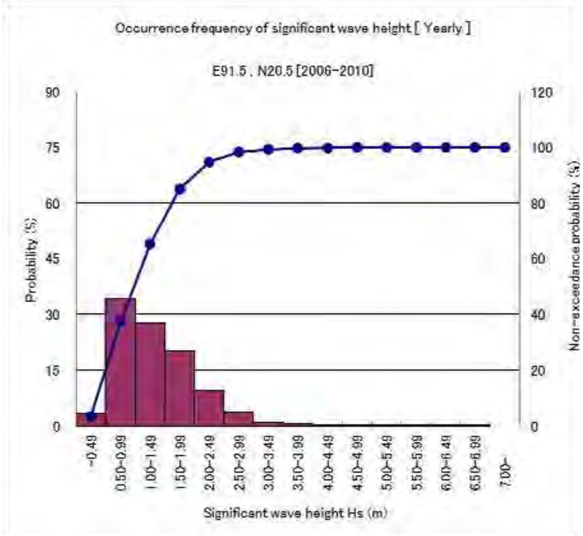
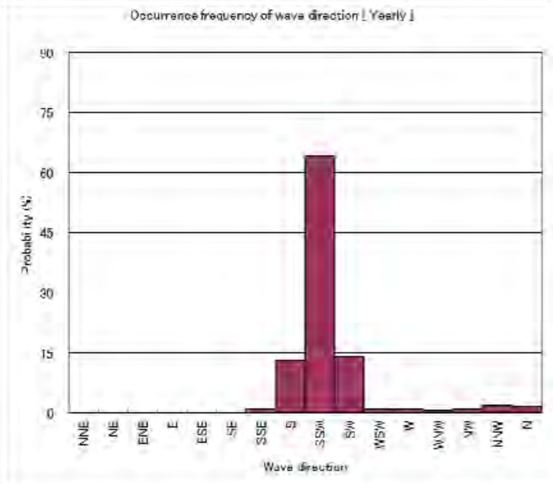


Figure 4.3-3 Area of Wave Forecasting Data

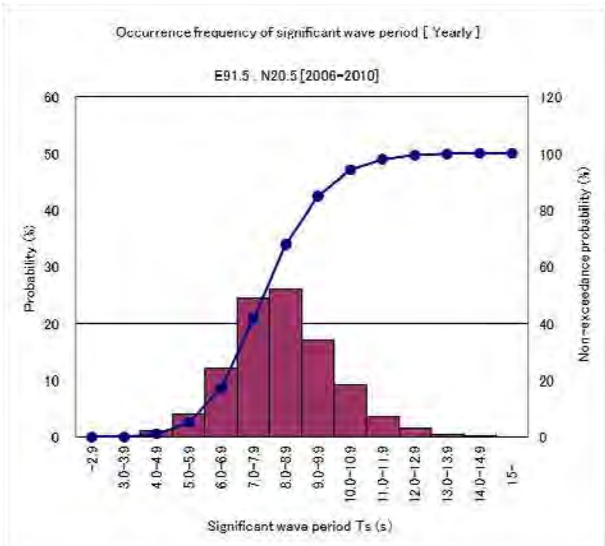
Statistical analysis of ordinary deep water waves has been carried out based on wave estimation data. The composite occurrence frequency of significant wave height, period and direction are indicated respectively in Figure 4.3-4.



Predominant Wave Height
- 0.50m～0.99m ;34%
- 1.00m～1.49m ;28%
- 1.50m～1.99m ;20%



Predominant Wave Direction
- 8.0s～8.9s ;64%
- 7.0s～7.9s ;25%
- 9.0s～9.9s ;17%



Predominant Wave Period
- SSW ;64%
- SW ;14%
- S ;13%

Figure 4.3-4 Occurrence Frequency of Significant Wave Height, Period and Direction [Deep water Yearly]

3) Current

Table 4.3-1 Current around Sonadia Island

(m/s)

Flood		Ebb	
Velocity	Direction	Velocity	Direction
1.45	NNE	1.20	SSW

Source：based on current observation data (unreliable data source)

4) Tidal Levels

Table 4.3-2 Tidal Levels of Sonadia Island

H.W.L	M.S.L	L.W.L
+1.94	±0.00	-2.08

Source：based on tidal observation data (unreliable data source)

4.3.3 Design condition of the port and harbor planning

(1) Dimensions of target vessel

The dimensions of the target vessels based on actual records of a vessel arriving in HITATI-NAKA Port have been assumed as indicated in Table 4.3-3.

Table 4.3-3 Dimensions of Target Vessels

Type	Class (DWT)	Length L(m)	Breadth B(m)	Draft Df(m)
Coal carrier	80,000	220	36.0	13.0

(2) Dimensions of navigation channel and mooring basin

The dimensions of the navigation channel and mooring basin are as indicated in Table 4.3-4.

Table 4.3-4 Dimensions of Channel and Mooring Basin

Type	Channel			Mooring Basin		Berth
	Width (m)	Length (m)	Depth (m)	Width (m)	Depth (m)	Length (m)
Coal carrier	250 (1 L)	1200 (5 L)	15.0 (1.1Df)	500 (2 L)	15.0 (1.1 Df)	600 (*)

*：coal vessel 80,000DWT×1、oil vessel 10,000DWT×1

(3) Conditions of harbor (water calmness)

Conditions of harbor calmness are as indicated in Table 4.3-5.

In principle, calmness levels of 95% to 97.5% are necessary on anchorage or mooring days. In this study, the calmness level was set to 96%.

Table 4.3-5 Conditions of Harbor Calmness

Area	Threshold Wave Height	Remarks
Entrance of Channel	1.5m	Stopping wave height of target vessels
Coal Berth	1.0m	Threshold wave height for cargo handling of coal carriers

Threshold wave height is based on TECHNICAL STANDARDS AND COMMENTARIES FOR PORT AND HARBOR FACILITIES IN JAPAN.

4.4 Layout Planning (Port & Harbor Facilities)

On the basis of the wave conditions set in Clause 4.3 above, the layout of the port and harbor facilities for receiving coal carriers has been studied.

Meanwhile, the layout design of the port and harbor facilities has been carried out according to the following policy:

- In the water area to be used for arrivals, departure of coal carriers and coal handling, a mooring basin with a depth of 500m will be provided at a water depth of -16.0m or deeper.
- A straight line navigation channel with a width of 250m will be provided over the space of 1200m from the center of the mooring basin.
- In consideration that the direction of waves approaching these project sites are limited to S to SW, a breakwater will be built to protect the navigation route and anchorage from waves in these directions. In this case, dispersion equivalent to roughly half the direction should be taken into consideration for the direction.

The preliminary layout design of the port and harbor facilities studied based on the above policy is indicated the following table and figures.

Table 4.4-1 Layout Planning

Plan	A-1	A-2	B
Candidate Site	Matarbari	Matarbari	North Maheshkhali
Length of Channel	2000m	3000m	7000m
Width of Channel	250m	250m	250m
Presence of Breakwater	1500m	Without breakwater	Without breakwater
Remarks	The port is calm because of the breakwater. This plan is the Conventional Type.	The port is calm because of the excavated land. This plan is Artificially Excavated Port Type.	The port is a shoal. There are mangroves around the port.

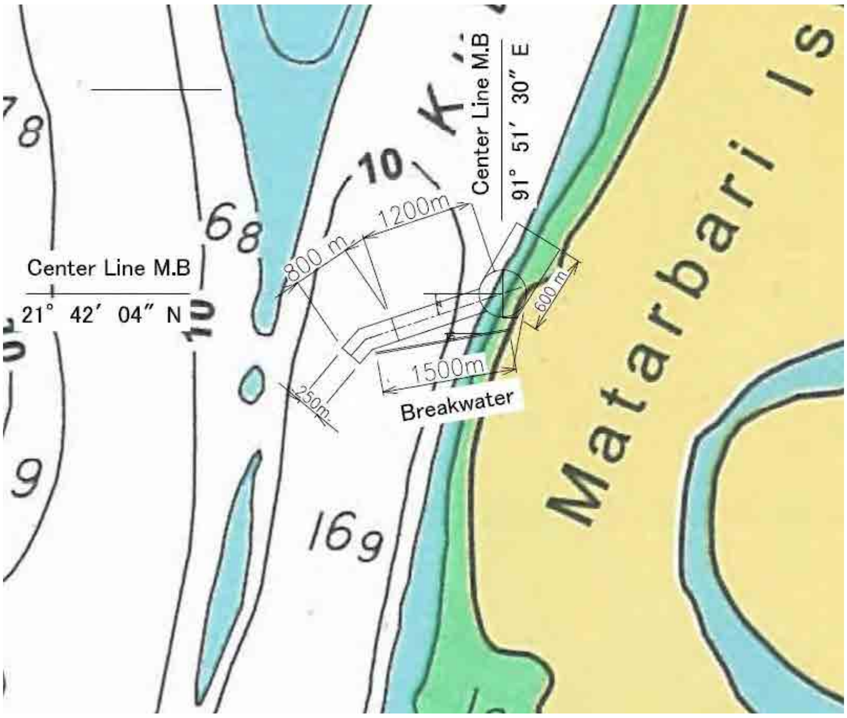


Figure 4.4-1 Layout Planning A-1 (Matarbari Site (Conventional Type))

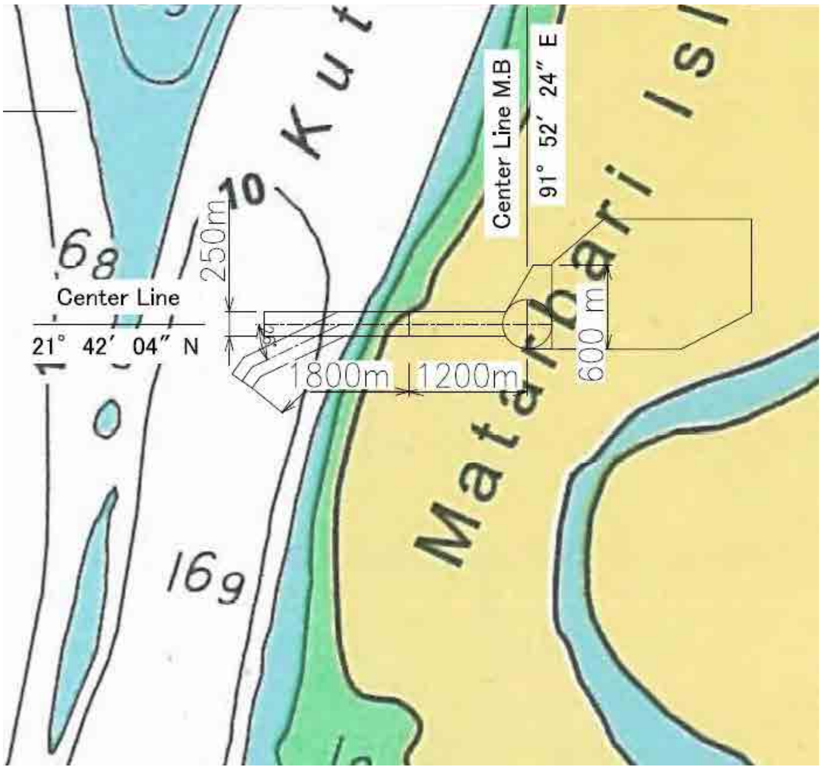


Figure 4.4-2 Layout Planning A-2 (Matarbari Site (Excavated Type))

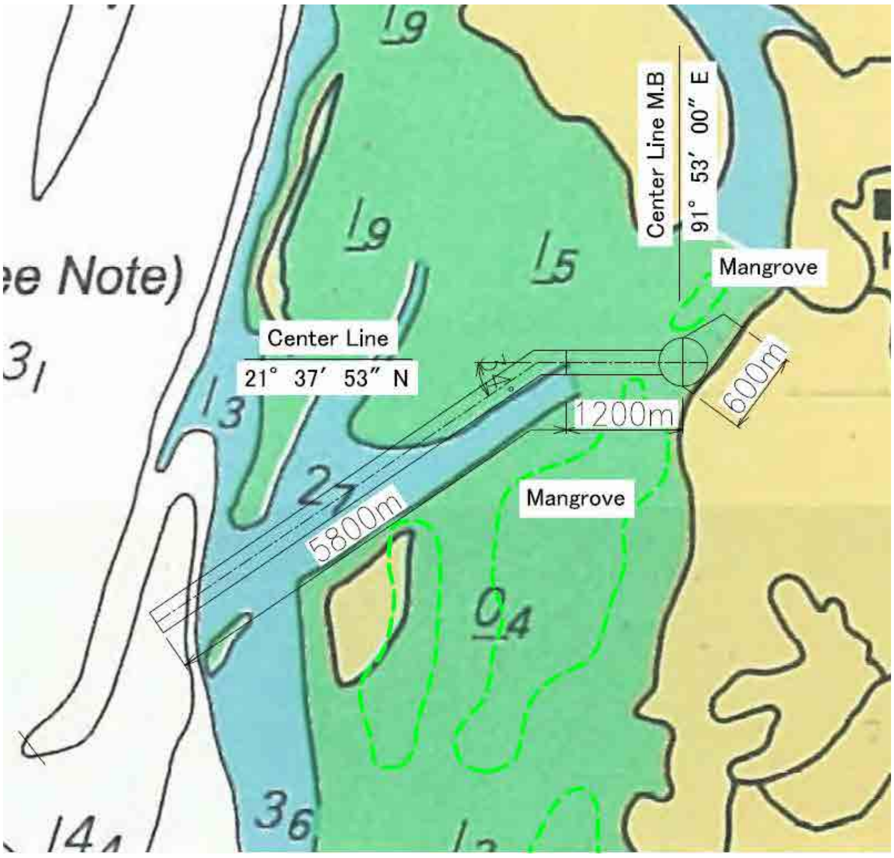


Figure 4.4-3 Layout Planning B (North Maheshkhali Site)

4.5 Comparison of the Candidate Sites

4.5.1 Study of harbor (water calmness)

(1) Outline

With regard to the port and harbor layout designs reviewed in clause 4.4 above, the water calmness inside the port and harbor has been studied.

Generally, waves, wind, ship motions, and operation conditions of oceangoing vessels, are involved in the water calmness inside the port. In this case, however, the water calmness has been evaluated based on the occurrence probability of less intensive waves than the critical level for cargo or coal handling by focusing on the waves causing the largest impact upon the water calmness inside the port.

For studying the water calmness inside the port, it is essential to obtain the wave height ratio to incidence waves in the respective water areas inside the port.

The diffraction and shoaling of waves have been calculated by using the beach evolution analysis model. The analysis conditions are as shown below.

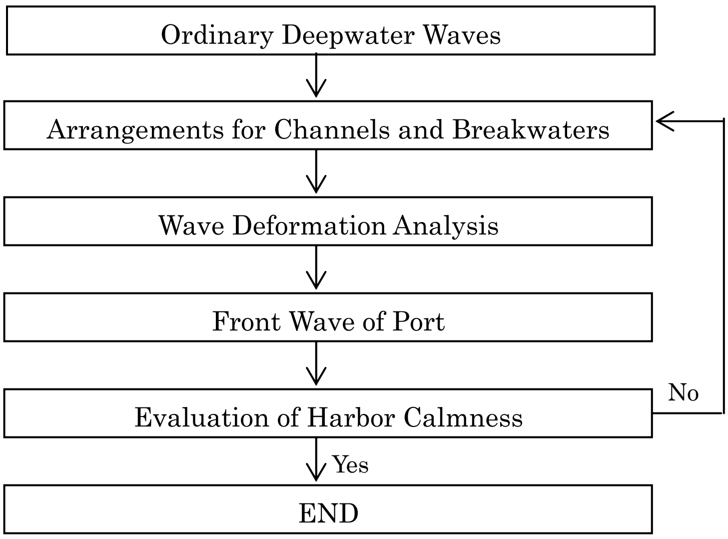


Figure 4.5-1 Flow of Study

- Analyzed area : 70km × 40km
- Water depth : based on the Hydrographic Chart
- Incident waves
  - Significant wave period : T1/3= 6s, 9s,12s
  - Wave directions : SSE, S, SSW
  - Sea level ; M.S.L ＝ ±0.0m

(2) Study of Harbor Calmness Analysis Results

1) Plan : A-1 Matarbari Site (Conventional Type)

(i) Wave height ratio

The wave height ratio and wave direction obtained from wave deformation analysis is indicated in Figure 4.5-2 and Figure 4.5-3.

The results of calculating the wave height ratio at the port entrance and mooring basin are indicated in Table 4.5-1 and Table 4.5-2.

Wave height ratio ＝ $H／H_0$

H：site wave height、H_0：deep water wave height

Table 4.5-1 Wave Height Ratio at the Port (without Breakwater)

H/H_0

Point	Incident Wave	$T_{1/3}$= 6 s	$T_{1/3}$= 9 s	$T_{1/3}$=12 s
Port Entrance	SSE	0.42	0.36	0.33
	S	0.57	0.56	0.58
	SSW	0.67	0.64	0.62
Mooring Basin	SSE	0.22	0.20	0.20
	S	0.31	0.32	0.34
	SSW	0.38	0.37	0.37

Table 4.5-2 Wave Height Ratio at the Port (Breakwater Construction)

H/H_0

Point	Incident Wave	$T_{1/3}$= 6 s	$T_{1/3}$= 9 s	$T_{1/3}$=12 s
Port Entrance	SSE	0.26	0.25	0.25
	S	0.38	0.40	0.43
	SSW	0.46	0.47	0.46
Mooring Basin	SSE	0.09	0.09	0.09
	S	0.16	0.14	0.15
	SSW	0.21	0.17	0.17

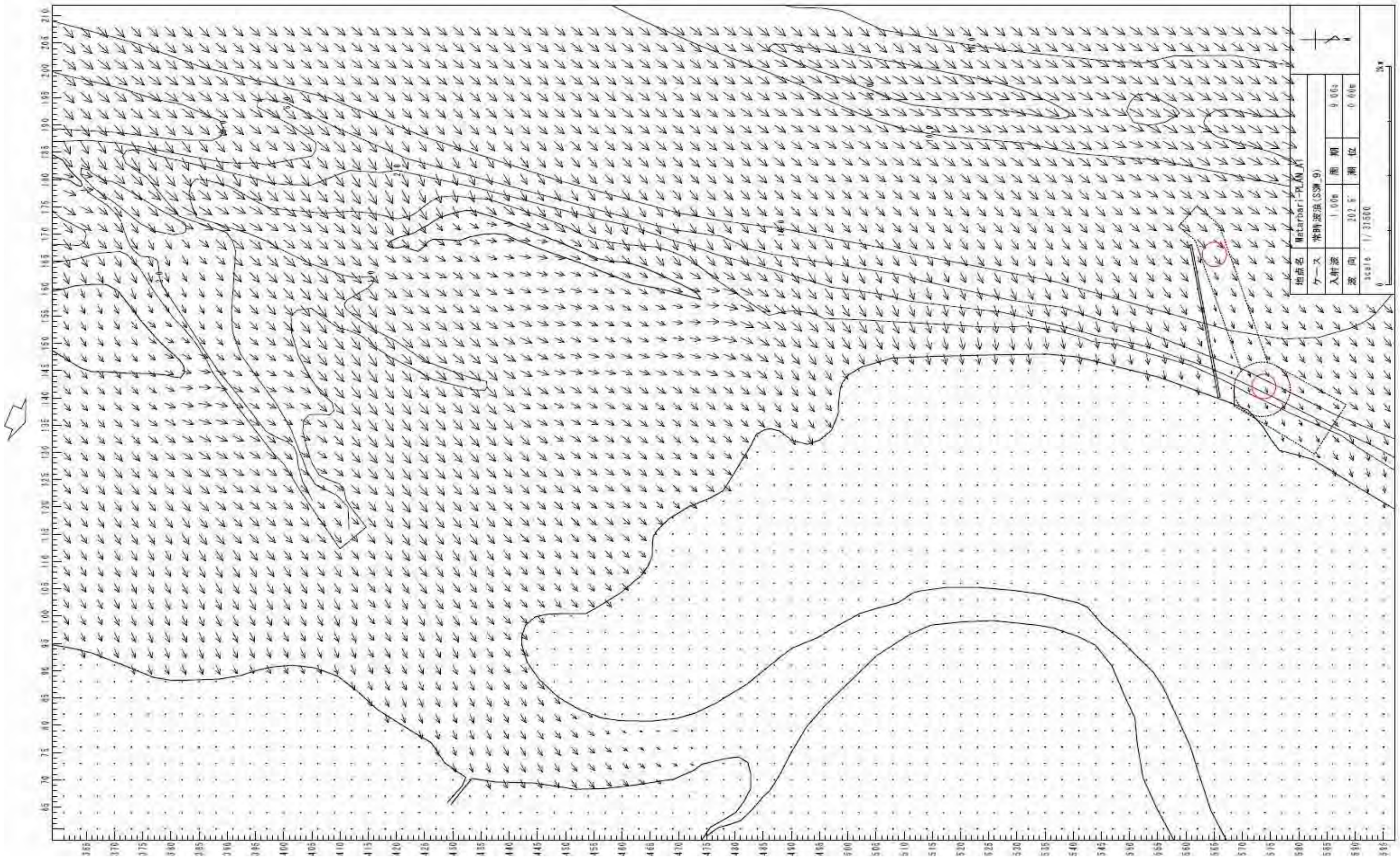


Figure 4.5-2 Wave Direction by Deformation Analysis

($T_{1/3}$=9s, direction: SSW)

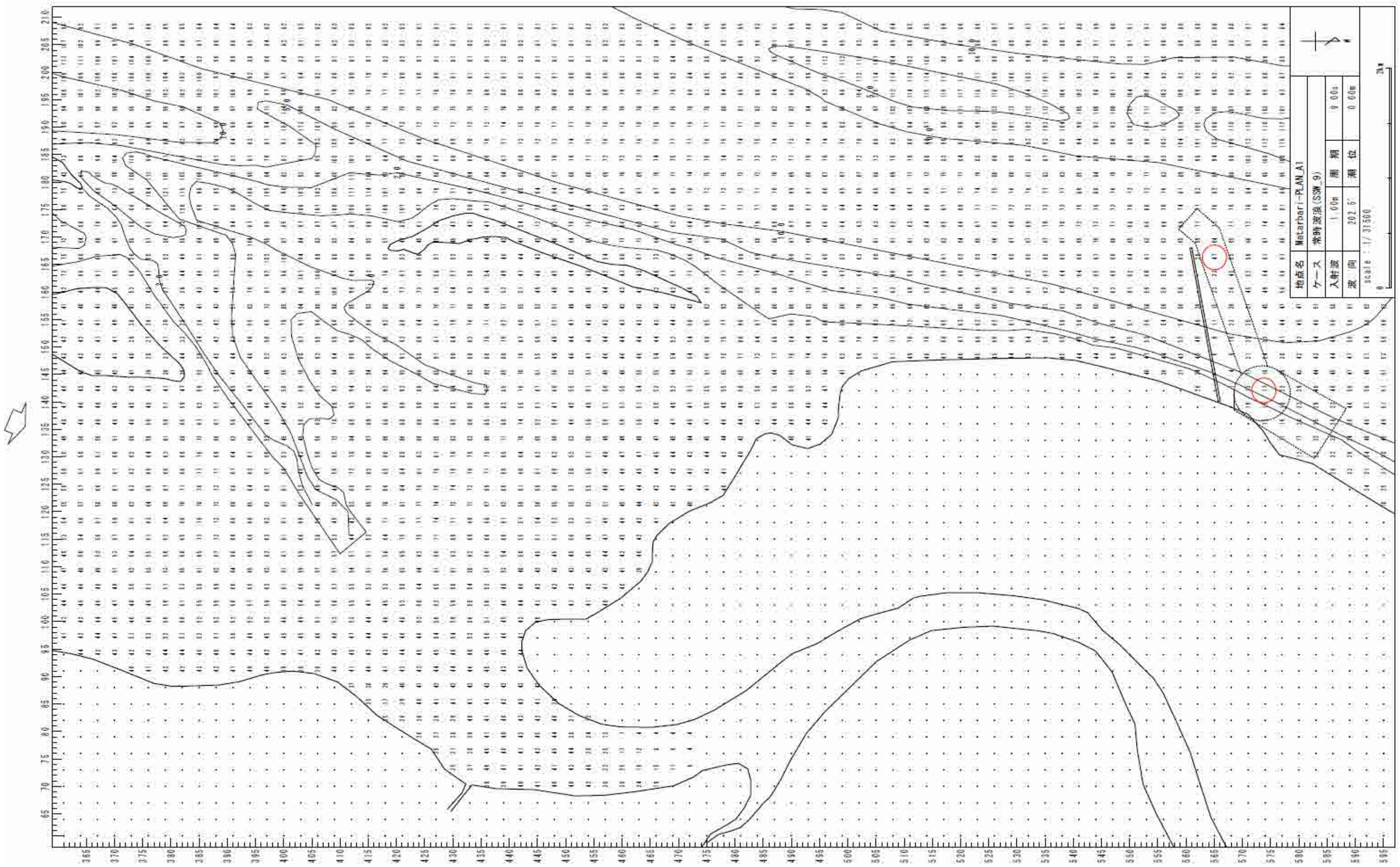


Figure 4.5-3 Wave Height Ratio by Deformation Analysis

($T_{1/3}$=9s, direction: SSW)

(ii) Evaluation of harbor water calmness

Evaluating the water calmness inside the port is based on the availability of stopping wave height of target vessels and cargo handling of coal carriers. The wave height inside the port is calculated by multiplying the wave height at the planned breakwater position, the wave height ratio at the respective water areas inside the port, and after fitting the critical wave height for service in the respective water area to the wave height values obtained above, the probability of lower waves than the critical height for service was calculated and studied.

The composite occurrence frequency of significant wave height and period are indicated respectively in Table 4.5-5. From this table, the availability of stopping wave height of target vessels and cargo handling of coal carriers is indicated in Table 4.5-3 and Table 4.5-4.

Based on the results of this study, the construction of a breakwater is envisaged in this plan, otherwise the port could not maintain water calmness.

Table 4.5-3 Rate of Effective Working Days at Port (without Breakwater)

Area	Threshold Wave Height	Rate of Effective Working Days
Entrance of Channel	1.5m	94.7% ＜96% ・・ Not sufficient
Coal Berth	1.0m	93.5%＜96% ・・ Not sufficient

Table 4.5-4 Rate of Effective Working Days at Port (Breakwater Construction)

Area	Threshold Wave Height	Rate of Effective Working Days
Entrance of Channel	1.5m	99.2% ＞96% ・・Good
Coal Berth	1.0m	96.5%＞96% ・・Good

Table 4.5-5 Composite Frequency of Significant Wave Height and Period (at Mooring Basin, Annually)

Wave Height	Priod (s)															
	0～	3.1～	4.1～	5.1～	6.1～	7.1～	8.1～	9.1～	10.1～	11.1～	12.1～	13.1～	14.1～	15.1～	total	Sum up	percentage
0.00～0.20	0	0	9	234	1105	2611	4894	4398	2713	896	371	62	28	0	17321	17321	39.52%
0.21～0.40	0	0	116	381	1969	4351	4618	2167	1039	475	218	115	0	0	15449	32770	74.77%
0.41～0.60	0	0	8	551	1500	1849	904	254	45	45	24	0	0	0	5180	37950	86.59%
0.61～0.80	0	0	13	550	642	874	398	82	14	3	0	0	0	0	2576	40526	92.46%
0.81～1.00	0	0	20	299	721	478	173	44	14	8	2	0	0	0	1759	42285	96.48%
1.01～1.20	0	0	0	28	215	350	148	4	36	0	0	0	0	0	781	43066	98.26%
1.21～1.50	0	0	0	0	205	319	94	0	0	0	0	0	0	0	618	43684	99.67%
1.51～2.00	0	0	0	0	9	99	22	0	0	0	0	0	0	0	130	43814	99.97%
2.01～2.50	0	0	0	0	0	11	4	0	0	0	0	0	0	0	15	43829	100.00%
2.51～3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
3.01～3.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
3.51～4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
4.01～4.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
4.51～5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
5.01～5.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
5.51～6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
6.01～6.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
6.51～7.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
7.01～	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
total	0	0	166	2043	6366	10942	11255	6949	3861	1427	615	177	28	0	43829		

(iii) The necessity to construct a breakwater

Based on the evaluation of harbor calmness results, the JICA Study Team considers that a breakwater must be constructed at the front of the Matarbari site in order to protect it from sea waves.

The reasons are outlined below.

- According to annual data, to ensure calmness at the entrance of the channel and coal berth a breakwater is required. (Table 4.5-4)
- Based on the wave data arranged according to months, coal vessels cannot arrive at all in port in July, because there are no calm days. (Table 4.5-6)
- In the same way, coal vessels can arrive for a few days in June because of less than 96% calmness-ratio. That means that coal vessels are restricted in their operations by the weather conditions. (Table 4.5-7)
- The amount of coal storage is considered to be in port for about 60 days. It is considered that arrivals in port are limited in June and in July because of wave height.

We think it is necessary that the breakwater has to construct for port & harbor's ability in this preliminary design.

Table 4.5-6 Frequency of Significant Wave Height and Period (at Mooring Basin, in July)

	0～	3.1～	4.1～	5.1～	6.1～	7.1～	8.1～	9.1～	10.1～	11.1～	12.1～	13.1～	14.1～	15.1～	total	sum total	percentage
0.00～0.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
0.21～0.40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
0.41～0.60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
0.61～0.80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
0.81～1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
1.01～1.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00%
1.21～1.50	0	0	0	0	114	68	33	52	0	0	0	0	0	0	267	267	7.18%
1.51～2.00	0	0	0	9	463	392	327	111	91	0	0	0	0	0	1393	1660	44.62%
2.01～2.50	0	0	0	0	368	510	396	105	0	0	0	0	0	0	1379	3039	81.69%
2.51～3.00	0	0	0	0	138	247	106	0	0	0	0	0	0	0	491	3530	94.89%
3.01～3.50	0	0	0	0	9	94	24	0	0	0	0	0	0	0	127	3657	98.31%
3.51～4.00	0	0	0	0	1	28	15	0	0	0	0	0	0	0	44	3701	99.49%
4.01～4.50	0	0	0	0	0	0	11	0	0	0	0	0	0	0	11	3712	99.78%
4.51～5.00	0	0	0	0	0	0	8	0	0	0	0	0	0	0	8	3720	100.00%
5.01～5.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3720	100.00%
5.51～6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3720	100.00%
6.01～6.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3720	100.00%
6.51～7.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3720	100.00%
7.01～	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3720	100.00%
total	0	0	0	9	1093	1339	920	268	91	0	0	0	0	0	3720		

Table 4.5-7 Frequency of Significant Wave Height and Period (at Mooring Basin, in June)

	0～	3.1～	4.1～	5.1～	6.1～	7.1～	8.1～	9.1～	10.1～	11.1～	12.1～	13.1～	14.1～	15.1～	total	sum total	percentage
0.00～0.20	0	0	0	1	57	33	13	0	0	0	0	0	0	0	104	104	2.89%
0.21～0.40	0	0	0	40	468	949	638	138	30	68	34	0	0	0	2365	2469	68.58%
0.41～0.60	0	0	0	0	192	217	100	83	25	13	0	0	0	0	630	3099	86.08%
0.61～0.80	0	0	0	0	23	23	9	26	0	0	0	0	0	0	81	3180	88.33%
0.81～1.00	0	0	0	0	19	19	2	12	5	0	0	0	0	0	57	3237	89.92%
1.01～1.20	0	0	0	0	2	68	76	0	10	0	0	0	0	0	156	3393	94.25%
1.21～1.50	0	0	0	0	19	111	25	0	0	0	0	0	0	0	155	3548	98.56%
1.51～2.00	0	0	0	0	0	33	8	0	0	0	0	0	0	0	41	3589	99.69%
2.01～2.50	0	0	0	0	0	11	0	0	0	0	0	0	0	0	11	3600	100.00%
2.51～3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
3.01～3.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
3.51～4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
4.01～4.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
4.51～5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
5.01～5.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
5.51～6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
6.01～6.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
6.51～7.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
7.01～	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3600	100.00%
total	0	0	0	41	780	1464	871	259	70	81	34	0	0	0	3600		

2) Plan ; A-2 Matarbari Site (Excavated Type)

(i) Wave height ratio

The wave height ratio and wave direction obtained from wave deformation analysis is indicated in Figure 4.5-4 and Figure 4.5-5.

The results of calculating the wave height ratio at the port entrance and mooring basin are indicated in Table 4.5-8.

Wave height ratio = H / H_0

H : site wave height、H0 : deep water wave height

Table 4.5-8 Wave Height Ratio at the Port (without Breakwater)

H/H_0

Point	Incident Wave	$T_{1/3}$= 6 s	$T_{1/3}$= 9 s	$T_{1/3}$=12 s
Port Entrance	SSE	0.30	0.35	0.38
	S	0.42	0.55	0.64
	SSW	0.51	0.64	0.70
Mooring Basin	SW	0.16	0.13	0.13
	WSW	0.42	0.33	0.32
	W	0.62	0.53	0.47

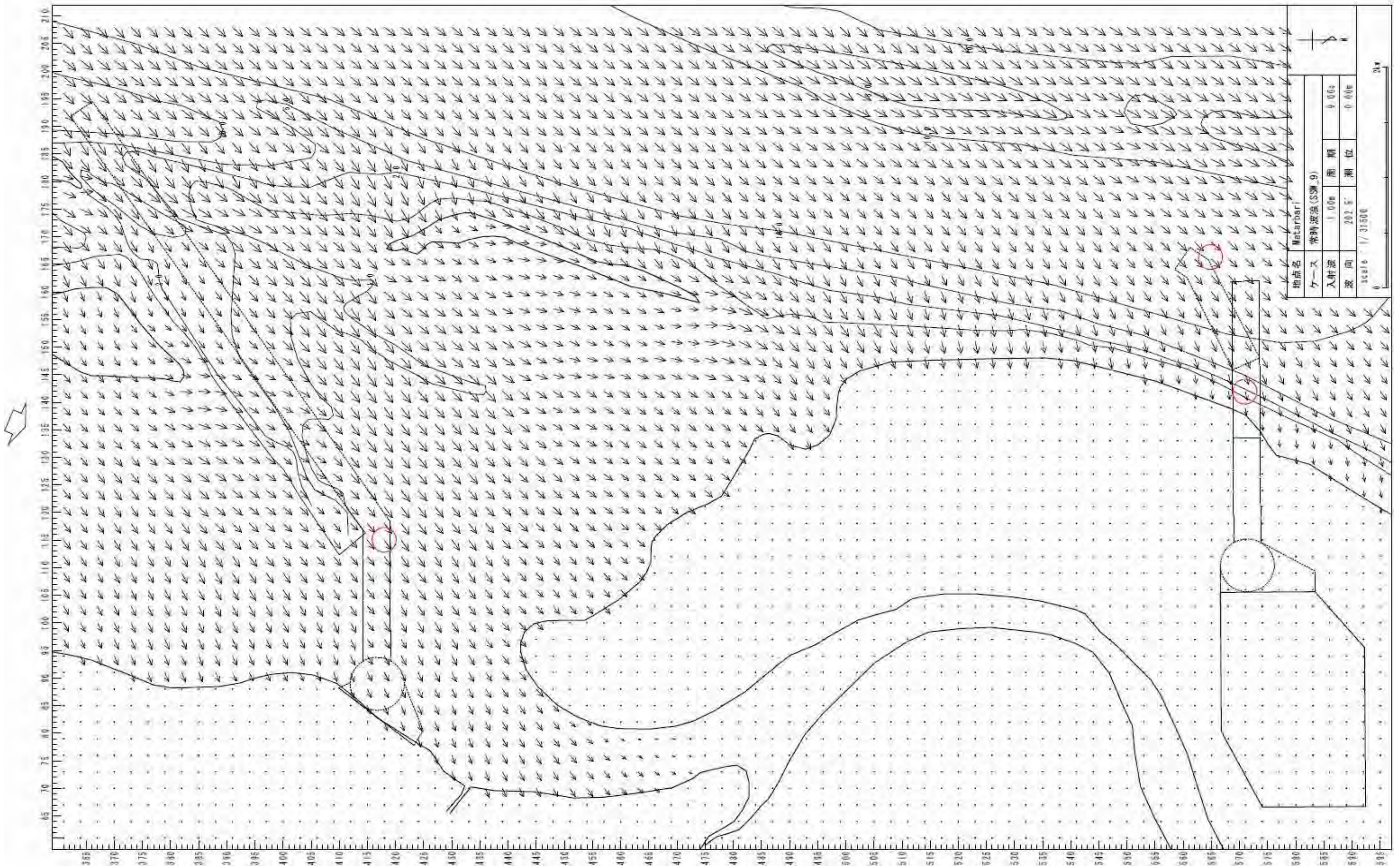


Figure 4.5-4 Wave Direction by Deformation Analysis

(T1/3=9s, direction: SSW)

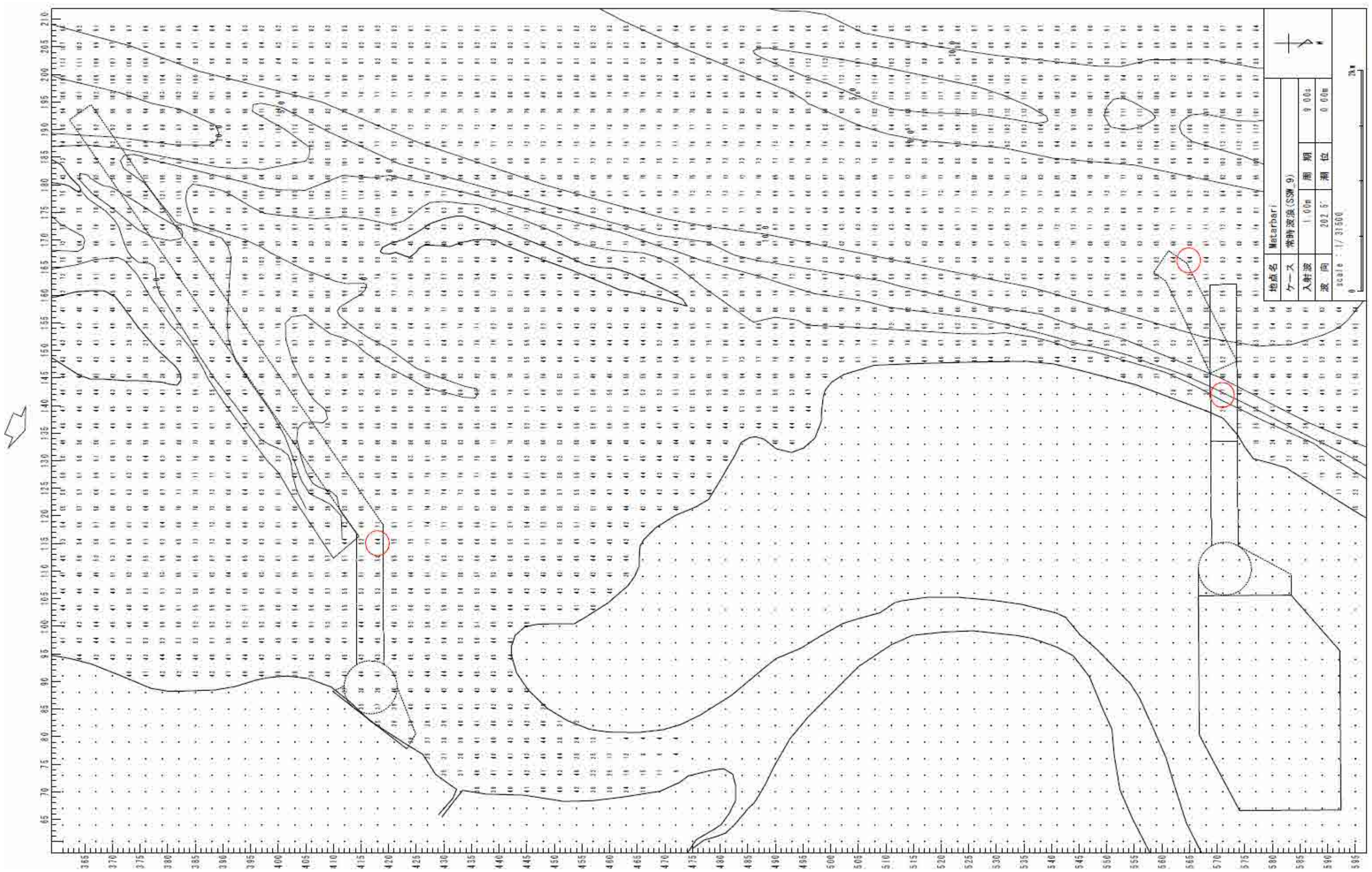


Figure 4.5-5 (1) Wave Height Ratio by Deformation Analysis

(Entrance of channel, $T_{1/3}$=9s, direction: SSW)

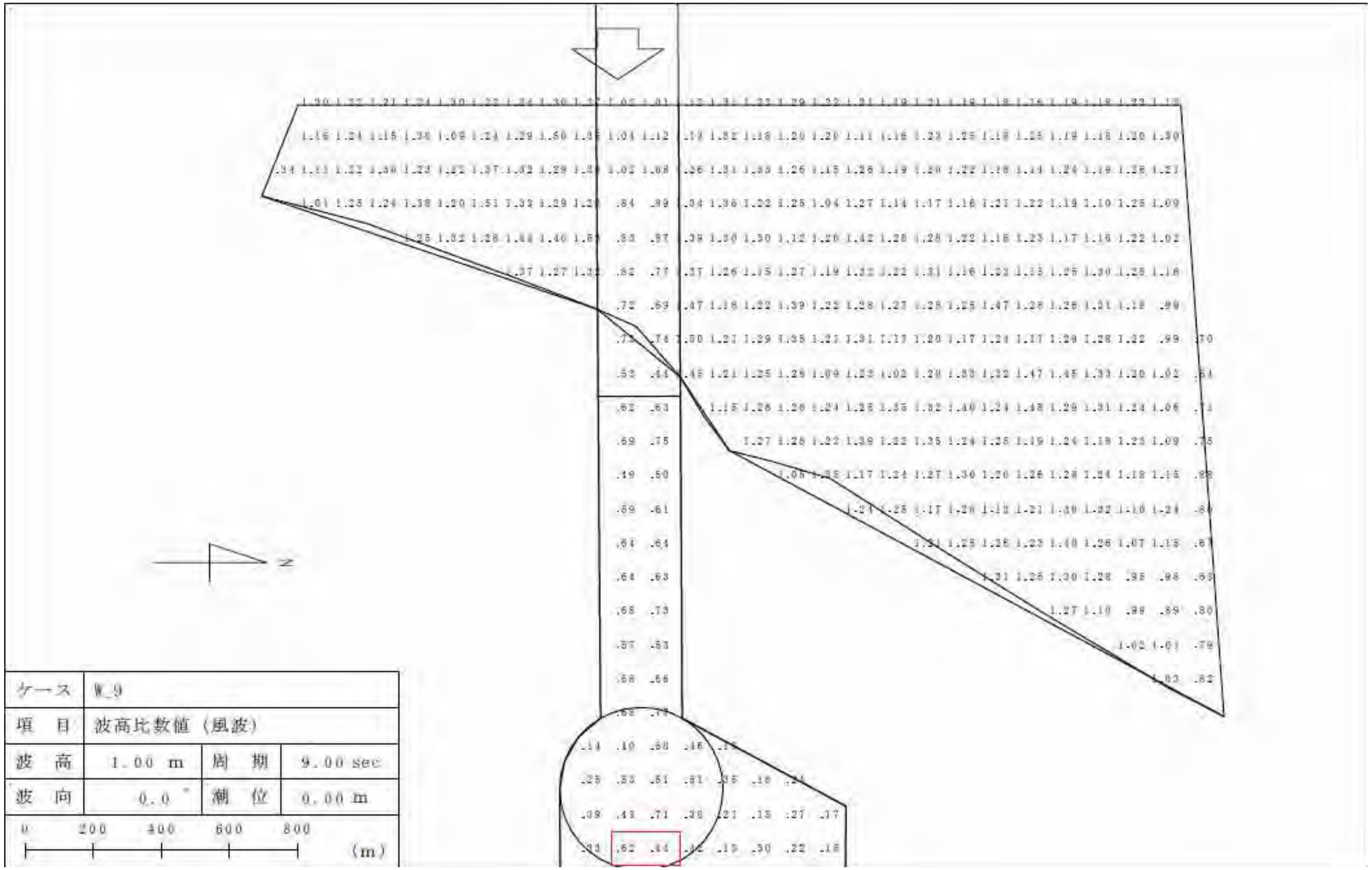


Figure 4.5-5 (2) Wave Height Ratio by Refraction Coefficient Analysis

(Mooring basin, $T_{1/3}$=9s, direction: W)

(ii) Evaluation of harbor calmness

Evaluating the water calmness inside the port is based on the availability of stopping wave height of target vessels and cargo handling of coal carriers. The wave height inside the port is calculated by multiplying the wave height at the planned breakwater position, the wave height ratio at the respective water areas inside the port, and after fitting the critical wave height for service in the respective water area to the wave height values obtained above, the probability of the lower waves than the critical height for service was calculated and studied.

The composite occurrence frequency of significant wave height and period are indicated respectively in Table 4.5-9. From this table, the availability is indicated in Table 4.5-10.

Based on the result of the study, the port was evaluated as being calm.

Table 4.5-9 Rate of Effective Working Day at Port (without Breakwater)

Area	Threshold Wave height	Rate of Effective Working Days
Entrance of Channel	1.5m	99.4%＞96% ・・Good
Coal Berth	1.0m	99.9%＞96% ・・Good

Table 4.5-10 Composite Frequency of Significant Wave Height and Period (at Mooring Basin, Annually)

Wave Height	Priod (s)														total	Sum up	percentage
	0～	3.1～	4.1～	5.1～	6.1～	7.1～	8.1～	9.1～	10.1～	11.1～	12.1～	13.1～	14.1～	15.1～			
0.00～0.20	0	0	13	555	4540	9988	10764	6440	3748	1085	206	35	26	0	37400	37400	85.33%
0.21～0.40	0	0	132	888	1227	647	475	484	105	276	202	24	2	0	4462	41862	95.51%
0.41～0.60	0	0	21	590	492	240	14	20	5	29	170	87	0	0	1668	43530	99.32%
0.61～0.80	0	0	0	10	106	61	2	5	1	35	28	31	0	0	279	43809	99.95%
0.81～1.00	0	0	0	0	1	6	0	0	2	1	7	0	0	0	17	43826	99.99%
1.01～1.20	0	0	0	0	0	0	0	0	0	1	2	0	0	0	3	43829	100.00%
1.21～1.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
1.51～2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
2.01～2.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
2.51～3.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
3.01～3.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
3.51～4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
4.01～4.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
4.51～5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
5.01～5.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
5.51～6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
6.01～6.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
6.51～7.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
7.01～	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
total	0	0	166	2043	6366	10942	11255	6949	3861	1427	615	177	28	0	43829		

3) Plan : B North Maheshkhali Site

(i) Wave height ratio

The wave height ratio and wave direction obtained from wave deformation analysis is indicated in Figure 4.5-6 and Figure 4.5-7.

The results of calculating the wave height ratio at the port entrance and mooring basin are indicated in Table 4.5-11.

Wave height ratio ＝ $H／H_0$

H : site wave height、H_0 : deep water wave height

Table 4.5-11 Wave Height Ratio at the Port (without Breakwater)

H/H_0

Point	Incident Wave	$T_{1/3}$= 6 s	$T_{1/3}$= 9 s	$T_{1/3}$=12 s
Port Entrance	SSE	0.30	0.35	0.38
	S	0.42	0.55	0.64
	SSW	0.51	0.64	0.70
Mooring Basin	SSE	0.30	0.31	0.33
	S	0.36	0.38	0.40
	SSW	0.37	0.39	0.40

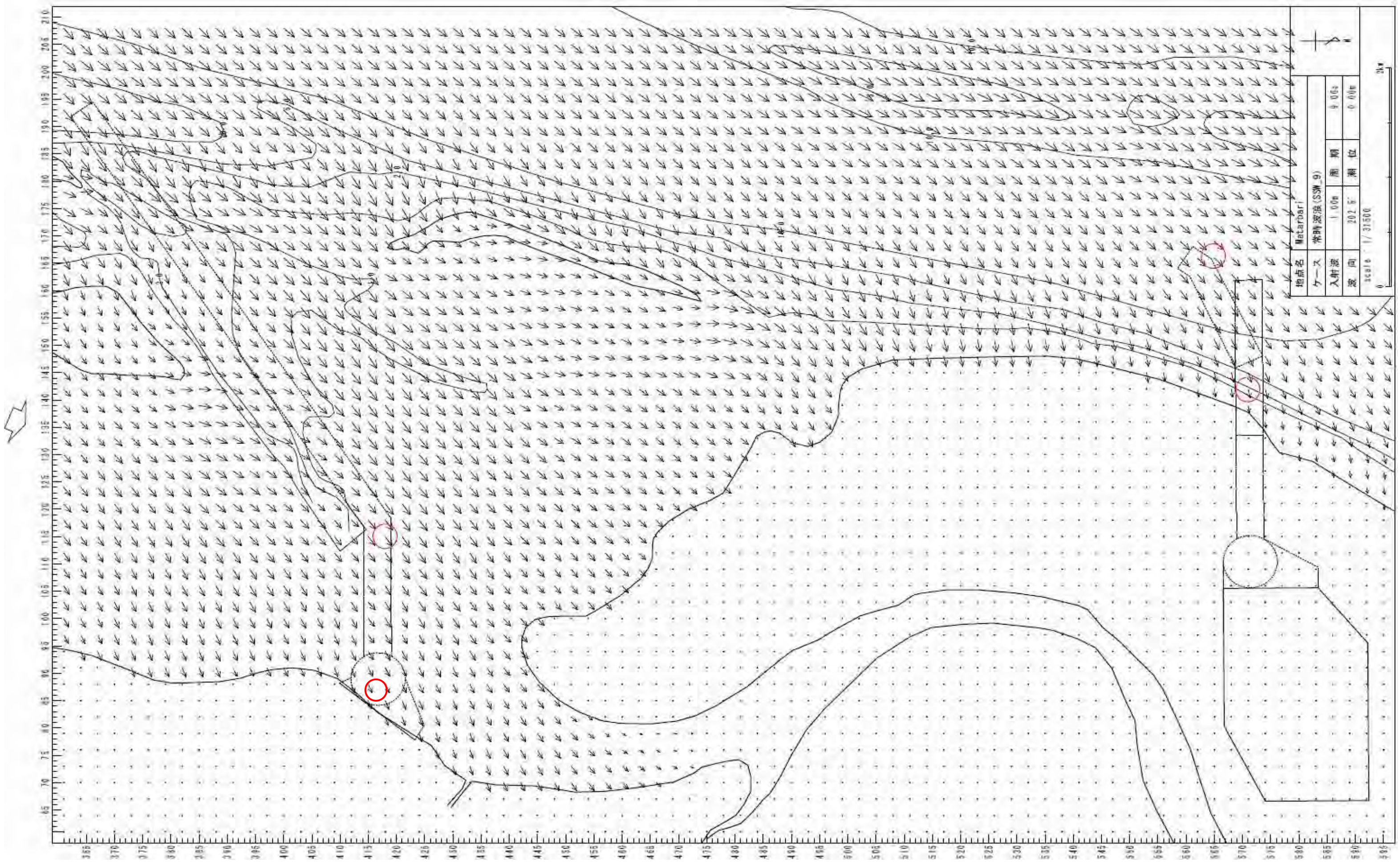


Figure 4.5-6 Wave Direction by Deformation Analysis

($T_{1/3}$=9s, direction: SSW)

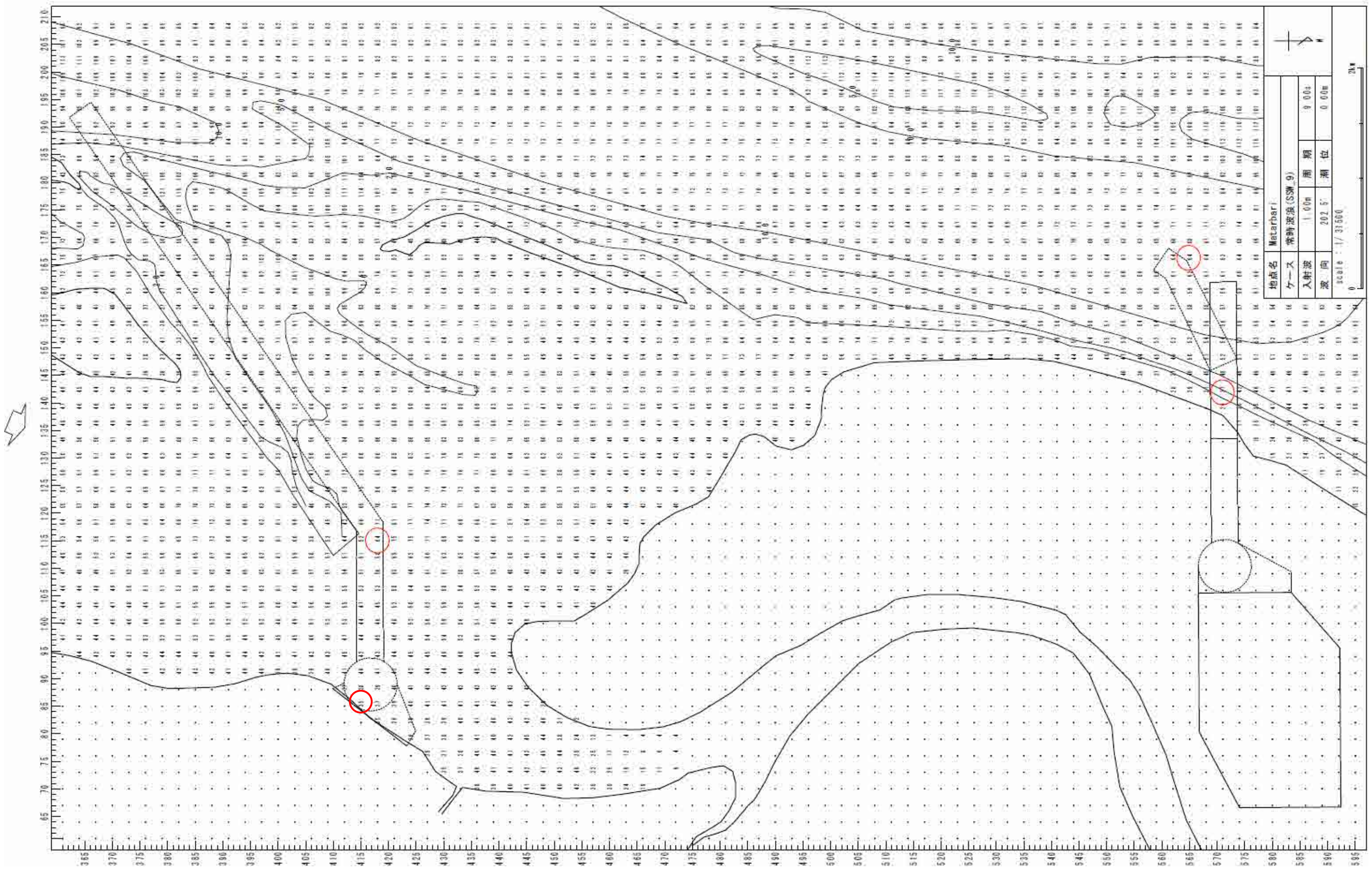


Figure 4.5-7 Wave Height Ratio by Deformation Analysis

($T_{1/3}$=9s, direction: SSW)

(ii) Evaluation of harbor calmness

Evaluating the water calmness inside the port is based on the availability of stopping wave height of target vessels and cargo handling of coal carriers. The wave height inside the port is calculated by multiplying the wave height at the planned breakwater position by the wave height ratio at the respective water areas inside the port, and after fitting the critical wave height for service in the respective water area to the wave height values obtained above, the probability of the lower waves than the critical height for service was calculated and studied.

The composite occurrence frequency of significant wave height and period are indicated respectively in Table 4.5-13. From this table, the availability of stopping wave height of target vessels and cargo handling of coal carriers is indicated in Table 4.5-12.

Based on the result of study, the port was evaluated as being calm.

Table 4.5-12 Rate of Effective Working Day at Port (Breakwater Construction)

Area	Threshold Wave Height	Rate of Effective Working Days
Entrance of Channel	1.5m	96.8%＞96% ・・Good
Coal Berth	1.0m	96.2%＞96% ・・Good

In principle, calmness levels of 95% to 97.5% are necessary on anchorage or mooring days based on the standard. In this study, calmness was set to 96% as the mean value.

.

Table 4.5-13 Composite Frequency of Significant Wave Height and Period (at Mooring Basin, Annually)

Wave Height	Priod (s)														total	Sum up	percentage
	0～	3.1～	4.1～	5.1～	6.1～	7.1～	8.1～	9.1～	10.1～	11.1～	12.1～	13.1～	14.1～	15.1～			
0.00～0.20	0	0	125	135	286	549	605	544	172	37	8	0	0	0	2461	2461	5.62%
0.21～0.40	0	0	20	1195	1971	2819	3997	3309	1816	491	178	17	15	0	15828	18289	41.73%
0.41～0.60	0	0	21	608	1530	2866	3070	1659	1237	711	315	96	13	0	12126	30415	69.39%
0.61～0.80	0	0	0	103	1697	2656	2387	941	494	101	61	64	0	0	8504	38919	88.80%
0.81～1.00	0	0	0	2	755	1133	792	337	115	66	29	0	0	0	3229	42148	96.16%
1.01～1.20	0	0	0	0	123	633	258	121	12	11	24	0	0	0	1182	43330	98.86%
1.21～1.50	0	0	0	0	4	259	75	7	0	10	0	0	0	0	355	43685	99.67%
1.51～2.00	0	0	0	0	0	27	59	20	0	0	0	0	0	0	106	43791	99.91%
2.01～2.50	0	0	0	0	0	0	12	11	8	0	0	0	0	0	31	43822	99.98%
2.51～3.00	0	0	0	0	0	0	0	0	7	0	0	0	0	0	7	43829	100.00%
3.01～3.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
3.51～4.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
4.01～4.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
4.51～5.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
5.01～5.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
5.51～6.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
6.01～6.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
6.51～7.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
7.01～	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43829	100.00%
total	0	0	166	2043	6366	10942	11255	6949	3861	1427	615	177	28	0	43829		

4.5.2 Computer simulation of sediment transport

(1) Outline

The JICA Study Team carried out a simulation of sediment transport.

As shown in the figure below, it is considered that sediment transport of the seashore is caused by near shore currents, tidal currents and the inflow discharge of rivers.

Suspended sediment accrues in areas where the velocity distribution is low, and where the velocity distribution is high, tides erode the sediment.

Regarded in this light, modification of the project site is envisaged.

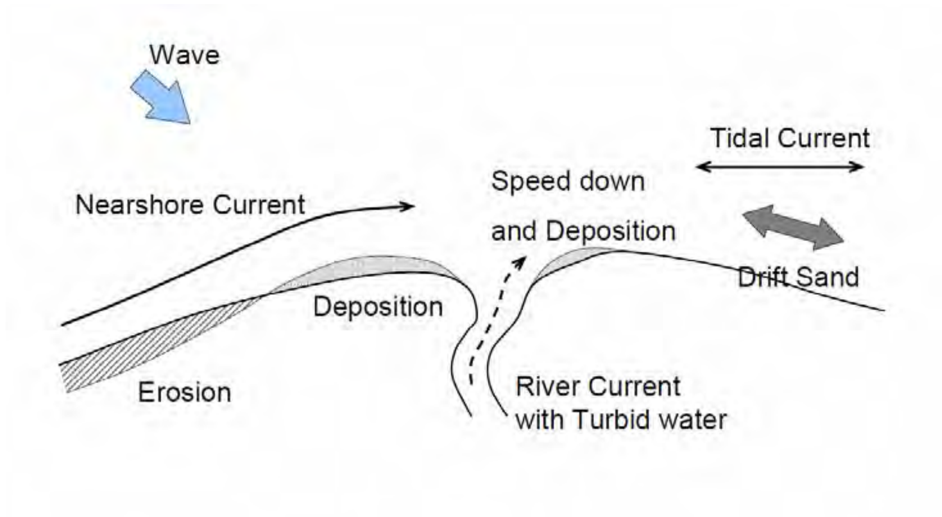


Figure 4.5-8 Mechanism of Sediment Transport

*Deposition : the natural process of leaving a layer of soil

**Erosion : the result of being eroded,

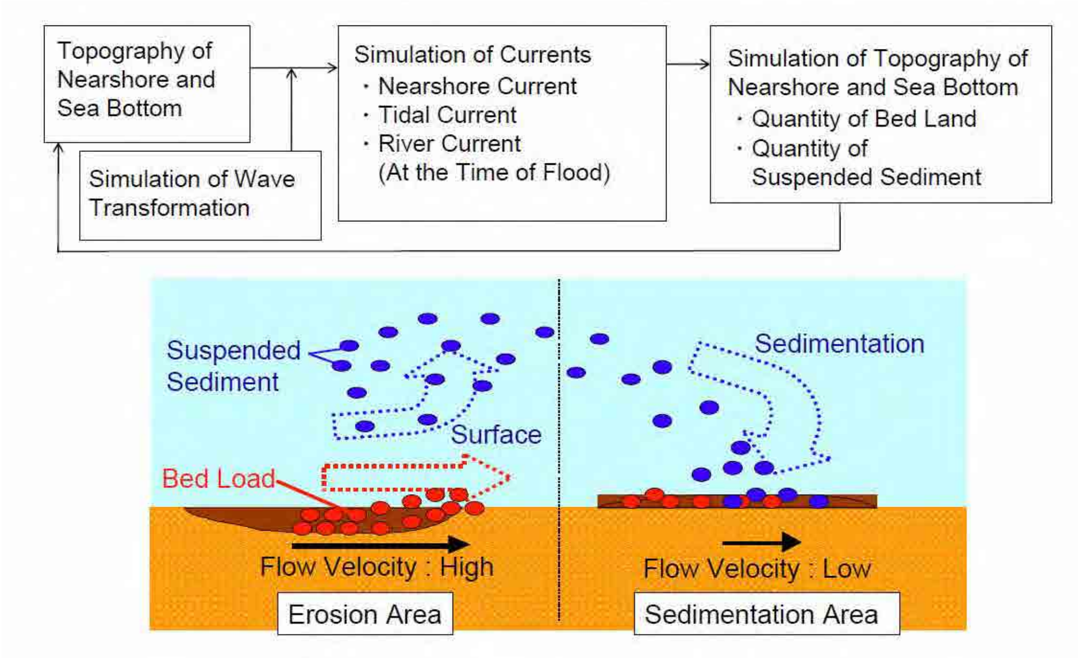


Figure 4.5-9 Simulation Model of Sediment Transport

— Analyzed area : 70km × 40km
— Water depth : based on the Hydrographic Chart
— Input conditions
  ・ Wave Height : 6.1 m (maximum wave of a neighborhood point)
  ・ Tidal Current : flood 1.45 m/s, ebb 1.20 m/s
  ・ SS (Suspended Solid) : 3.2 mg/l (at St. Matin's Island data)
  ・ River flow rate : Maiskhali Channel 3,200m^3/s, Kohalia River 320 m^3/s
  (based on data of a nearby hydrological observatory)
— Survey Results
  ・Water depth : based on the Survey Result of Sounding map
  ・Tidal Current : flood 1.50 m/s, ebb 1.30 m/s
  (based on site survey results)

(2) Sediment Transport Model Analysis Result

The JICA Study Team analyzed the case shown in the layout plan.

While these analysis result figures were shown in the figure, the result effects of each plan form were summarized in the table.

Table 4.5-14 Comparison of Sediment Transport Model Analysis Result

<table>
<tr><th colspan="2">Plan</th><th>A-1 : Matarbari (Conventional Type)</th><th>A-2 : Matarbari (Excavated Type)</th><th>B : North Maheshkhali</th></tr>
<tr><td rowspan="2">Eroded
—
Accreted Effect</td><td>Caused by near shore current</td><td>—Deposition occurs along the outlying part of break water and close to the channel, but there is not considerable siltation in the channel. (Figure 4.5-10)
—Deposition and erosion do not occur in the bow sandbar located south of Matarbari and the mangrove located west of Maheshkhali. (Figure 4.5-10)</td><td>—Deposition occurs close to the channel, but there is not considerable siltation in the channel. (Figure 4.5-13)
—Same as the left comment</td><td>— Deposition occurs from unusual waves from Bengal bay, and there is considerable siltation, which is tens of centimeters thick in the outlying part of the channel (Figure 4.5-20)
—The mangroves located in the immediate vicinity of channel are eroded. (Figure 4.5-20)</td></tr>
<tr><td>Caused by tidal current</td><td>—Breakwater effects tidal current changes around the port area, but there are no considerable changes to the bow sandbar and mangroves . (Figure 4.5-12)
—Erosion occurs at the tip of the breakwater and channel, and leads to instability of the breakwater. (Figure 4.5-11)
— Deposition occurs beside the port. But this phenomenon does not greatly affect the bow sandbar and mangroves. (Figure 4.5-11)</td><td>—Dredged channel effects tidal current changes in the channel, but there are no considerable changes to the bow sandbar and mangroves. (Figure 4.5-19)
—Deposition occurs slightly in a part of channel. But this phenomenon does not greatly affect the bow sandbar and mangroves. (Figure 4.5-16)
Figure4.5-16～Figure4.5-19 is based on the latest data. The JICA Study Team tried to simulate again, it was effectively the same results as before .</td><td>— Dredged channel effects tidal current changes throughout the channel, and there are considerable changes to north of the mooring basin near the mangroves. (Figure 4.5-22)
—Deposition occurs in the channel in tens of centimeters. (Figure4.5-21)
—Erosion occurs to the north of he mooring basin near the mangrove swamps. (Figure 4.5-21)</td></tr>
<tr><td colspan="2" rowspan="2">Result</td><td>—This plan confirms costal changes in a part of the breakwater.
—No significant impact on the environment.</td><td>—This plan confirms slight coastal changes in a part of the channel.
—No significantly impact on the environment.</td><td>—This plan confirms deposition throughout the channel (7 km in length) and also confirms erosion in the mangrove swamps.</td></tr>
<tr><td>△</td><td>○</td><td>×</td></tr>
</table>

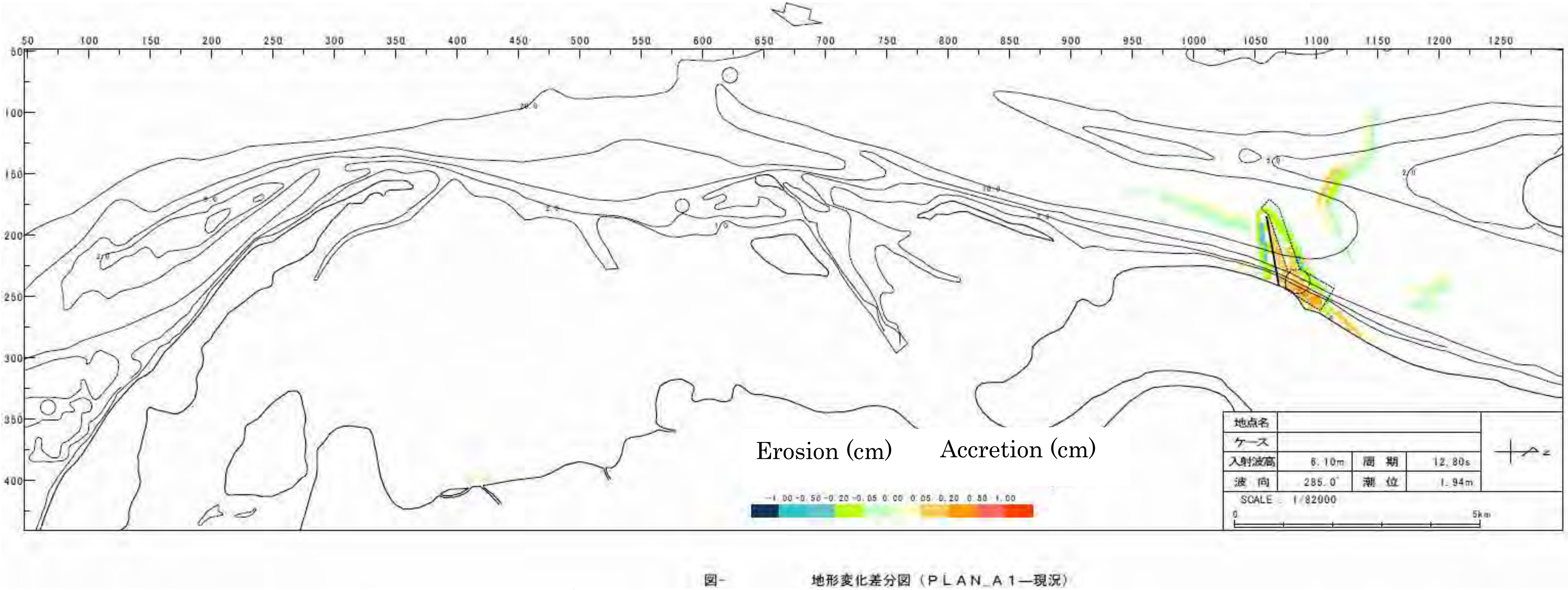


Figure 4.5-10 Transition of Coastal Topography (Plan A-1, caused by near shore current)

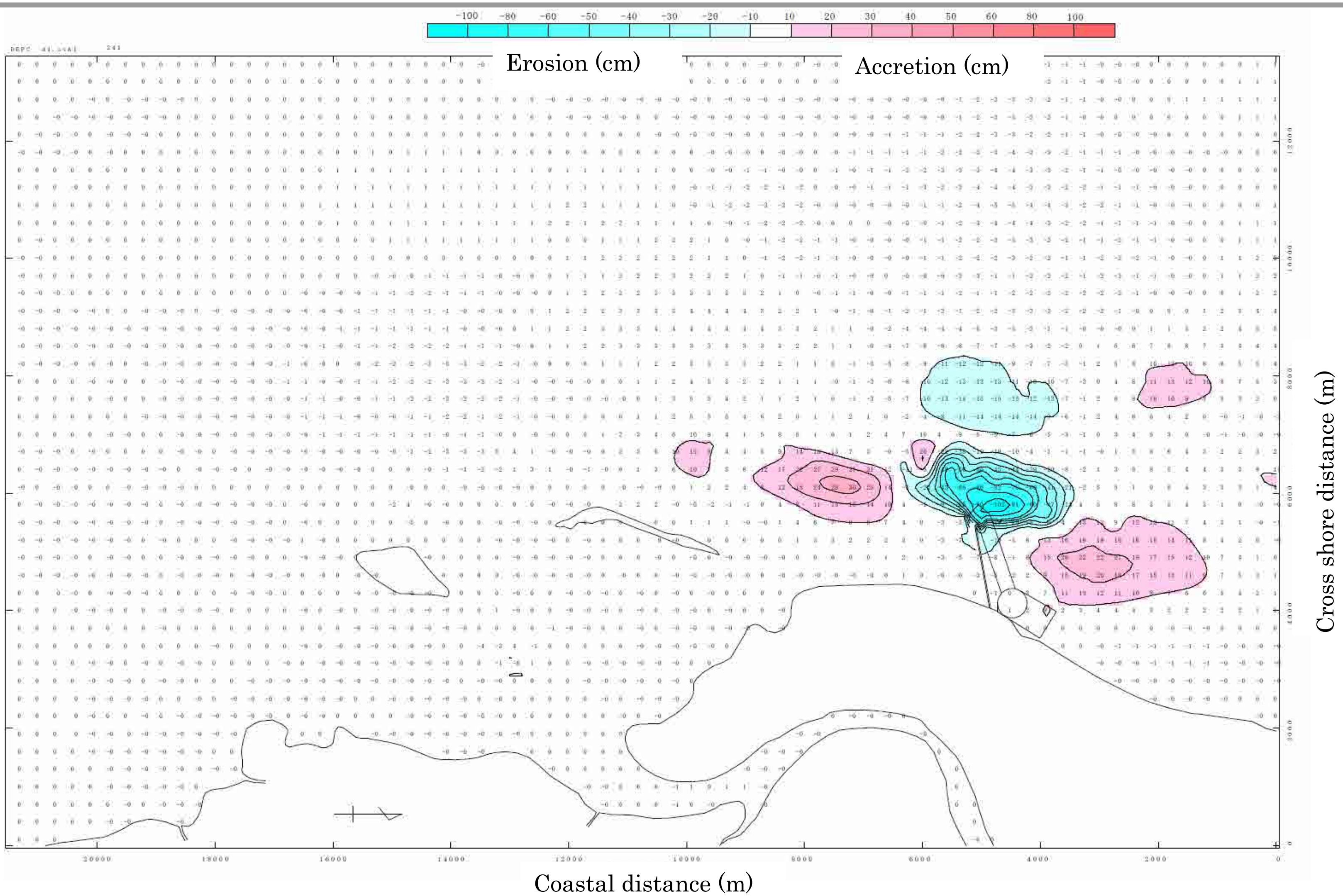


Figure 4.5-11 Transition of Coastal Topography (Plan A-1, caused by tidal current)

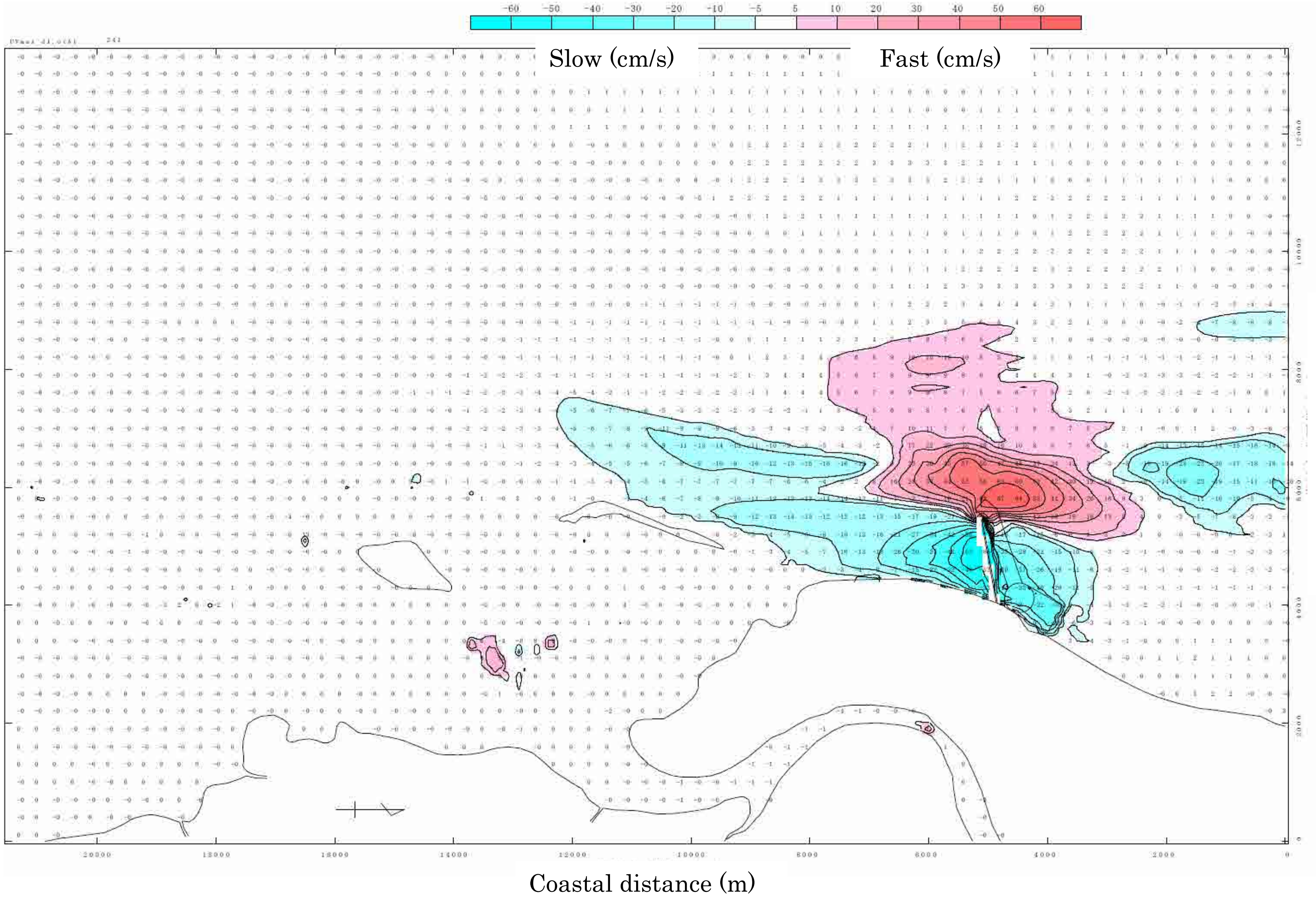


Figure 4.5-12 Transition of Velocity Distribution (Plan A-1, caused by tidal current)

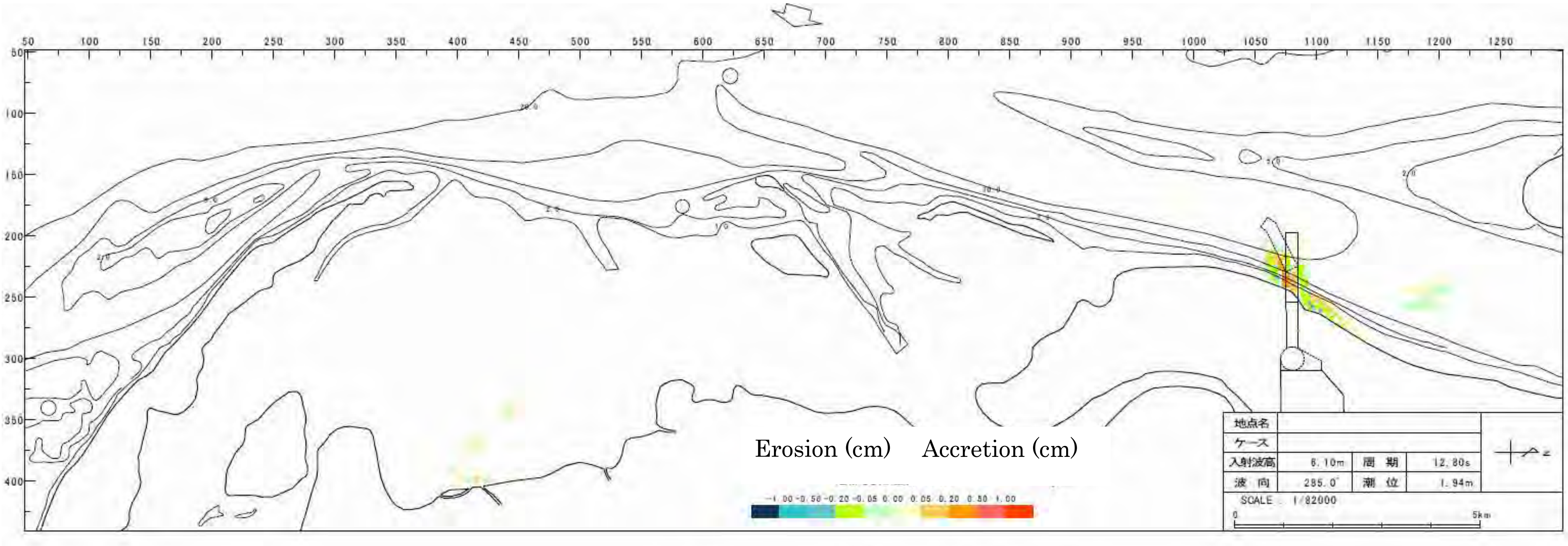


Figure 4.5-13 Transition of Coastal Topography (Plan A-2, cause by near shore current)

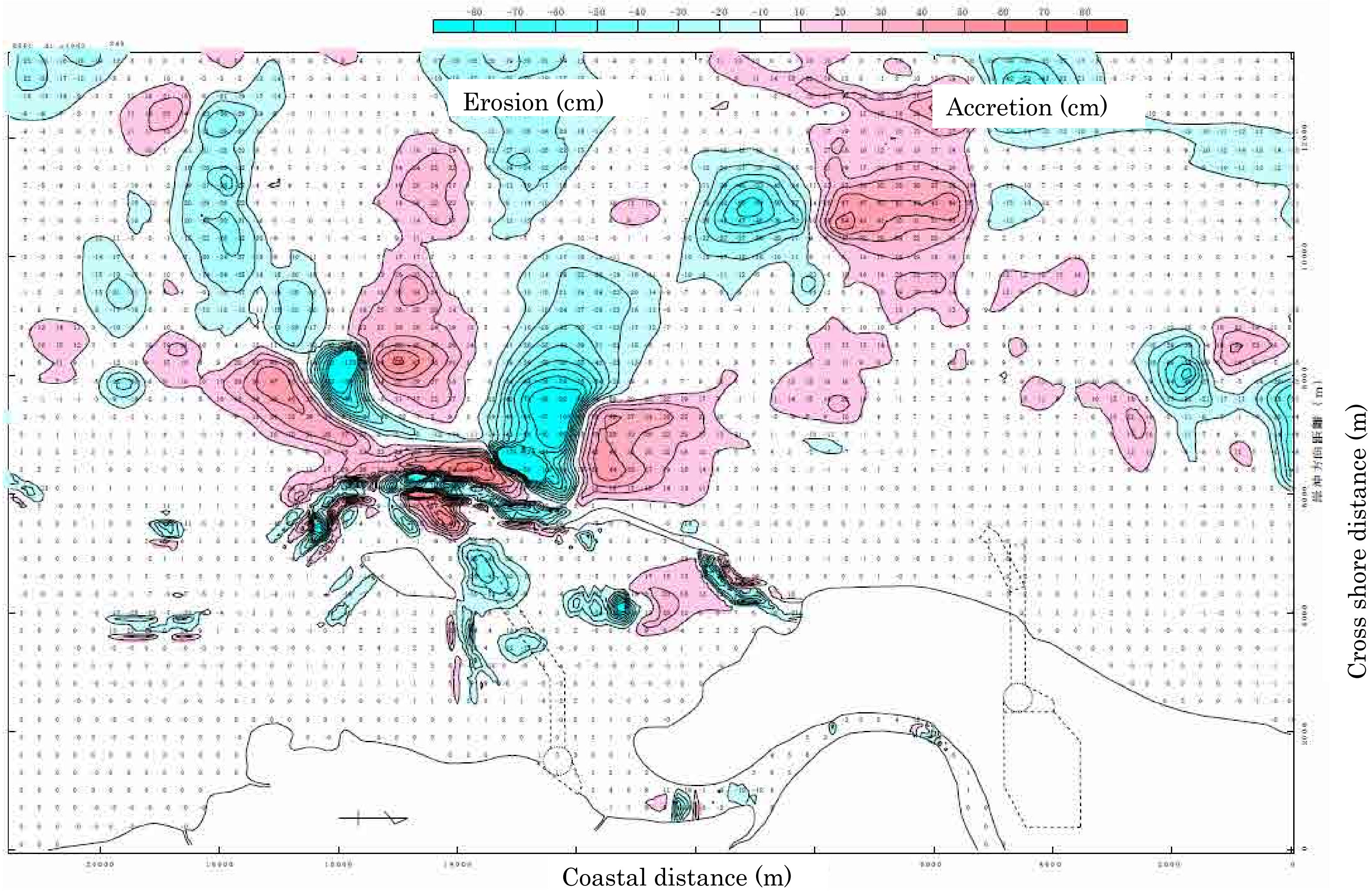


Figure 4.5-14 Transition of Coastal Topography (Present condition , caused by tidal current ,absolute value)

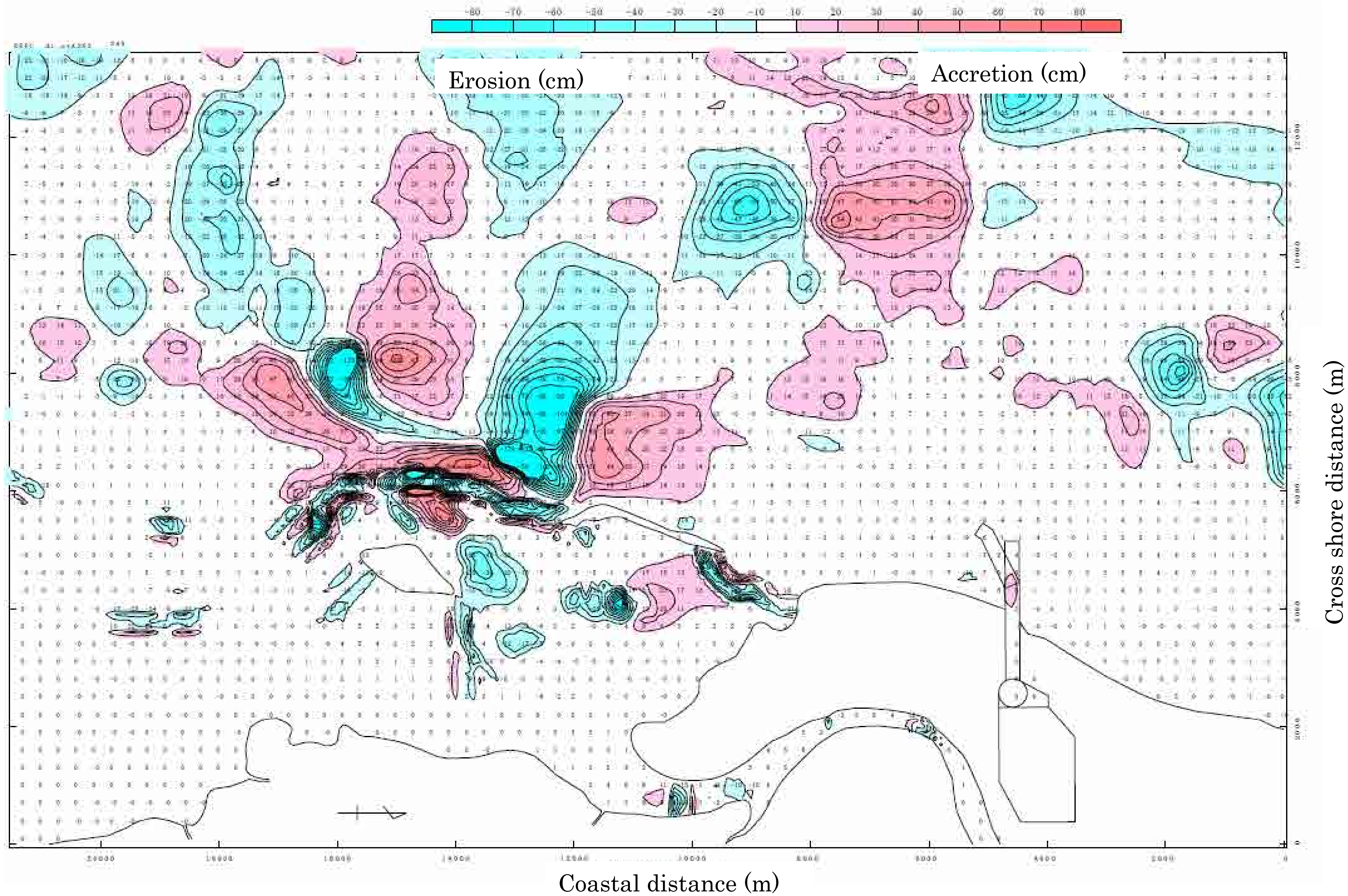


Figure 4.5-15 Transition of Coastal Topography (Plan A-2, caused by tidal current , absolute value)

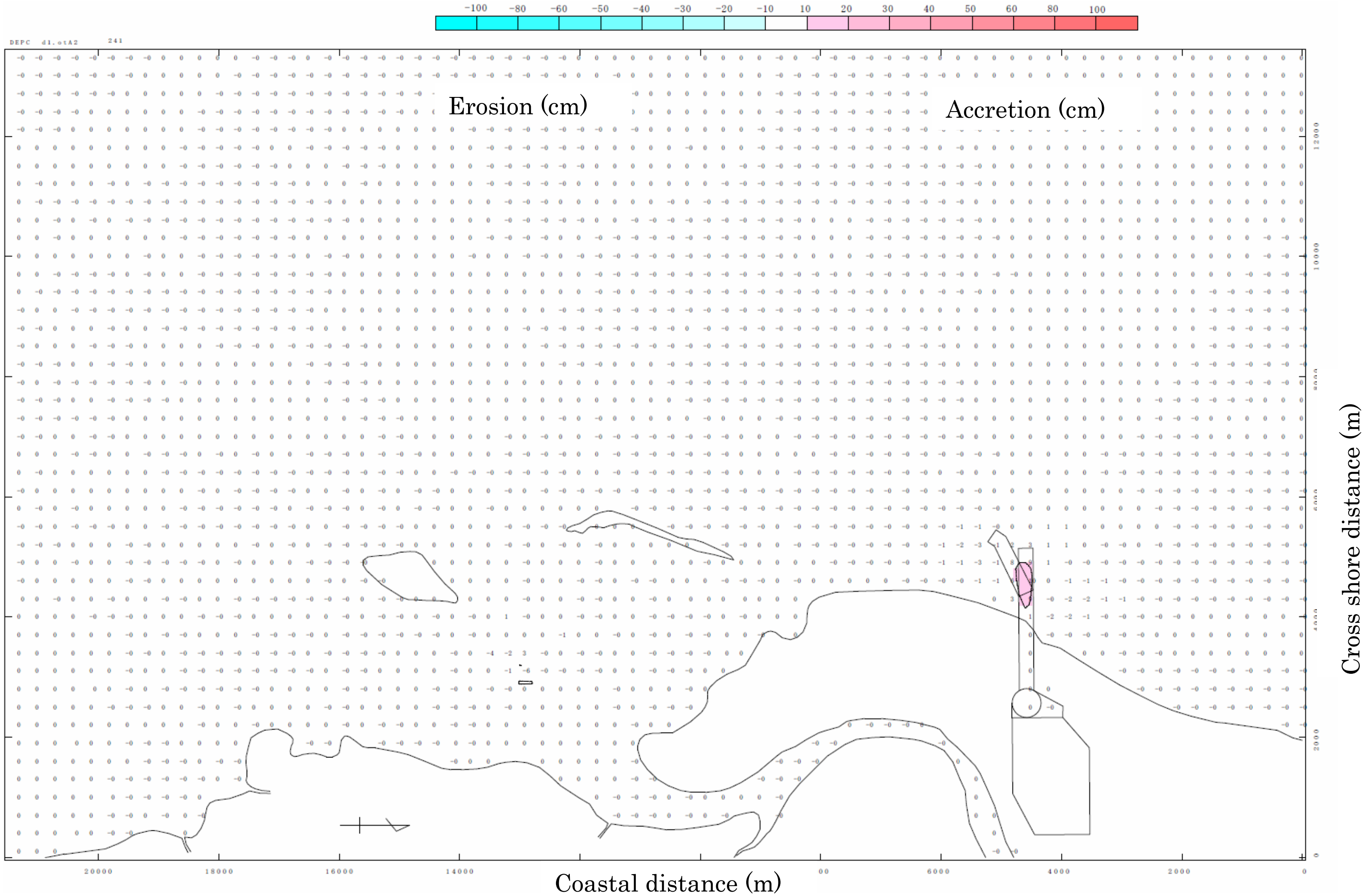


Figure 4.5-16 Transition of Coastal Topography (Plan A-2, caused by tidal current , difference value)

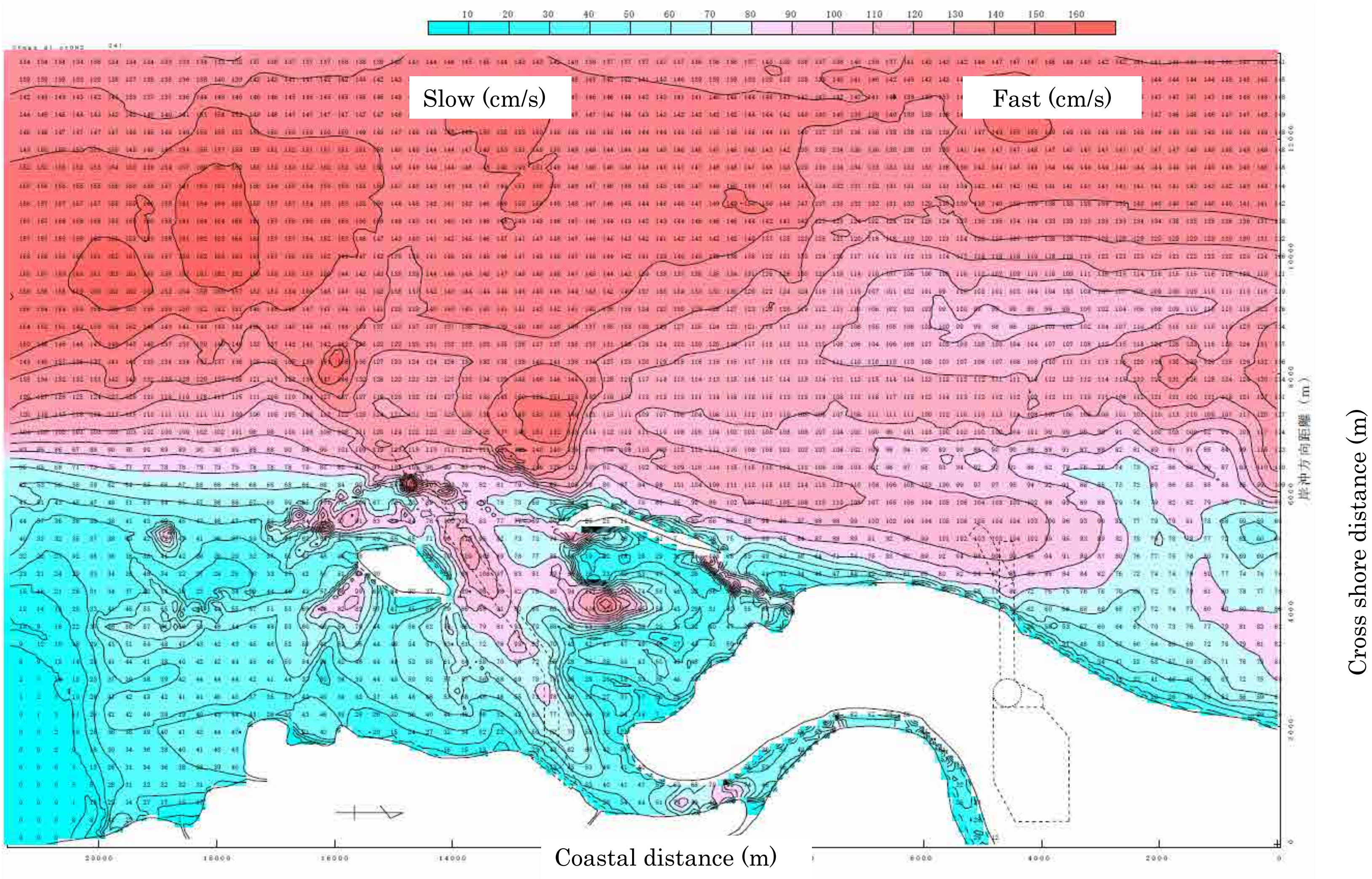


Figure 4.5-17 Transition of Maximum Velocity Distribution (Present condition, caused by tidal current, absolute value)

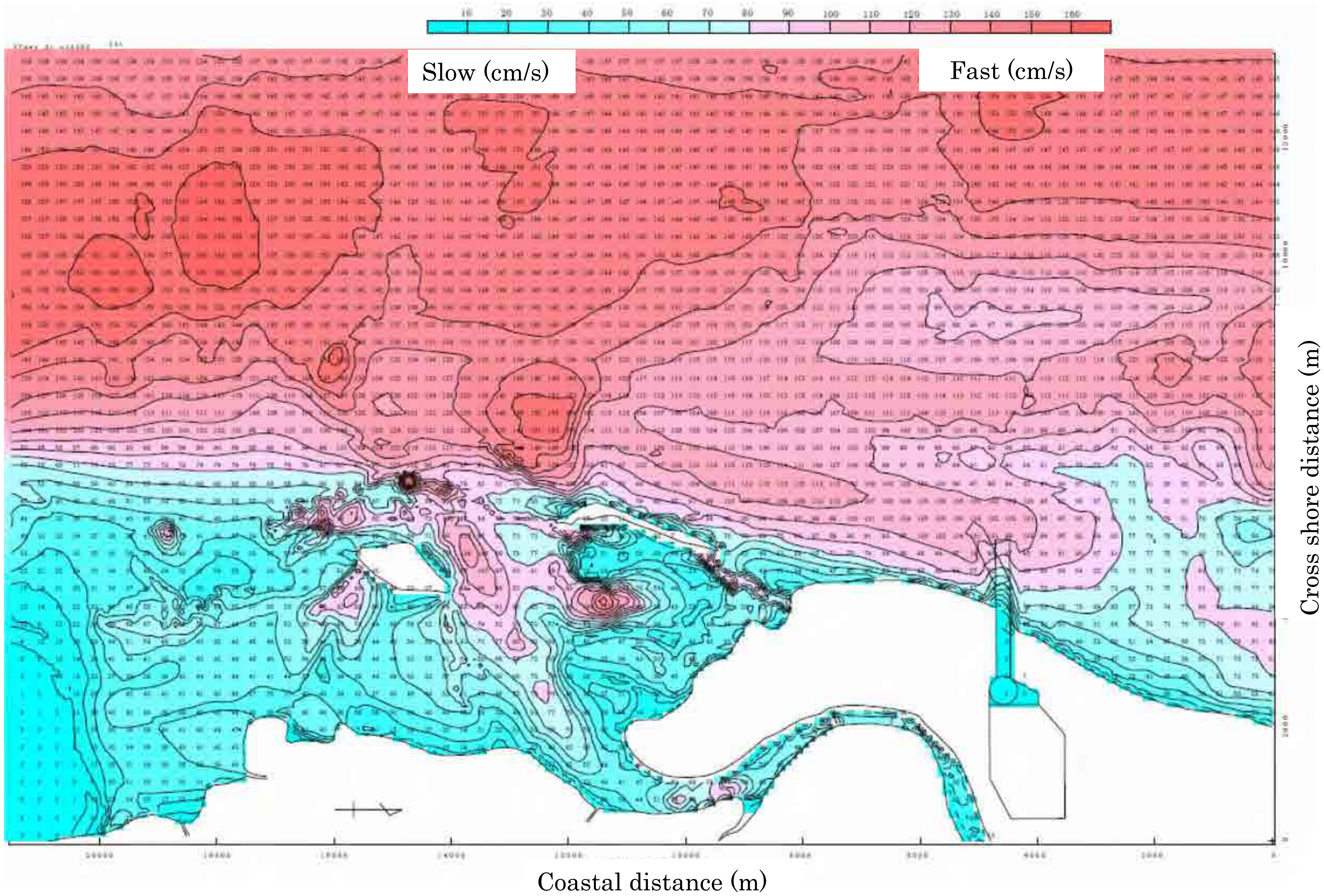


Figure 4.5-18 Transition of Maximum Velocity Cistribution (Plan A-2, caused by tidal current, absolute value)

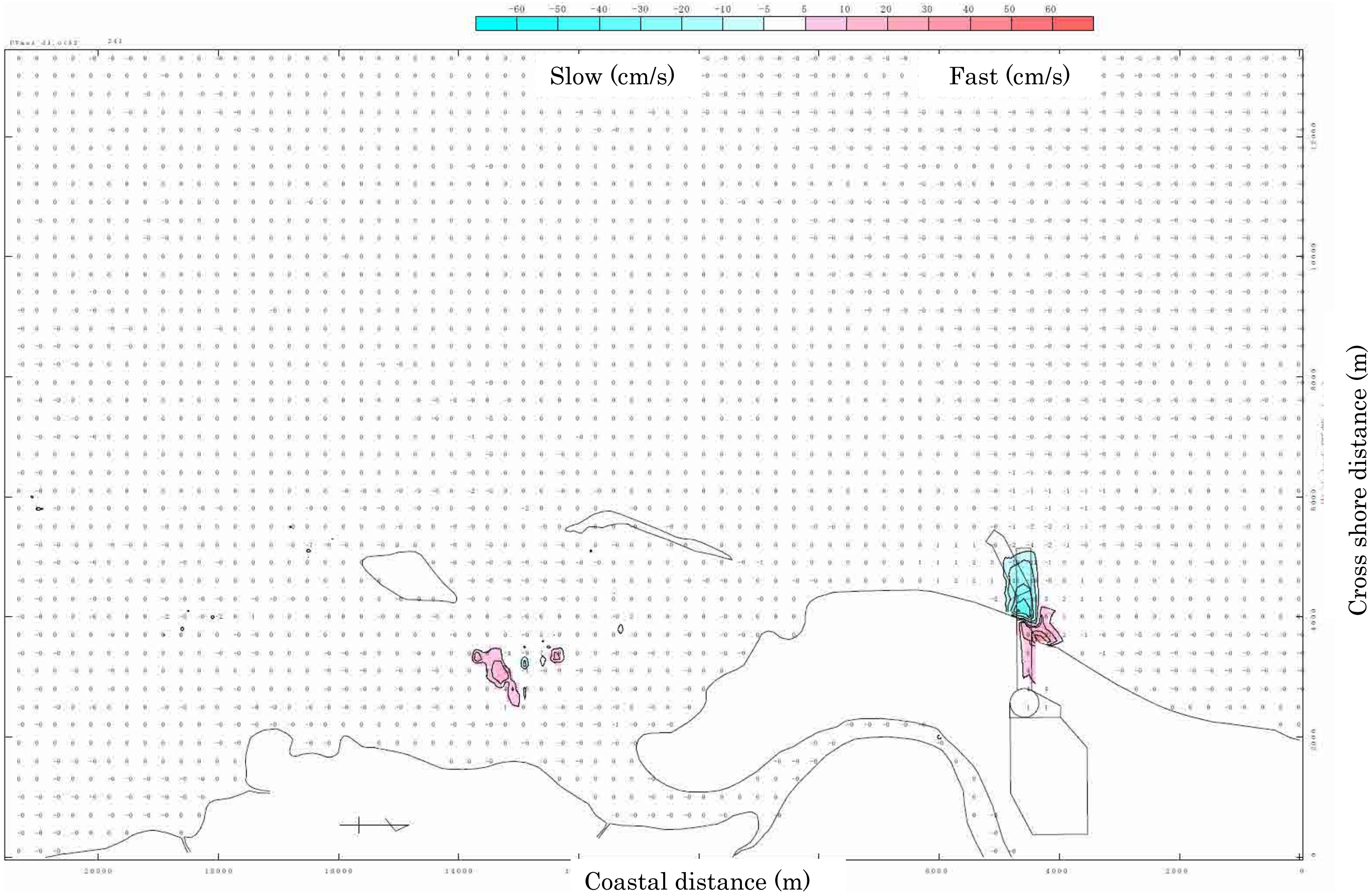


Figure 4.5-19 Transition of Velocity Distribution (Plan A-2, caused by tidal current)

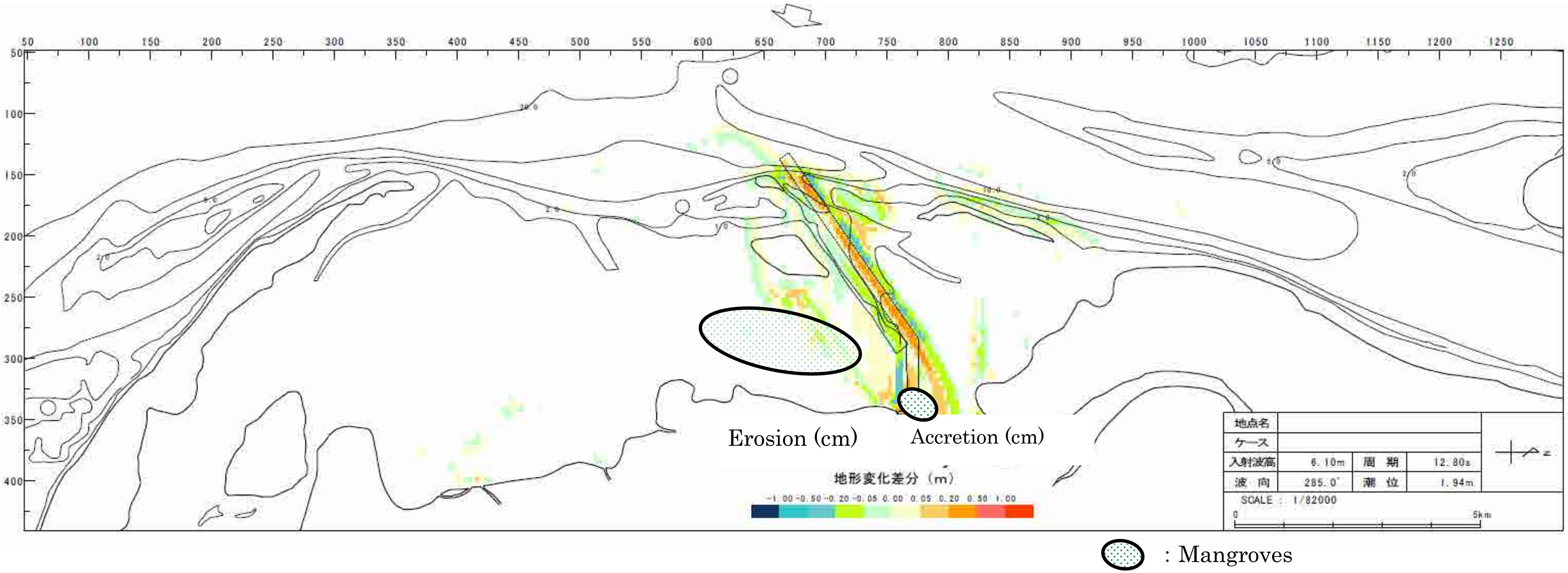


Figure 4.5-20 Transition of Coastal Topography (Plan B, caused by near shore current)

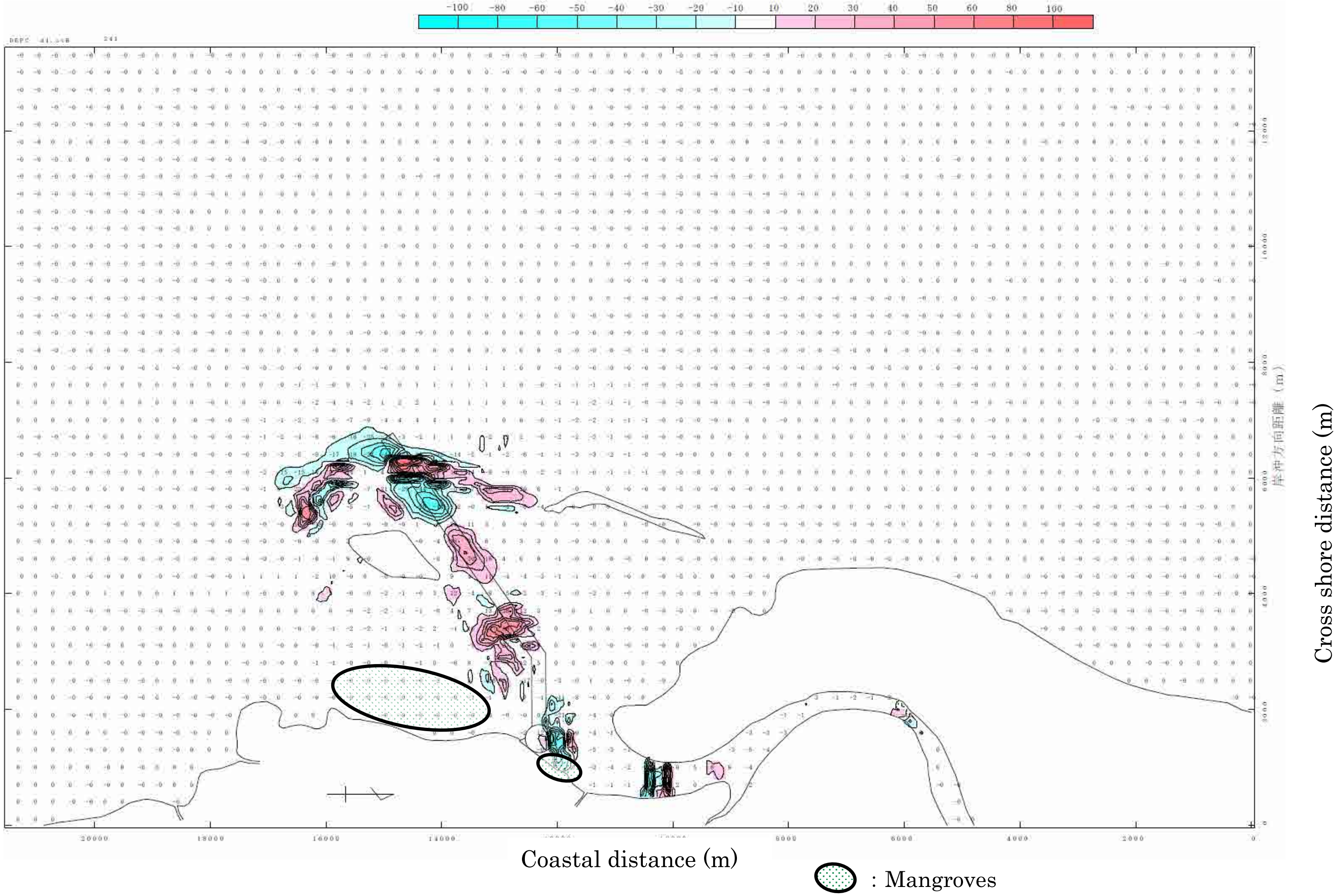


Figure 4.5-21 Transition of Coastal Topography (Plan B, caused by tidal current)

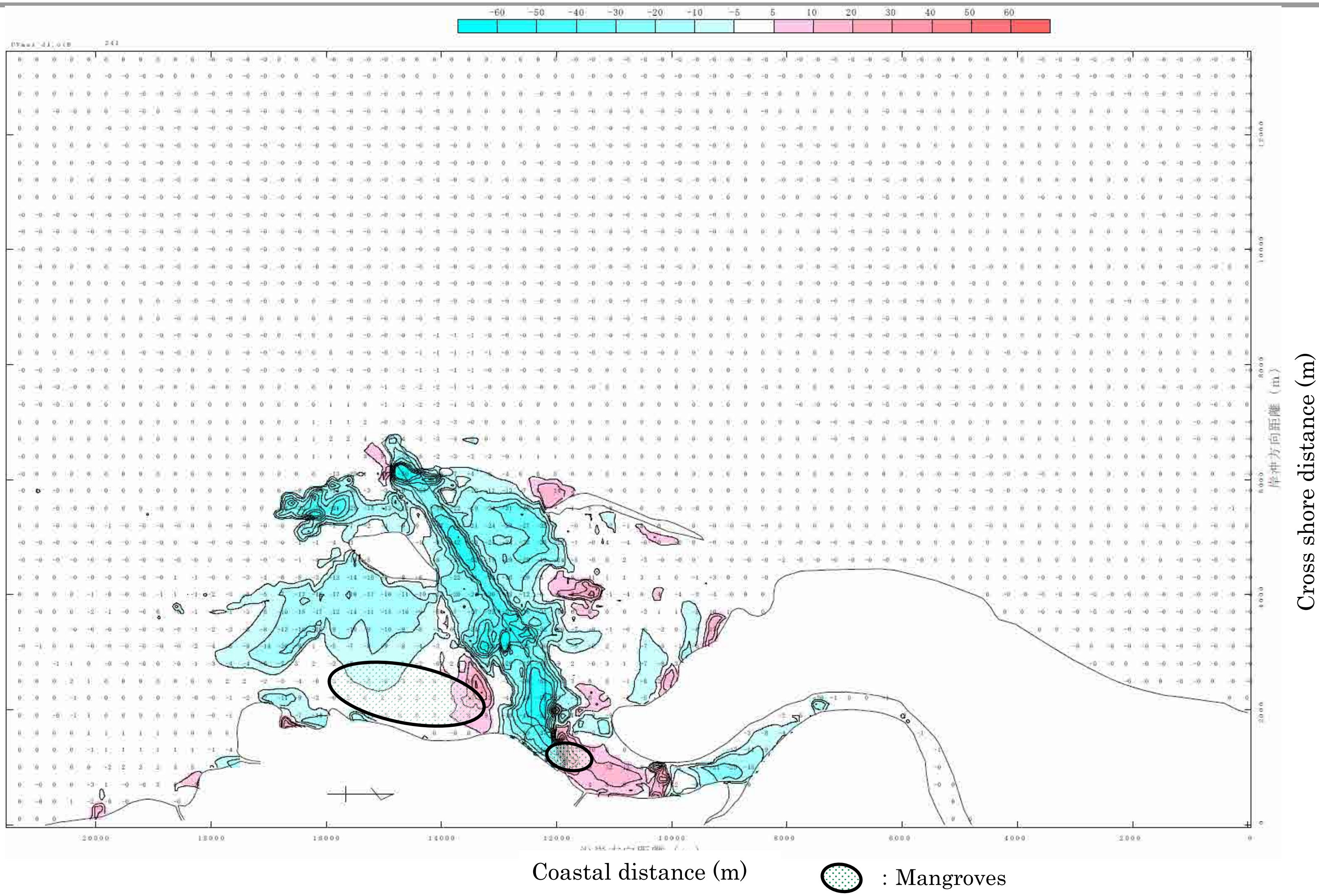


Figure 4.5-22 Transition of Velocity Distribution (Plan B, caused by tidal current)

4.5.3 Site selection result (from the viewpoint of port and harbor engineering)

(1) Proposed candidate site

On the basis of the results thus far, the JICA Study Team of port and harbor engineering has concluded that the Matarbari Site should have higher priority than the Maheshkhali Site. The comparative table is as shown below.

- The site conditions are based on field studies
- Maintenance dredging is based on the computer simulation of sediment transport results
- Operability is based on the calmness analysis results

The expansion of port and harbor is based on the land–use planning with the related surrounding circumstances.

Table 4.5-15 Site Selection Result (from the viewpoint of port and harbor engineering)

Items	Matarbari Site	Maheshkhali Site
Site Conditions	It is possible to plan a power plant at this site.	It is possible to plan a power plant at this site.
	○	○
Maintenance Dredging	Need maintenance dredging, but less than the Maheshkhali Site.	Need continuous maintenance dredging throughout the channel.
	△ (approx. 600m in length, Figure4.5-14)	× (7 km in length, Figure4.5-17)
Operability of Coal Vessels	Channel and mooring basin are calm because of the breakwater or the artificially excavated land, so there is no impact on cargo handling.	Ship handling demands extreme care through the restricted channel on account of several dipper dredgers working on the channel (7 km in length).
	○ (reduce wave height about from 30 percent to 87 percent at port entrance)	△
Expansion of Port & Harbor	Can expand port and harbor, with little effect on coastal change.	To expand port and harbor increases risk of negatively impacting mangroves.
	○	×
Results	**Candidate site for a Power Plant**	Unsuitable
	○	×

(2) Study of the optimal Port and Harbor Type

The JICA Study Team carried out a study of optimal port and harbor planning. Optimal port and harbor arrangements were made at the Matarbari site selected as a candidate site for the power plant.

We selected two types of ports, one is a conventional type that has a breakwater to shelter it from sea waves, the other is an excavated type that has an artificial bay extending far inland. A comparison examination was performed of these two types of ports as follows;

- Options for reducing costs (refer to 8.2.2 Comparison of layout)
- Site development requires a large quantity of sandy soil to develop the Power Plant Area, in order to protect it against cyclonic storm surges and ocean waves.
- Expansion of port and harbor is based on the land–use planning and related surrounding circumstances. We have considered the possibility of expanding the port and harbor.

The comparative table is as shown below.

Table 4.5-16 Study of the Optimal Port and Harbor

Items	Matarbari Site	
Port Type	Conventional Type	Excavated Type
Comparison of costs	－Relatively expensive	－Cost benefits
	× (relative cost ratio 1.6)	○ (relative cost ratio 1.0)
Site Development	－Needs a large pile of stones to build a breakwater which extends to a length of 1.5 km. Choosing a concrete-caisson breakwater requires a caisson yard on this site. －Dredging of the channel extends for 1.5 km and will produce dredged sandy soil that is good for land fill. Using a hauling scheme, this is efficient construction.	－The artificially excavated port will produce dredged sandy soils that is good for land fill. Using a hauling scheme, this is efficient construction. (refer to 8.1.5)
	△	○
Expansion of Port & Harbor	－In the case that the site is bought, there is opportunity to expand the port and harbor, with little impact on the environment. －Some sort of reinforcement work is necessary for the extension of the breakwater.	－Same as the left comment －It is necessary to expand the excavated area, but the amount of excavated sandy soil can be used in site development.
	△	○
Results	Unsuitable	**Proposed basic plan**
	△	○

4.6 Layout Planning (Port & Harbor Facilities)

4.6.1 General

The offshore unloading system is one method to unload coal for thermal power plants.
This method is shown in Figure 4.6-1. First, a large coal vessel that has transported coal from a production site will be berthed at an offshore terminal, coal unloading berth or mooring derrick barge. At the offshore terminal, coal shall be transhipped from the large coal vessel to small coal vessels or coal barges. Then, the small vessels and barges or bridges shall transport the coal to the thermal power plant.
The photographs by Google Earth in Table 4.6-1 show some examples of the offshore unloading system.

To have a successful offshore unloading system, the three following conditions must be met.

- The depth of sea under the offshore terminal is deep enough for mooring a large vessel.
- The sea conditions around the offshore terminal are calm enough for unloading coal.
- When small vessels of barges are used, there must be port facilities at the thermal power plant which can be used for unloading coal by small coal vessels or coal barges.

To satisfy these conditions, the offshore unloading system is often used in inner harbors which are not affected by big waves.

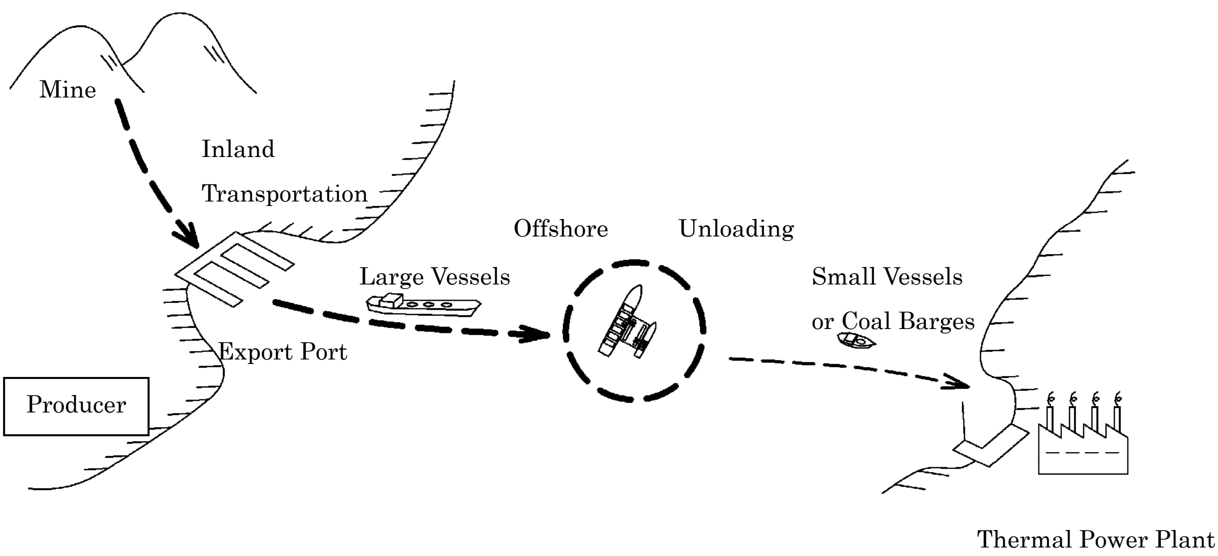
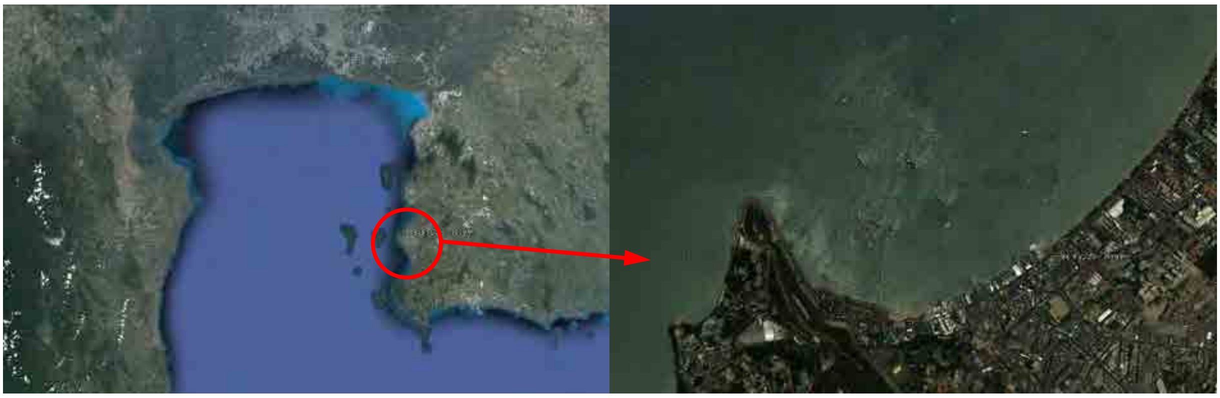


Figure 4.6-1 Concept of Offshore Unloading System

Table 4.6-1 (1) Examples of Offshore Unloading Sites

India - Marmugao

Thai - Pattaya



Indonesia - Kalimantan

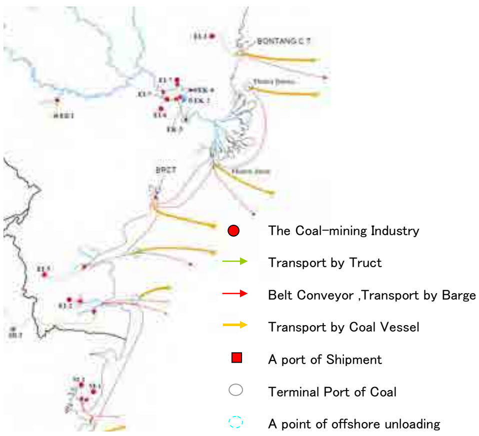
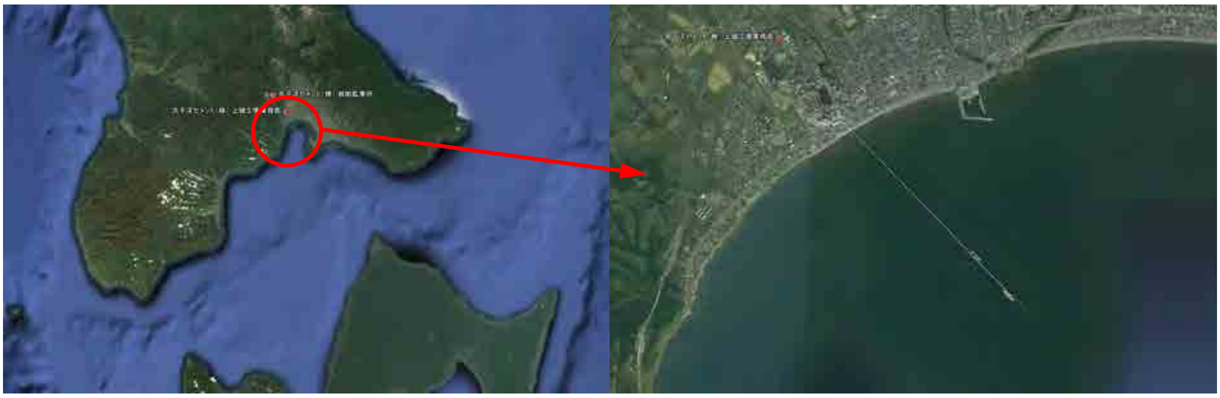


Table 4.6-1 (2) Examples of Offshore Unloading Sites

Japan - Hakodate

Japan - Okinawa


4.6.2 Study of adoption of offshore unloading system

The below is an analysis of whether the offshore unloading system can be used at the candidate sites.

(1) The sea area of the offshore unloading system

The offshore unloading system can be used in sea areas with sufficient depth. If the large coal vessels are 80,000DWT class (Panamax size), a sea depth of over -15m is required.

Figure 4.6-2 shows the sea areas with over -15m depth around the candidate sites.

These sea areas are affected by big waves from the open sea.

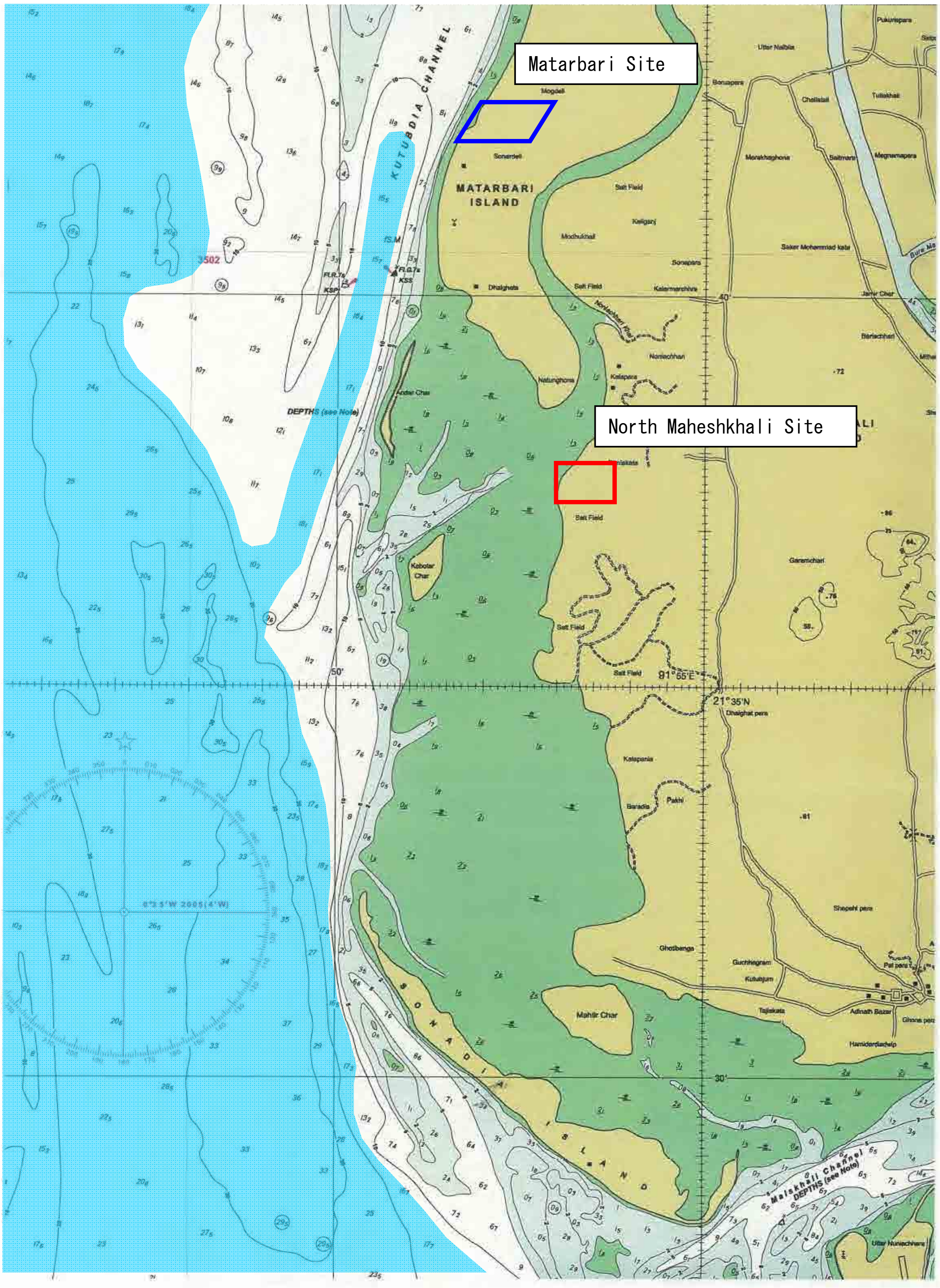


Figure 4.6-2 The Sea Areas

(2) Frequency of high waves around the candidate sites

Figure 4.6-3 shows the probability of not having high waves offshore on a monthly basis.

For coal handling to unloading berth, wave height must be under 1.0 m. Around the candidate sites, the probability of not having waves under 1.0 m is 37.8%, about 140 days a year. From May to September, the probability is below 5%, about 8 days. In this case, it is not possible to unload the necessary amount of coal required for operating the thermal power plant.

Waves must be under 2.0 m to allow coal handling to mooring derrick barges. Around the candidate sites, the probability of not having waves under 2.0 m wave height is 85.1%, about 310 days a year. From June to August, the probability is below 65%. In this case, there may be a shortage of coal for operating the thermal power plant.

Due to the frequency of high waves, a breakwater is necessary for the adoption of the offshore unloading system at the candidate sites. The cost of this system will be very high.

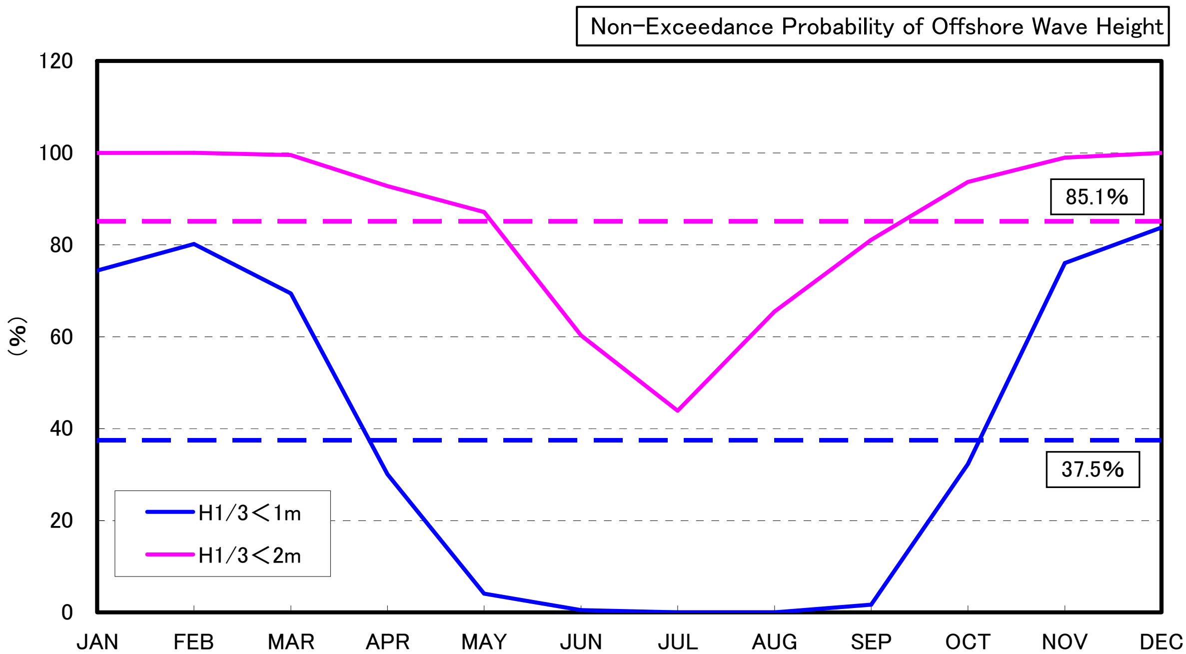


Figure 4.6-3 Monthly Probability of Not Having High Waves

To summarize our interpretation of the results, we conclude that an offshore unloading system cannot be applied for the following reasons.

- According to the annual average frequency of high waves at the planning point for the candidate sites, the ratio of 2.0 m high waves or less is 85%, and in the rainy season it is only 60% or less (Figure 4.6-3) . In such a case, the offshore unloading system may not be able to operate its coal handling functions due to a lack of effective working days in the rainy season.

- In order to use an offshore unloading system, a breakwater that is a conventional structural is required. In this case, there are no advantages in unloading offshore.

- Ports, such as those in India and Thailand, which have adopted offshore unloading systems, are not directly affected by ocean waves due to topographic features. However, in this project site there are no such capes or sheltered areas.

4.7 Consideration of Alternatives

(1) Natural Environment Conditions

(a) Background

To get up-to-date information about the natural environment surrounding each project site, the JICA Study Team has conducted interviews with environmental specialists who have been working as nature commentators on site (Sonadia Island) and held a meeting with some environmental specialists at Cox's Bazar Field Office of the Bangladesh Government Department of Environment (DoE).

Environmental specialists have emphasized the importance of the protection of mangrove vegetation, sand dunes, beaches, sandy shoals, and mudflats in and around Sonadia Island (including Maheshkhali areas), as saying that they provide an excellent wintering ground for migratory waterfowl and shorebirds, and a nursing and feeding ground for fish and shrimp species, especially the sand dunes provide nesting grounds for marine turtles.

(b) Number of preliminary alternative sites to have been assessed of their relative merits

The JICA Study Team has adopted three preliminary alternative sites, in which two sites have been considered as candidate project sites by the "Study for the Master Plan (2010)," and the additional site has been added at the stage of this Preparatory Survey (2012) from the perspective of avoiding risks to the mudflats and its ecosystem.

(c) Results of evaluations on Matarbari and Maheshkhali

a) Result of 1st field survey conducted by the JICA Study Team

Table 4.7-2 shows a comparison of the Matarbari and Maheshkhali sites from the viewpoint of the natural environment based on the 1st field survey conducted by the JICA Study Team. Both the Matarbari and Maheshkhali sites have poor vegetation and a limited number of animals were observed on land, thus there is no difference between the two sites as a better project site. However, the Maheshkhali site has a huge mangrove forest and sandbar at the sea side of the site; therefore, it is predicted that the mangrove forest and sandbar may be affected during the construction and operation phase of the power plant, if the Maheshkhali site is selected as the project site.

Table 4.7-1 Comparison of Matarbari & Maheshkhali from Natural Environment Conditions

Items	Matarbari	Maheskhali
Vegetation	- Site: Poor - Forest: There are few trees place on the nearest residence area - Mangrove: No Mangrove	- Site: Poor - Forest: There are few trees place on the nearest residence area - Mangrove: There are huge mangrove forests offshore.
Animal	- Site: Sedentary birds observed -Surrounding area: Sedentary birds observed	- Site: Sedentary birds observed - Surrounding area: Sedentary birds are observed over the mangrove forests
Endanger species	- Site: Not observed - Surrounding area: Not observed	- Site: Not observed - Surrounding area: Not observed
Habitat condition surrounding the site	- Corral reef: Not observed - Seaweed bed: Not observed - Sandy beach: Observed Mudflat: Observed - Sandbar: Not observed	- Corral reef: Not observed - Seaweed bed: Not observed - Sandy beach: Not observed - Mudflat: Observed Sand bar: There is a sandbar in estuarine region around 4km away from the site

Source: JICA Study Team

b) Simulation of Waves and Currents

To evaluate the effects of some main activities planned in each project site on the surrounding natural environment of alternative project sites, the following types of simulations have been conducted. (See detailed description in this chapter.)

i. Simulation of wave-height and its effects on geological conditions offshore

ii. Simulation of tidal currents and its effects on geological conditions offshore

iii. Simulation of dredging and its effects on geological conditions offshore

Table 4.7-2 shows the main results of simulation on environmental issues (project sites) caused by dredging activity.

Table 4.7-2 Main Results of Simulation on Environmental Issues (Project Sites)

Project sites / Items	Matarbari	Maheshkhali
Wave-height	A little (almost negligible) ✓ A little change on the mud-sediment around the dredging site	Notable ✓ Mud-erosion around dredging site covered with mangroves
Tidal current	None	Notable ✓ Mud-sediment around dredging site covered with mangroves Mud-erosion around dredging site covered with mangroves
Dredging	A little ✓ Periodical dredging is needed but less frequently than Alternative III	Notable ✓ Periodical dredging covering a wide area is needed

Source: JICA Study Team

c) Comparison of the Matarbari and Maheshkhali sites

Both the Matarbari and Maheshkhali sites have been compared to each other by rating in the degree of environmental impact. The rating using a quantifiable method for the natural environment is not established as an academic discipline yet, therefore, numbers (from 0 to -3) are used to evaluate the natural environment of alternative sites, just as a qualitative tendency.

0: *No impact*

-1: *A small impact but not serious*

-2: *Serious impact but not irreversible*

-3: *Irreversible impact*

From a comparison of the two project sites, the negative points of each alternative site is as below (Table 4.7-3).

Matarbari: -2

Maheshkhali: -10

The Maheshkhali site receives a larger negative point and there are impacts on the surrounding mangrove forest, which is an ecologically sensitive area. From the viewpoint of environmental consideration, the Maheshkhali site is not recommended.

Table 4.7-3 Comparison of Project Alternative Sites

Impact		**Matarbari**		**Maheshkhali**	
Impact on mudflats		(By wave, a little -1)	-1	(By wave, serious -2) (By current, serious -2)	-4
Impact on sea bottom		(By dredging, serious-2)	-2	(By dredging, serious-2)	-2
Impact on sand beach		(By drifting, serious-2)	-2	(By drifting, a little-1)	-1
Impact to flora and fauna	Impact on migratory birds	None	0	None	0
	Impact on sea turtles	None	0	(By dredging near turtle habitat, a little -1)	-1
	Impact on dolphins	None	0	None	0[1]
	Impact no young fish	None	0	None	0
	Impact on mangroves	None	0	(By wave, serious -2) (By current, serious -2)	-4[2]
	Impact on benthos[3]	(By dredging, a little -1)	-1	(By dredging, a little-1)	-1
Distance to Sonadia ECA		None	0	None	0
Evaluation			**-6**		**-13**

Note) 0[1] : There is some apprehension regarding impact on dolphins by dredging with 7Km front to offshore, but no information or data available

-4[2] : There is no direct impact of cutting down mangrove vegetation, but deterioration of habitat by losing mudflats near its root would cause many harsh consequences, such as mangroves falling down

Benthos[3] : Including sea grass and

(d) Results of evaluations on two alternative sites at Matarbari

a) Simulation of Waves and Currents

Two different types of sites in Matarbari have been considered and evaluated: one is Alternative I (Conventional Type), with a harbor constructed; and the other is Alternative II (Excavated Type), with a dredged channel. The main results of simulation on environmental issues for the two different alternative sites is shown in Table 4.7-4.

Table 4.7-4 Main Results of Simulation on Environmental Issues (Alternative Types)

Project sites / Items	Alternative I: Conventional Type	Alternative II: Excavated Type
Wave-height	A little (but some area serious) ✓ A small change to mud-sediment around breakwater	A little (almost negligible) ✓ A small change to mud-sediment around the dredging site
Tidal current	Notable ✓ Change of mud-sediment around the breakwater and dredging site but just limited to the site	None
Dredging	None	A little ✓ Periodical dredging is needed but its frequency is less than Alternative III

Source: JICA Study Team

b) Comparison of the Alternative types

Both alternative types have been compared to each other on the degree of environmental impact by rating in the same way as the comparison of the project alternative sites. From the comparison of the two alternative types, the negative point of each alternative site is as below (Table 4.7-5).

Alternative I (Conventional Type): -3

Alternative II (Excavated Type): -2

Comparing Alternative I and II, Alternative I (Conventional Type) receives a larger negative point than Alternative II (Excavated Type), but the difference between the two is not significant. <u>Therefore, it is concluded that Alternative I and II have nearly equal priority from the viewpoint of environmental consideration.</u>

Table 4.7-5 Comparison of the Alternative Types

Impact	**Alternative I (Conventional Type)**		**Alternative II (Excavated Type)**	
Impact on mudflats	(By wave, a little -1) (By current, serious -2)	-3	(By wave, a little -1)	-1
Impact on migratory birds	None	0	None	0
Impact on sea turtles	None	0	None	0
Impact on dolphins	None	0	None	0
Impact on young fish	None	0	None	0
Impact on mangroves	None	0	None	0
Impact on benthos	None	0	(By dredging, a little -1)	-1
Distance to Sonadia ECA	None	0	None	0
Evaluation		**-3**		**-2**

Source: JICA Study Team

Therefore, it is concluded that Alternative I and II have nearly equal priority from the viewpoint of environmental consideration.

Additional Comments concerning Mangrove Vegetation and Ecosystem

The possible impacts of soil-erosion and soil-sedimentation on mangrove vegetation are the following:

1) Biological features of mangrove vegetation

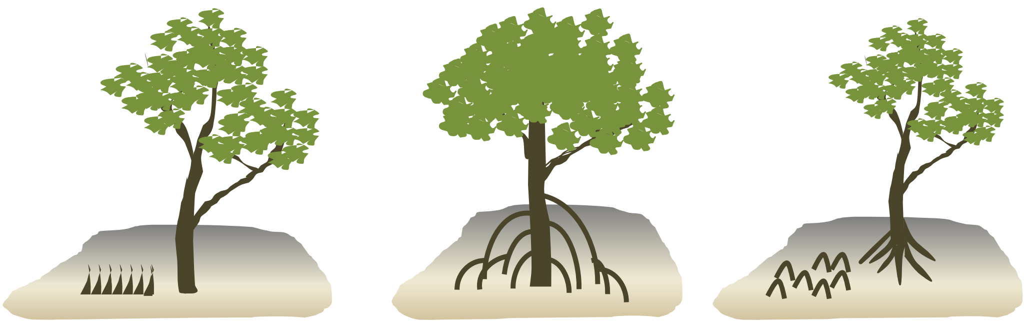
Mangrove forests, composed of several species of mangrove plants, grow in the estuaries of tropical-subtropical areas in the world. About 100 species of mangrove plants are known in the world. The aspects of adaptation to their habitats are quite different from other common terrestrial plants.

- **Tolerance against high salinity**

Many of the species have ‘salt glands’ for excluding salt from the body.

- **Tolerance against anaerobic condition**

Many of the species develop aerial roots as the ‘breathing tubes’ for adaptation against low oxygen conditions of the salty habitat. Aerial roots are distinguished in accordance with their features such as the ‘peg type’, ‘stilt type’ and ‘knee type’ (see figure).



Peg type Stilt type Knee type

Types of aerial roots in mangrove trees

It is known as well that each species of mangrove plants grows in a restricted range (lower, middle or higher part) in the tidal zone (so-called as ‘zonation’).

2) Mangrove species distributed within the 15 km radius of the project site

Matarbari and Maheshkhali are the candidate project sites of the coal fire power plant construction. To identify the mangrove species distributed in the range of 15 km radius of the project sites, a report “Sonadia Island ECA (Ecologically Critical Area) Conservation Management Plan (2006)” is helpful because Sonadia Island is located within the range. According to the report, 28 mangrove species are distributed in the island.

The following are the mangrove species that are found to be concerned to the project.

- ***Avicennia officinalis***

It grows along the estuarine coast line slightly inside of the forefront of the surf line. It grows up to a 20 m, a tree or a shrub. It develops stilt-type roots. It is categorized as least concern (LC) in the IUCN red list.

- ***Avicennia marina***

It grows at the forefront of the surf line before the other species (thus it is called the pioneer species). It is relatively a low tree or shrub, 1-3 m tall. It develops aerial roots of the peg-type. It is categorized as LC in the IUCN red list

- ***Avicennia alba***

It grows at the forefront of the surf line. It develops aerial roots of the peg-type. It grows up to 20 m –tall as a tree or shrub. It is categorized as LC in the IUCN red list.

- ***Sonneratia apetala***

It is a pioneer species that grows in the lower tidal zone nearest to the sea. It develops peg-like simple aerial roots upwards above the water. It grows up to about 20 m-tall as a tree or shrub. It is listed in the IUCN red list as LC.

- ***Aegicerus corniculatum***

It does not develop aerial roots. It grows up to about 4 m-tall as a tree or shrub. It is not listed in the IUCN red list.

- ***Ceriops decandra***

It grows from the middle to higher part of the tidal zone. It develops typical stilt like aerial roots. It is categorized as '**near threatened (NT)**' in the IUCN red list.

- ***Aegialitis rotundifoli*a**

It grows in places with relatively higher salinity (30-40 ppt). It grows up to 2-3 m-tall as a tree or shrub. It does not develop aerial roots. It is categorized as **NT** in the IUCN red list.

3) Impacts of wave shocks caused by the traffic of ships to mangrove species

Wave shocks caused by the traffic of ships (approximately 45 times round-trips per year) might be a disturbance for the mangrove species, especially for some 'pioneer species' such as *Avicennia alba* and *Sonneratia apetala* that are growing on the forefront or outer margin of tidal zones. Such pioneer species, however, develop simple peg-type aerial roots which could be relatively strong against waves and winds. Those roots are exposed to the air only in the time of lowest tide. Therefore, the impact of waves caused by the traffic of ships is presumed to be low (personal communication with Dr. Ichikawa of JWRC*).

4) Impacts of ballast to mangrove species

Ballast water is likely to be a carrier of invasive animal and plant species from outside areas thus it should be taken into account as a threat. In the case of this project, however, ships arrive full of coal, and ballast water is filled at the project site, thus no ballast water from outside is disposed of at the site. Therefore, there is no impact by ballast on the ecosystem around the project site.

5) Impact of ship oil leakages on mangrove species

Continuous oil leakages from ships could affect mangrove forests. If there is just small leakage in regular traffic, it may not matter because the location is open to the ocean. However, if the leakage is unusual (i.e., not from regular traffic), or a large leakage like in an accident, mangrove forests will be seriously damaged because their aerial roots will be covered and they can no longer ‘breath’.

6) Impacts of spread of silt by dredging

Silt is spread not only in the first dredging of the channel, etc., but also in any additional dredging for the maintenance of adequate depth. Therefore, unusual sedimentation and accumulation of silt on the mangrove forests is predicted. This may cause problems but the subject mangrove species around the project site are basically adapted to anaerobic silty conditions, and they can extend their aerial roots in accordance with any increment of silt. Therefore, the silt accumulation might cause minimal damage to the mangrove forests around the project site (as advised by personal communication with Dr. Ichikawa of JWRC[1]), but, if the margin of the dredging range is near the mangrove forests, erosion of the forest substrata may be considered as serious. It may seriously damage the shallow-rooted mangroves there.

(2) Social Environment

(a) Analysis of Secondary Data

The JICA Study Team collected secondary information and data such as the Population Census 2011, the Household Income and Expenditure Survey 2010, land use map of each Upazila of Cox’s Bazar District issued by the Ministry of Land, and various project reports, in order to help evaluate the potential impact on the local residents, local economies and social infrastructures caused by the project implementation at each project site and surrounding area.

a) Interviews with local administrative officers

To obtain up-to-date information about the socio-economic conditions of each project site, the JICA Study Team conducted interviews with local administrative officers from the Deputy Commissioner’s Office of Cox’s Bazar District, Statistical Officer, Agricultural Officer and Fishery Officer from Maheshkhali Upazila Nirbahi Office.

b) Interviews with local residents

The JICA Study Team also conducted interviews with local residents, by visiting a few households and organizing a focus group discussion among fishermen, who live nearby and on the project sites in order to take snapshots of their living conditions, livelihood means and income sources, economic status, assets, education levels, health

[1] Japan Wildlife Research Center

and sanitation etc.

(b) Overview of each site

The overview of each site is summarized in the tables below. Unlike the evaluation for the natural environment conditions, Alternatives I and II have been examined together as the design difference in this case will not likely have a large impact on the social environment. The Matarbari site includes at least Sairer Dail village and the Maheshkhali site includes Kalaghagir Para village. As it is not easy at this moment to identify all villages where alternative sites are located, a complete comparison of the two sites stays at the same level (Table 4.7-6).

Table 4.7-6 Specifications of Located Unions

Project sites / Items		Matarbari	Maheshkhali
Located Union		Matarbari Union* (Note) Part of Dhalghata Union may be included as the site is located at the union border.	Hoanak Union
1	Area	6,682 acres (approximately 2,704 ha)	9,165 acres (approximately 3,721 ha)
2	Population	8,168 households (44,937 people) living in 21 villages of the union.	9,373 households (51,587 people) living in 28 villages of the union.
3	Population density	1,661 people per square km	1,386 people per square km
4	Land use	Cultivated land: 600 ha Rice production: 2,328 metric ton	Cultivated land: 1,150 ha Rice production: 4,450 metric ton
5	Employment status	6,944 are employed out of 19,436 aged 7 and above not attending school	9,498 are employed out of 22,689 aged 7 and above not attending school
6	Field of activity	Agriculture: 75.6%, industry: 3.2%, service: 21.3%	Agriculture: 90.1%, industry: 1.7%, service: 8.1%
7	Source of drinking water	Tap: 0.2%, tube well: 95.0%, other: 4.8%	Tap: 0.2%, tube well: 91.3%, other: 8.5%
8	Literacy rate	27.7% (male: 26.1%, female: 29.4%)	29.9% (male: 28.8%, female: 31.1%)
9	Type of house structure	Permanent: 4.4% Semi-permanent: 4.8% Mud / bamboo: 71.7% Temporary: 19.1%	Permanent: 1.4% Semi-permanent: 3.4% Mud / bamboo: 93.8% Temporary: 1.3%
10	Toilet facility	Sanitary (water-sealed): 2.2% Sanitary (non water-sealed): 36.6% Non-sanitary: 49.6% None: 11.6%	Sanitary (water-sealed): 1.4%% Sanitary (non water-sealed): 21.7% Non-sanitary: 69.6% None: 7.3%

Source: Population Census 2011, data provided at the Agricultural Division of Maheshkhali Upazila Nirbahi Office.

According to secondary information[2], Maheshkhali Upazila has the highest concentration of salt farmers. Salt farmers are mostly poor and operate on a small scale. Their average size of farm is 0.62 ha. They work under adverse conditions. This hardworking job only interests the poor and the landless, and many of them lease land from others. They are in close proximity to the open sea and often face all the hazards of the sea. Total output is often washed away by heavy rain and storm surges because of a lack of storage facilities.

In the site survey of July 2012, there were salt farmers found at both sites, along with fishermen and shrimp farmers. They are the dominant occupation at both sites. According to interviews with local residents, household income varies from 5,000 Taka per month to 100,000 Taka, and the economy level of local residents at the two sites is judged as similar.

(c) Evaluation for social impact

Items for evaluation of the social environment are based on the items of scope for social environment as quoted in the JICA Guidelines. Hierarchies among the said items have not been analyzed, and each rating is not reflective as the degree of each impact remains unknown. Therefore, the number (-1, 0 or +1) simply reflects if the potential impacts are either negative, neglect able (or none), or positive:

-1*: Negative (adverse) impact anticipated*

0*: No impact or neglect able anticipated*

+1*: Positive impact anticipated*

The evaluation result of social impact is shown as Table 4.7-7.

(d) The priority project site taking into account socio-economic conditions

From a comparison of the two project sites, the total rating of each alternative site is as below (Table 4.7-7).

- **Matarbari: design / construction stage -24, operation stage +2**
- **Maheshkhali: design / construction stage -20, operation stage +2**

Both sites have scores worse than -20 in the design / construction stage, whereas there is expected to be a positive impact in the operation stage: +2 at both sites. Not only cash compensation stipulated by the relevant laws in Bangladesh, however assistance packages should also be taken into consideration for both cases, especially for the loss of livelihood means and income sources. Therefore, there is no significant difference expected between the two sites from the social environmental point of view.

[2] Program Development Office for Integrated Coastal Zone Management Plan, Water Resources Planning Organization, Ministry of Water Resources of the Government of Bangladesh. “Living in the Coast: People and Livelihoods” (2004).

Table 4.7-7 Comparison of Project Alternative Sites

Site			Matarbari				Maheshkhali			
			Design / Construction Period		Operation Period		Design / Construction Period		Operation Period	
Evaluation	Social Environment	Resettlement	- Loss of land: -1 - Loss of residential structure: -1 - Temporary loss of land during construction: -1	-3	None	0	None	0	None	0
		Disturbance to Poor People	- Loss of khas land: -1 - Loss of (or damage to) livelihood means / income sources: -1 - Loss of (or damage to) standing crops, shrimps and fish: -1 - Loss of (or damage to) timber and fruit bearing trees: -1 - Temporary loss of (or damage to) livelihood means / income source during construction: -1 - Temporary loss of (or disturbance to) access to land, structures, utilities, common property resources during construction: -1	-6	- Deterioration of household economies may occur: -1 - Have better access to social services because of the upgrade of local infrastructure: +1	0	- Loss of khas land: -1 - Loss of (or damage to) livelihood means / income sources: -1 - Loss of (or damage to) standing crops, shrimps and fish: -1 - Temporary loss of (or damage to) livelihood means / income source during construction: -1 - Temporary loss of (or disturbance to) access to land, structures, utilities, common property resources during construction: -1	-5	- Deterioration of household economies may occur: -1 - Have better access to social services because of the upgrade of local infrastructure: +1	0

Site			Matarbari				Maheshkhali			
		Disturbance to Ethnic Minority Groups and Indigenous People	None	0	None	0	None	0	None	0
		Deterioration of Local Economy such as Losses of Employment and Livelihood Means	- Loss of (or damage to) commercial structure: -1 - Loss of (or damage to) livelihood means / income sources: -1 - Loss of (or damage to) standing crops, shrimps and fish: -1 - Loss of (or damage to) timber and fruit bearing trees: -1 - Temporary loss of (or damage to) livelihood means / income source during construction: -1 - Temporary employment opportunities during construction: **+1**	-4	- Loss of (or damage to) livelihood means / income sources: -1 - Employment opportunities at power station and others: **+1**	0	- Loss of (or damage to) commercial structure: -1 - Loss of (or damage to) livelihood means / income sources: -1 - Loss of (or damage to) standing crops, shrimps and fish: -1 - Loss of (or damage to) timber and fruit bearing trees: -1 - Temporary loss of (or damage to) livelihood means / income source during construction: -1 - Temporary employment opportunities during construction: **+1**	-4	- Loss of (or damage to) livelihood means / income sources: -1 - Employment opportunities at power station and others: +1	0
		Land Use and Utilization of Local Resources	- Loss of (or damage to) standing crops, shrimps and fish: -1 - Temporary loss of (or disturbance to) access to land, structures,	-2	- Permanent change of the land use and utilization of local resources: -1	-1	- Loss of (or damage to) standing crops, shrimps and fish: -1 - Temporary loss of (or disturbance to) access to land, structures,	-2	- Permanent change of the land use and utilization of local resources: -1	-1

Site			Matarbari				Maheshkhali			
			utilities, common property resources during construction: -1				utilities, common property resources during construction: -1			
		Disturbance to Water Usage, Water Rights, etc.	- Potential loss of (or damage to) water source: -1 - Local economy may be affected by the discharged water from the construction site: -1	-2	- Local economy may be affected by the discharged water from the power station to the sea: -1	-1	- Potential loss of (or damage to) water source: -1 - Local economy may be affected by the discharged water from the construction site: -1	-2	- Local economy may be affected by the discharged water from the power station to the sea: -1	-1
		Disturbance to the Existing Social Infrastructure and Services	- Temporary loss of (or disturbance to) access to land, structures, utilities, common property resources during construction: -1 - Temporary increase of traffic volume during construction: -1	-2	- Increase of traffic volume: -1 - Increase of local access to social services and market: **+1**	0	- Temporary loss of (or disturbance to) access to land, structures, utilities, common property resources during construction: -1 - Temporary increase of traffic volume during construction: -1	-2	- Increase of traffic volume: -1 - Increase of local access to social services and market: **+1**	0
		Social Institutions such as Social Infrastructure and Local Decision-making Institutions	- Land acquisition procedure will involve local government office, residents and others: -1	-1	None	0	- Land acquisition procedure will involve local government office, residents and others: -1	-1	None	0
		Misdistribution of Benefits and	- It can occur among residents, workers,	-1	- Increase of local access to social	-1	- It can occur among residents, workers,	-1	- Increase of local access to social	-1

Site			Matarbari				Maheshkhali			
		Damages	government officers, and local politicians: -1		services and market: **+1**		government officers, and local politicians: -1		services and market: **+1**	
		Local Conflicts of Interest	- It can occur among residents, workers, government officers, and local politicians: -1	-1	- Increase of local access to social services and market: **+1**	-1	- It can occur among residents, workers, government officers, and local politicians: -1	-1	- Increase of local access to social services and market: **+1**	-1
		Cultural Heritage	None	0	None	0	None	0	None	0
		Landscape	None	0	None	0	None	0	None	0
		Gender	None	0	- Increase of local access to social services and market: **+1**	+1	None	0	- Increase of local access to social services and market: **+1**	+1
		Childrens` Rights	None	0	- Increase of local access to social services and market: **+1**	+1	None	0	- Increase of local access to social services and market: **+1**	+1
		Infectious Diseases such as HIV/AIDS	- Temporary influx of migrant labor during construction may increase risk of affection: -1	-1	None	0	- Temporary influx of migrant labor during construction may increase risk of affection: -1	-1	None	0
		Working environment (including working safety)	- Possible accidents: -1	-1	None	0	- Possible accidents: -1	-1	None	0
		Evaluation		**-24**		**+2**		**-20**		**+2**

Note: Each rating does not reflect the degree of impact as it is unknown yet.

Source: JICA Study Team

4.8 Conclusion

Table 4.8-1 provides the total assessment results of the study. The Matarbari site is considered to be more advantageous than the Maheshkhali site. Therefore, the JICA Survey Team suggests the Matarbari site to the BPDB as the project site.

Table 4.8-1 Results of the Site Selection

Impact	Matarbari Site		Maheshkhali Site
Technical and economic aspects (port engineering)	- A channel will be necessary for continuous maintenance dredging but to a lesser extent than the Maheshkhali site. - The Matarbari site has greater potential for expansion.	>	- A channel will be necessary with continuous maintenance dredging throughout the channel, 7 km in length. The maintenance dredging work will be a financial burden. - There is no real opportunity for expansion of the port and harbor because of increased risks of negatively impacting the mangrove forest.
Natural environment	- There is no mangrove forest near the Matarbari site, and the site will not be affected during the construction and operation phase of the power plant, since the amount of dredging soil will be less than the Maheshkhali site.	>	- The Maheshkhali site has a huge mangrove forest and sandbar at the seaside of the site, therefore, it is predicted that the mangrove forest and sandbar may be affected during the construction and operation phase of the power plant.
Social environment	- Local residents of the small disaster-stricken area will be forced to vacate. - Local residents will lose their private lots, standing crops, shrimps and fish that are their principal source of income.	<	-The Maheshkhali site has no local residents to vacate. - Local people will lose their private lots, standing crops, shrimps and fish that are their principal source of income as is the case of the Matarbari site. - This case will not likely have a large impact on the social environment.

In conclusion, Matarbari site is more superior as a project site from the viewpoint of technical, economical and natural environmental aspects, but not superior from the social environmental point of view. The impacts to the affected people will be mitigated through appropriately preparing and implementing Land Acquisition and Resettlement Action Plan (LARAP). Therefore, the over-all evaluation concludes Matarbari site to be more superior as a project site.

Chapter 5

Site Conditions

Chapter 5 Site Conditions

5.1 Cyclone

During the years 1960 to 2010, Bangladesh was hit by 53 severe cyclones, 32 of which were accompanied by storm surges. Table 5.1-1 lists the disasters with particular reference to the wind speed, surge height, and loss of life. The height of the surges is limited to a maximum of 10 meters in the bay.

Table 5.1-1 List of Major Cyclonic Storms from 1960 to 2011

Date of Landfall	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph	No. of Deaths	Surge Height
11.10.1960	S.C.S	Chittagong	160	3,450	6.0m
31.10.1960	S.C.S	Chittagong	193	5,149	6.6m
09.05.1961	S.C.S	Chittagong	160	11,468	5.0m
30.05.1961	S.C.S	Chittagong (Near Feni)	160	-	2.0-4.55m
28.05.1963	S.C.S	Chittagong-Cox's Bazar	200	11,520	6.0m
11.05.1965	S.C.S	Chittagong -Barisal Coast	160	19,279	3.7m
05.11.1965	S.C.S	Chittagong	160		6.1-7.6m
15.12.1965	S.C.S	Cox's Bazar	210	873	2.4-3.6m
23.09.1966	S.C.S	Noakhali coast	139	850	6-6.67m
07.12.1966	S.C.S	Cox's Bazar	81	-	-
08.11.1967	C.S	Khulna (Sundarban)	111 (sandheads)	1000 (India)	-
23.10.1967	S.C.S	Near Cox’s Bazar	107(cox’s) 145(M.mar)	51	-
23.10.1970	S.C.S of hurricane intensity	Bangladesh -West Bengal coast	163	300	4.7 m
12.11.1970	S.C.S with a core of hurricane winds	Chittagong	224	3,00,000	3-10m
8.05.1971	C.S	Chittagong	81	-	2.4-4.24m
29.09.1971	S.C.S	Sundarban coast	97-113	-	0.6m
6.11.1971	S.C.S	Chittagong-Noakhali coast	-	-	-
18.11.1973	S.C.S	Chittagong	102	-	-
30.05.1974	C.S	Patuakhali	74-83	-	-
28.11.1974	S.C.S	Chittagong-Cox's Bazar coast	163	20	3.0-5.1m
10.12.1981	C.S	Khulna	120	72	2.12-4.55m
15.10.1983	C.S	Chittagong	93	43	----
09.11.1983	S.C.S	Chittagong -Cox's Bazar coast	136	300	1.5m
24.05.1985	S.C.S	Chittagong	154	4,264	4.55m
29.11.1988	S.C.S with a core of hurricane winds	Khulna coast	160	5,683	4.4m
18.12.1990	Cyclonic Storm (crossed land as a depression)	Cox's Bazar Coast	115	-	-
29.04.1991	S.C.S with a core of hurricane winds	Chittagong	225	1,38,882	6-7.6m

Date of Landfall	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph	No. of Deaths	Surge Height
31.05.1991	C.S	Noakhali coast	83	--	2.5m
02.05.1994	S.C.S with a core of hurricane winds	Cox's Bazar-Teknaf Coast	200-250	184	3.64-4.85m
25.11.1995	S.C.S	South of Cox's Bazar	55	---	---
26.10.1996	C.S	Sundarban coast	70	09	1.5-2.0m
19.05.1997	S.C.S with a core of hurricane winds	Sitakundu	232	155	4.55 m
27.09.1997	S.C.S with a core of hurricane winds	Sitakundu	150	67	3.0-4.55m
20.05.1998	S.C.S with core of hurricane winds	Chittagong Coast near Sitakunda	173	14	0.9m
17.10.1999	S.C.S of hurricane intensity	Orissa Coast	-	-	-
25.10.1999	S.C.S of hurricane intensity	Orissa Coast	-	-	-
28.10.2000	Deep Depression (probably Cyclonic Storm)	Sundarban coast near Mongla	50-60	3	0.6-1.2m
16-10.2001	S.C.S	Andhra coast	65-85	-	-
12.11.2002	C.S	Sundarban coast near Raimangal river	65-85	2	1.5-2.1m
20.5.2003	C.S	Myanmar coast	65-85	-	0.9-1.5m
16.12.2003	S.C.S	Andhra coast	98-115	-	-
19.05.2004	C.S	Cox's Bazar & Akyab Coast	65-90	---	0.6-1.2m
28.10.2005	C.S	Andhra coast near Ongole.	-	-	-
10.12.2005	Cyclonic Storm (crossed land as a depression)	Tamilnadu coast near Nagapattnam.	-	-	-
29.04.2006	S.C.S with a core of Hurricane **"Mala"**	Arakan coast of Myanmar between Akyab & Sandoway	-	-	-
15.05.2007	C.S **"AKASH"**	Ctg- Cox's Bazar. Coast near	83	-	-
15.11.2007	S.C.S **"SIDR"** with a core of hurricane winds	Khulna-Barisal coast near Baleshwar river	223	3,363	4.6-6.1m
02.05.2008	S.C.S **"NARGIS"** with a core of hurricane winds	Myanmar coast near Bassein	-	-	-
26.10.2008	C.S **"Rashmi"**	Khulna-Barisal coast near Patharghata	-	---	1.5-2.1m
27.11.2008	C.S **"Nisha"**	Tamilnadu coast near Nagapathnam.	-	-	-
17.04.2009	C.S **"BIJLI"**	Chittagong-Cox'sBazar coast near Ctg.	90	---	---
25.05.2009	C.S **"AILA"**	West Bengal-Khulna (Bangladesh) coast near Sagar inland of India.	92	190	2.1-2.4m
20.05.2010	S.C.S **"LAILA"**	NE Andhra coast of India	-	-	-

S.C.S : Severe Cyclonic Storm、C.S : Cyclonic StormRefer to 4.1.2 Environmental Situation, (3) Cyclonic Storm Surges.

5.2 Topography

-Features of the project site

There are no structures in the project site.

There are some fish and salt cultivation land and some temporary houses in the project site. And there are many water courses in the project site, made manually for the purpose of fish and salt cultivation.

There are no features like electric poles, roads, etc., located anywhere in the boundary lines.

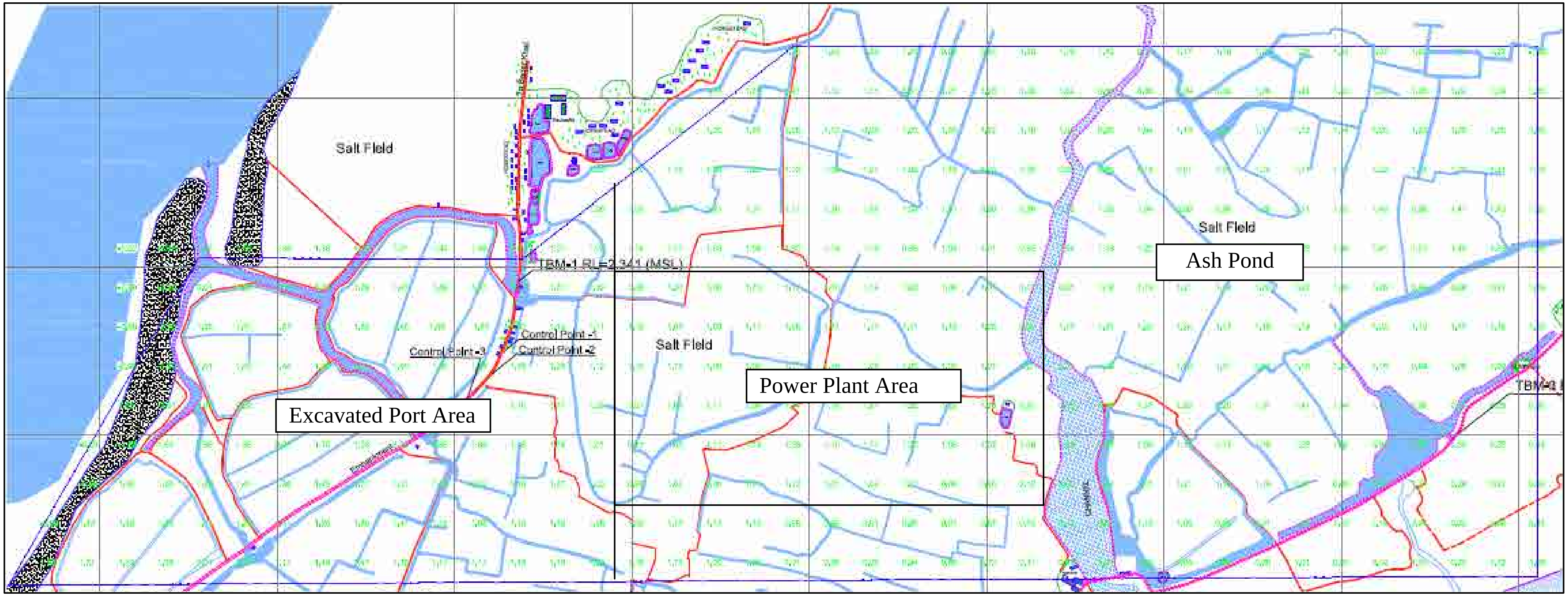
-Surrounds of the project site

There is a long water course and the Kohelia River on the East side, the Bay of Bengal on the West side, a Homestead village of Nasir Mohammad Deil on the South side, and another Homestead on the North side of the project site.

-Existing ground level

On the basis of the Topographical Map (refer to appendix C01-01), the existing ground level should be set based on the average level of the existing ground as follows:

- Existing ground level: +1.0m M.S.L.



The numbers in this figure show the elevation (M.S.L.) of the site.

Figure 5.2-1 Drawing of a Topographical Map of the Project Site

5.3 Geology

The JICA Study Team carried out a detailed soil investigation of the Matarbari area.
Ground investigation work is a main feature when designing the foundation of important structures in an intelligent, economic and satisfactory way. It provides necessary information on the strength and compressibility characteristics of the sub-soil to the design engineers to enable the selection of suitable depths and types of foundation for the proposed structures.
The investigation work included the execution of nine borings from the existing ground level and execution of an SPT test, collection of disturbed samples at specified depths under consideration, and a record of ground water levels, etc. All of these items of the field investigation have subsequently been followed up by the performance of laboratory tests.

-Boring points

The drilling implementation was determined on the basis of the power plant area and formation of a port.
A drawing of the boring points is shown in Figure 5.3-1.

-Field Investigation

Core drilling was conducted in 9 boreholes with a total depth of 696 m. The deepest hole was 100 m and the shallowest was 30 m. Information about those boreholes, comprising the borehole numbers, location, coordinates and elevation are shown in Table 5.4-1 below, including the related Bore Logs.

Table 5.3-1 Pilling List

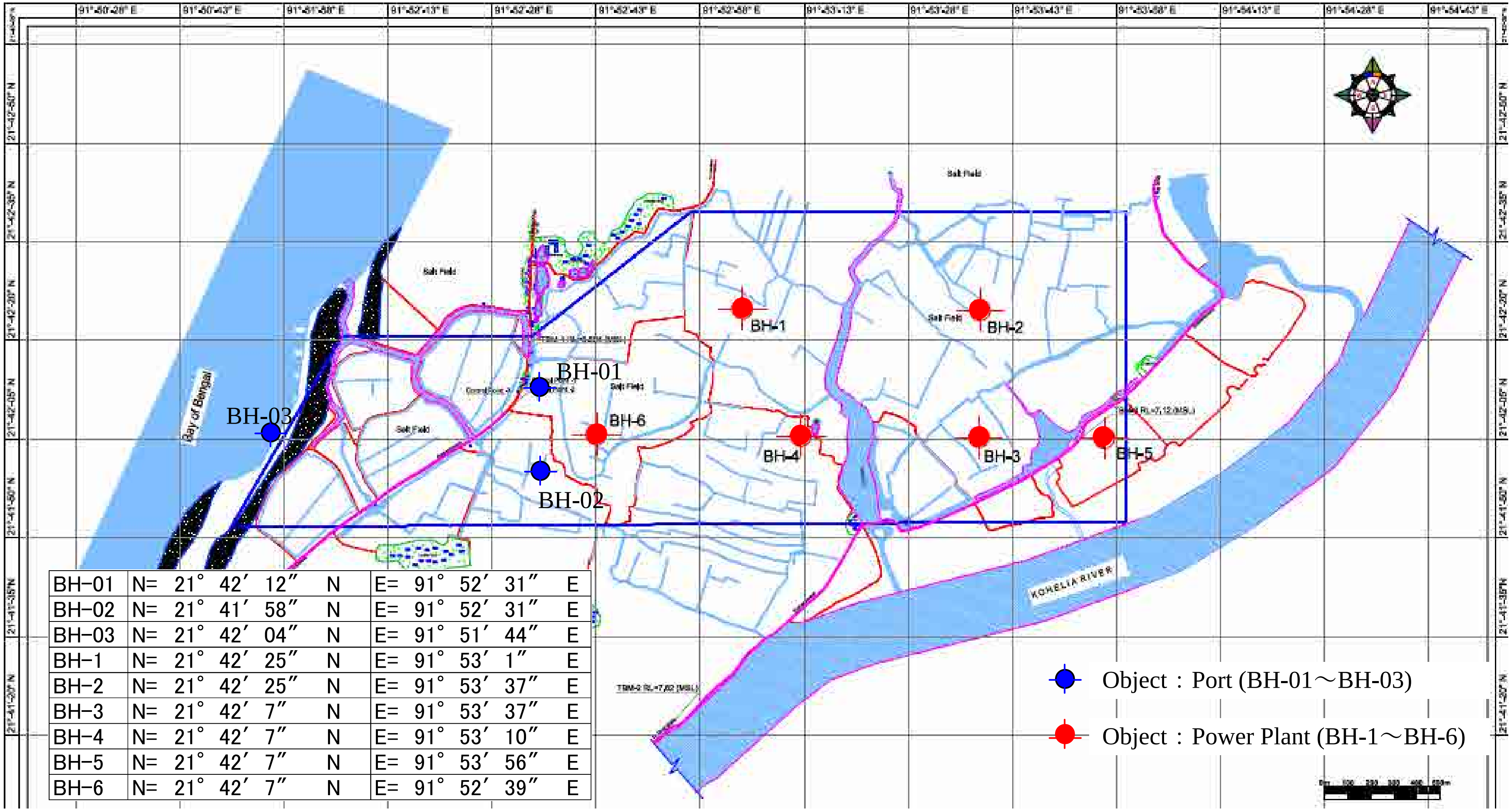
Bore No.	Coordinate		Depth	Loction
BH−01	N= 21° 42′ 12″ N	E= 91° 52′ 31″ E	33m	port
BH−02	N= 21° 41′ 58″ N	E= 91° 52′ 31″ E	33m	port
BH−03	N= 21° 42′ 04″ N	E= 91° 51′ 44″ E	30m	channel
BH−1	N= 21° 42′ 25″ N	E= 91° 53′ 1″ E	100m	Plant
BH−2	N= 21° 42′ 25″ N	E= 91° 53′ 37″ E	100m	Plant
BH−3	N= 21° 42′ 7″ N	E= 91° 53′ 37″ E	100m	Plant
BH−4	N= 21° 42′ 7″ N	E= 91° 53′ 10″ E	100m	Plant
BH−5	N= 21° 42′ 7″ N	E= 91° 53′ 56″ E	100m	Plant
BH−6	N= 21° 42′ 7″ N	E= 91° 52′ 39″ E	100m	Plant

- Geological survey results

The subsurface geology of the proposed project site has been revealed using BH-01～BH-03 borehole logs of the project site. The maximum depth of the boreholes is 33.0m from the existing ground surface. Mainly seven soil layers were observed in the studied site, i.e., very soft to medium stiff clay, loose to very dense silty fine sand, stiff clay, medium dense to very dense silty fine sand, very stiff silt, hard clay, and very dense silty fine sand. The stratigraphy of the project site is given in the table below.

Table 5.3-2 The Stratigraphy of the Project Site

Lithology	Average Thickness (m)
Unit-1: CLAY. It is very soft to medium stiff, grey to dark grey in color, medium to high plastic in nature.	8.0
Unit-2: Silty fine SAND. It is loose to very dense, grey to light grey in color with traces of mica.	4.0
Unit-3: CLAY. It is stiff, grey in color, medium plastic in nature.	2.0
Unit-4: Silty fine SAND. It is medium dense to very dense, light grey in color with traces of mica.	5.0
Unit-5: SILT. It is very stiff, light grey in color, non-plastic in nature.	2.0
Unit-6: CLAY. It is hard, grey spotted brown in color, medium plastic in nature.	4.0
Unit-7: Silty fine SAND. It is very dense, yellowish brown to reddish brown in color with traces of mica.	8.0



BH−01	N=	21°	42′	12″	N	E=	91°	52′	31″	E
BH−02	N=	21°	41′	58″	N	E=	91°	52′	31″	E
BH−03	N=	21°	42′	04″	N	E=	91°	51′	44″	E
BH−1	N=	21°	42′	25″	N	E=	91°	53′	1″	E
BH−2	N=	21°	42′	25″	N	E=	91°	53′	37″	E
BH−3	N=	21°	42′	7″	N	E=	91°	53′	37″	E
BH−4	N=	21°	42′	7″	N	E=	91°	53′	10″	E
BH−5	N=	21°	42′	7″	N	E=	91°	53′	56″	E
BH−6	N=	21°	42′	7″	N	E=	91°	52′	39″	E

The details of the bore logs are shown in appendix C04-02.

Figure 5.3-1 Drawing of Boring Points

5.4 Sediment

The JICA Study Team carried out a sediment sample collection at the Matarbari area in the rainy season and dry season. Results from each investigation are shown in Table 5.4-1(1) and Table 5.4-1(2).

The results show that seabed materials at the bottom of the sea can be classified in terms of sandy soil composition in the dry season. Meanwhile, some areas showed deposits of silty soils on the seabed in the rainy season. Given that the sea water looked thick and muddy during the rainy season, very fine grains of silty soil were deposited on the seabed.

Table 5.4-1 (1) Seabed Materials (Rainy Season)

(percentage)

<table>
<tr><th>Point</th><th>NAME/ID</th><th>Mean Diameter
(D50, mm)</th><th>Sand
(0.075mm～)</th><th>Silt
(0.075mm～0.005mm)</th><th>Clay
(～0.005mm)</th></tr>
<tr><td rowspan="5">Shore line</td><td>SS-01SL</td><td>0.20</td><td>100</td><td colspan="2">0</td></tr>
<tr><td>SS-02SL</td><td>0.12</td><td>98</td><td colspan="2">2</td></tr>
<tr><td>SS-03SL</td><td>0.12</td><td>96</td><td colspan="2">4</td></tr>
<tr><td>SS-04SL</td><td>0.01</td><td>2</td><td>88</td><td>10</td></tr>
<tr><td>SS-05SL</td><td>0.015</td><td>1</td><td>85</td><td>14</td></tr>
<tr><td rowspan="5">Wave Break zone</td><td>SS-01WB</td><td>0.10</td><td>80</td><td colspan="2">20</td></tr>
<tr><td>SS-02WB</td><td>0.16</td><td>98</td><td colspan="2">2</td></tr>
<tr><td>SS-03WB</td><td>0.12</td><td>100</td><td colspan="2">0</td></tr>
<tr><td>SS-04WB</td><td>0.14</td><td>100</td><td colspan="2">0</td></tr>
<tr><td>SS-05WB</td><td>0.018</td><td>2</td><td>84</td><td>14</td></tr>
<tr><td rowspan="3">Off shore</td><td>SS-01OS</td><td>0.015</td><td>2</td><td>82</td><td>10</td></tr>
<tr><td>SS-02OS</td><td>0.013</td><td>1</td><td>89</td><td>10</td></tr>
<tr><td>SS-03OS</td><td>0.01</td><td>1</td><td>81</td><td>18</td></tr>
</table>

The details of the investigation data are shown in appendix C04-03.

Sampling date：October ,2012

Table 5.4-1 (2) Seabed Materials (Dry Season)

(percentage)

Point	NAME/ID	Mean Diameter (D50, mm)	Sand (0.075mm～)	Silt (0.075mm～0.005mm)	Clay (～0.005mm)
Shore line	SS-01SL	0.12	92	8	
	SS-02SL	0.18	98	2	
	SS-03SL	0.12	96	4	
	SS-04SL	022	100	0	
	SS-05SL	0.18	100	0	
Wave Break zone	SS-01WB	0.19	100	0	
	SS-02WB	0.16	98	2	
	SS-03WB	0.21	100	0	
	SS-04WB	0.20	100	0	
	SS-05WB	0.20	100	0	
Off shore	SS-01OS	0.23	100	0	
	SS-02OS	0.20	100	0	
	SS-03OS	0.20	100	0	

The details of the investigation data are shown in appendix C04-03.

Sampling Date ：April. ,2013

5.5 Water Quality

The results of the investigation are shown in Table 5.5-1.

Table 5.5-1 Total Suspended Solids in Water

NAME/ID	Depth (m)	Total Solids (mg/L)		P^H of Water	
		Rainy Season	Dry Season	Rainy Season	Dry Season
WS-01	0.5	675	180	8.6	7.8
	1.0	700	720	8.7	8.3
	1.5	750	1160	8.9	7.8
WS-02	0.5	806	130	8.4	7.9
	5.0	780	310	8.5	7.8
	9.5	933	1380	8.7	7.8
WS-03	0.5	400	240	8.3	7.8
	5.0	380	460	8.5	7.2
	9.5	420	380	8.6	7.7
WS-04	0.5	650	260	9.0	8.0
	1.0	675	120	8.8	8.3
	1.5	750	880	9.1	8.4
WS-05	0.5	800	800	9.3	6.9
	5.0	820	1080	9.7	8.5
	9.5	880	200	9.6	6.6

The details of the investigation data are shown in appendix C04-03.

Sampling Date : Rainy Season / Octorber,2012 , Dry Season /April,2013

5.6 Water Depth

The JICA Study Team carried out a bottom sounding survey in front of the Matarbari site in the rainy season and dry season.

The entire topographic survey field works were carried out using highly accurate Electronic Total Station and RTK GPS Total Station. The data was then downloaded to the computer using data transfer software of Sokkia and Trimble. This data was processed using specialized survey and digital mapping software. The final presentation was done in AutoCAD and GIS format.

The bottom sounding survey data primary process was conducted in Hypac and PDS1000 software. A tide correction was performed to obtain the depth with respect to MSL. All bad and unwanted data was wiped from the survey line and data was provided in ASCII format.

The results of the investigation are shown in Figure 5.6-1(1) and Figure 5.6-1(2).

The results indicate that there is no a significant difference between the rainy season and dry season.

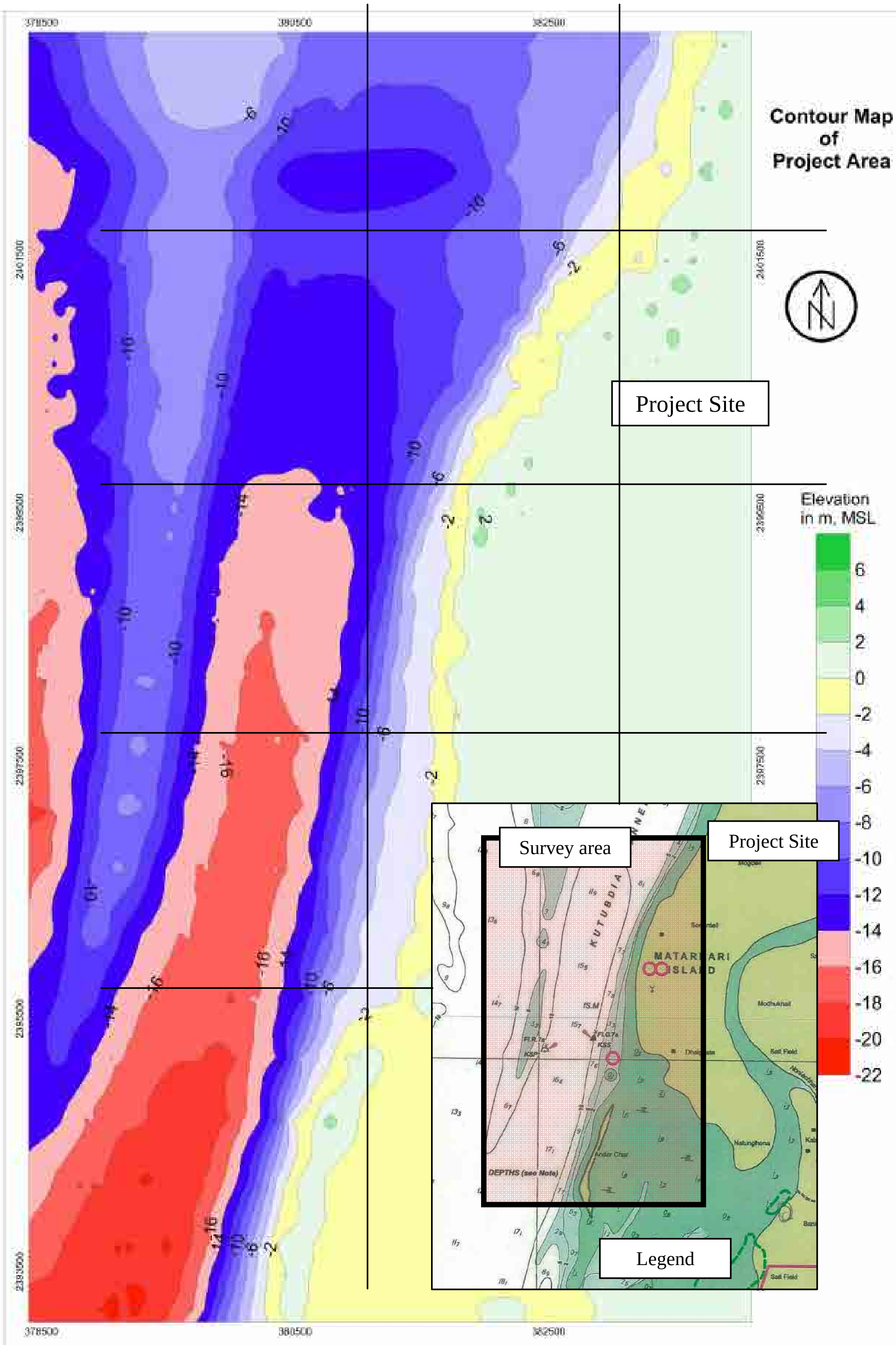


Figure 5.6-1 (1) Bathymetric Survey Map (Rainy Season)

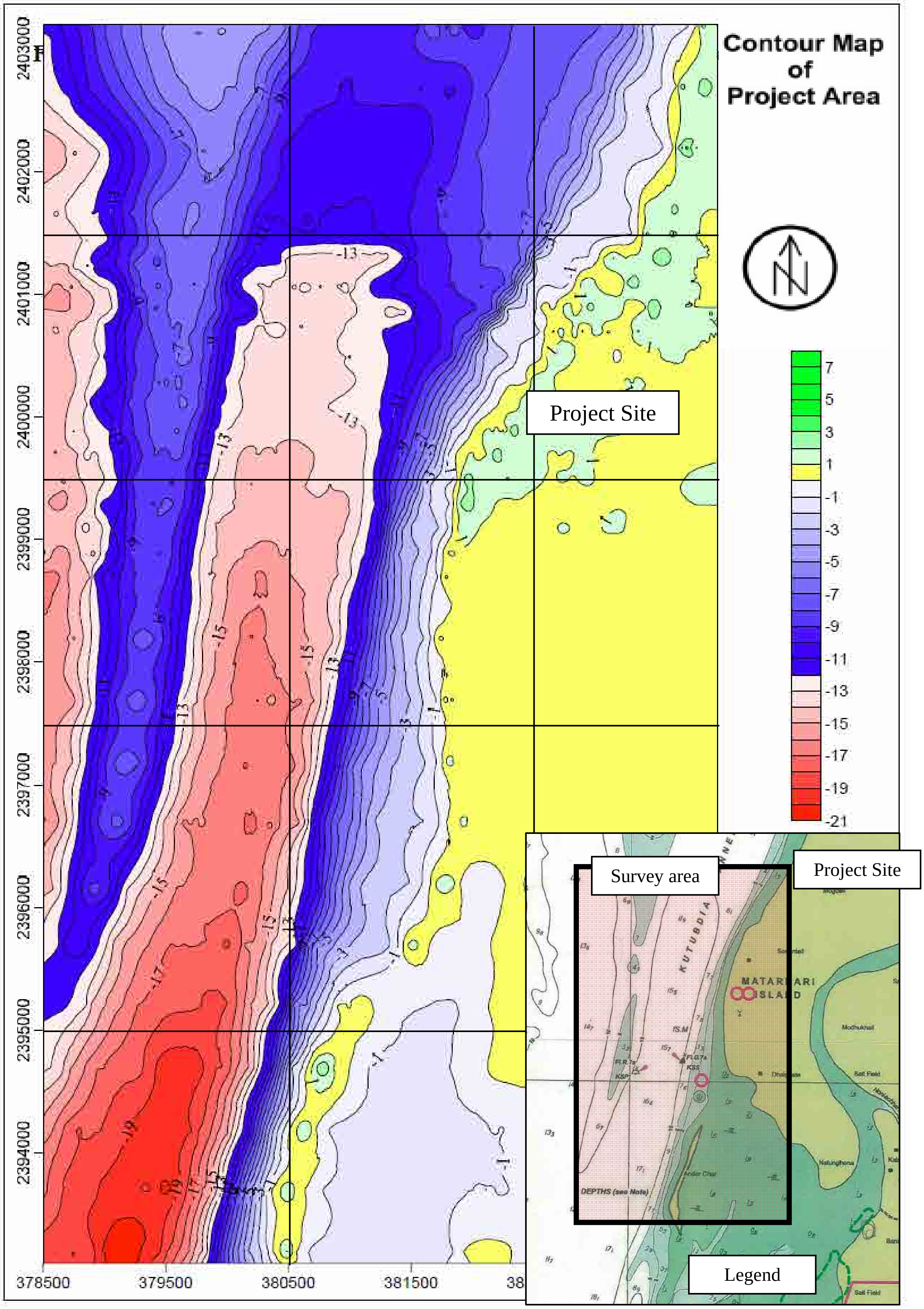


Figure 5.6-1 (2) Bathymetric Survey Map (Dry Season)

5.7 Tidal

(1) Tidal level

Water level was collected for one month from 29th September to 28th October. The location of the water level is shown in Figure 5.7-1.

Figure 5.7-1 Location of Water Level Station

-Design of Tidal Level (prediction of water level using harmonic analysis)

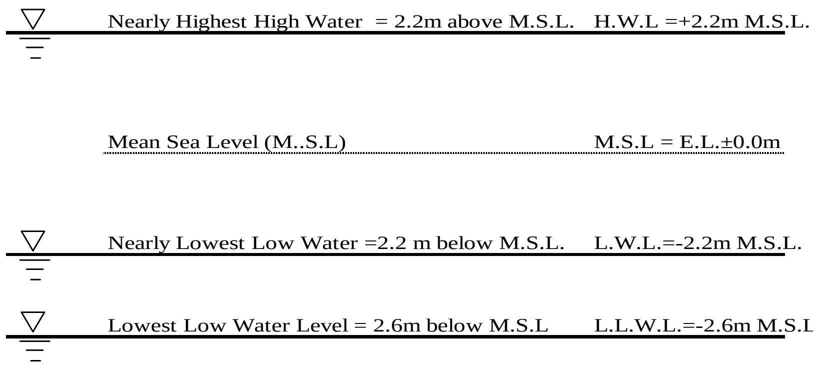
Harmonic analysis is the transformation of tidal observations from the time domain to the frequency domain. The tidal variations can then be given by the sum of the harmonic constituents, which period is associated with the period of the tide generating forces. The periods fall into three tidal species (long-period, lunar and semi- lunar). Each tidal species contains groups of harmonics, which can be separated by analysis of a month of observations. In turn each group contains constituents, which can be separated by analysis of a year of observations. Third lunar, fourth lunar and higher species of harmonics are generated by shallow water effects.

Normally long tidal records are needed to determine amplitude and phase for a larger number of constituents with high accuracy. Here we analyzed 30 days data and the calculated harmonic constituents are provided in Table5.7-1. The water level of 2012 was predicted using these tidal/harmonic constituents and compared with the measured data.

Table 5.7-1 Component Tide

Component Tide	M2	S2	N2	K2	K1	O1	P1	M4	Ms4	Z0
Amplitude	1.34m	0.61m	0.27m	0.13m	0.17m	0.05m	0.05m	0.01m	0.006m	0.45m

- Nearly Highest High Water ≒ （M2 + S2 + K1 + O1 ） above M.S.L
  ≒ 2.2 m above M.S.L
- Nearly Lowest Low Water ≒ （M2 + S2 + K1 + O1 ） below M.S.L
  ≒ 2.2 m above M.S.L
- Lowest Low Water Level ≒ （M2 + S2 + N2 + K2 +K1 + O1 + P1 + M4 + MS4） below M.S.L ≒ 2.6 m above M.S.L



* The Chart Datum (CD) is 2.69m below M.S.L at SONADIA

The details of the investigation data are shown in appendix C04-03.

Figure 5.7-2 Tidal Conditions at Matarbari

(2) Tidal current

Current speed data was collected for 15 days for four selected locations. The four locations are provided in Figure 5.7-3.

Of the four locations, three locations are almost close but location 3 is more towards the sea. It is evident from the results of the investigation that the current speed varies from 0.03 m/s to 1.26 m/s (location 1), and 0.025 m/s to 1.5 m/s (locations 2 and 3), and the dominant direction follows 0 to 90 degrees and 180 to 270 degrees (locations 1,2 and 3). In addition, it was found that the current speed of location 4 varies from 0.06 m/s to 1.88 m/s and the dominant direction is 0 to 90 degrees.

From all the current profiles it is evident that almost 90% of the direction falls either from 0 to

90 degrees (Northeast direction) or from 180 to 270 degrees (Southwest direction). This happens because it represents the tide. When there is a flood tide the water goes towards shore/land, then it follows a southwest direction (180 to 270 degrees), whereas when there is an ebb tide the water goes towards the sea then it follows a northeast direction (0 to 90 degrees).

Table 5.7-2 Tidal Current Observation Point/Line

SL	NAME/ID	LAT (WGS84)	LON (WGS84)	EASTING (UTM)	NORTHING (UTM)	REMARKS
1	TC-01	21°42' 20"N	91°51' 35"E	382048	2400946	at -5m depth
2	TC-02	21°41' 45"N	91°51' 18"E	381526	2399615	at -5m depth
3	TC-03	21°41' 45"N	91°50' 49"E	380699	2399600	at -15m depth
4	TC-04	21°38' 39"N	91°53' 21"E	385033	2393849	RIVER END

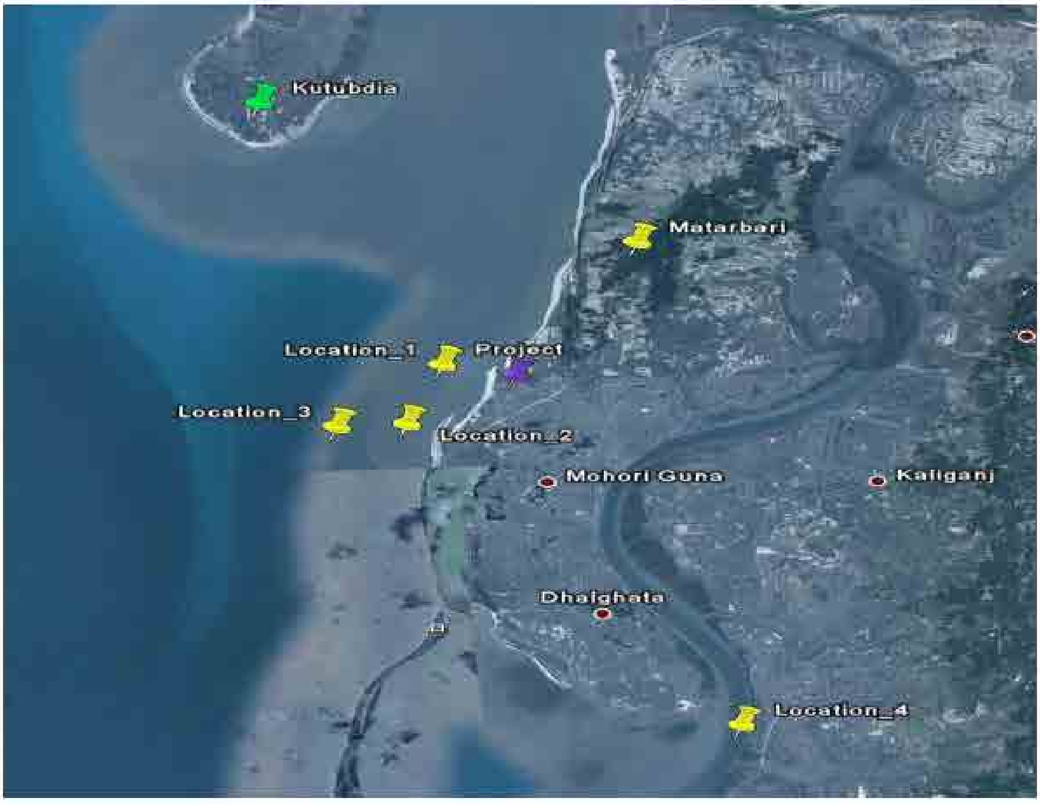


Figure 5.7-3 Point Map

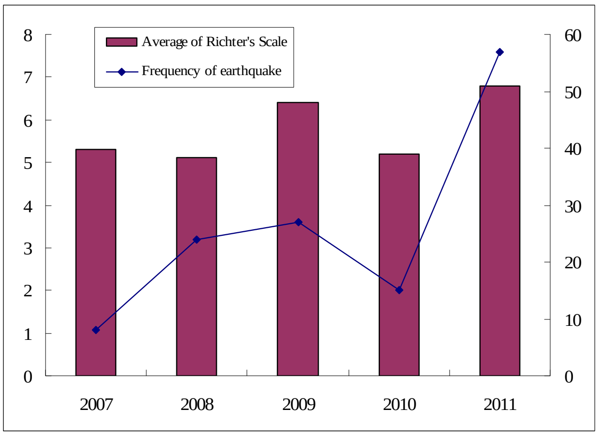
5.8 Wave

Refer to 4.3.2 Environment Situation, (2) Ocean graphic Conditions.

5.9 Seismic Coefficient

Earthquakes which have occurred in Bangladesh and the surrounding area since 2007 are recorded by the Bangladesh Meteorological Department (only major earthquakes that caused serious damage had been recorded prior to 2007). Eight earthquakes were recorded in 2007, while 24 to 27 earthquakes were recorded from 2008 to 2009. Fifteen earthquakes were recorded in 2010, while the number increased to 81 in 2011. The number recorded in 2011 included earthquakes with remote epicenters, of which 57 had been recorded prior to 2011 (Figure 5.9-1).

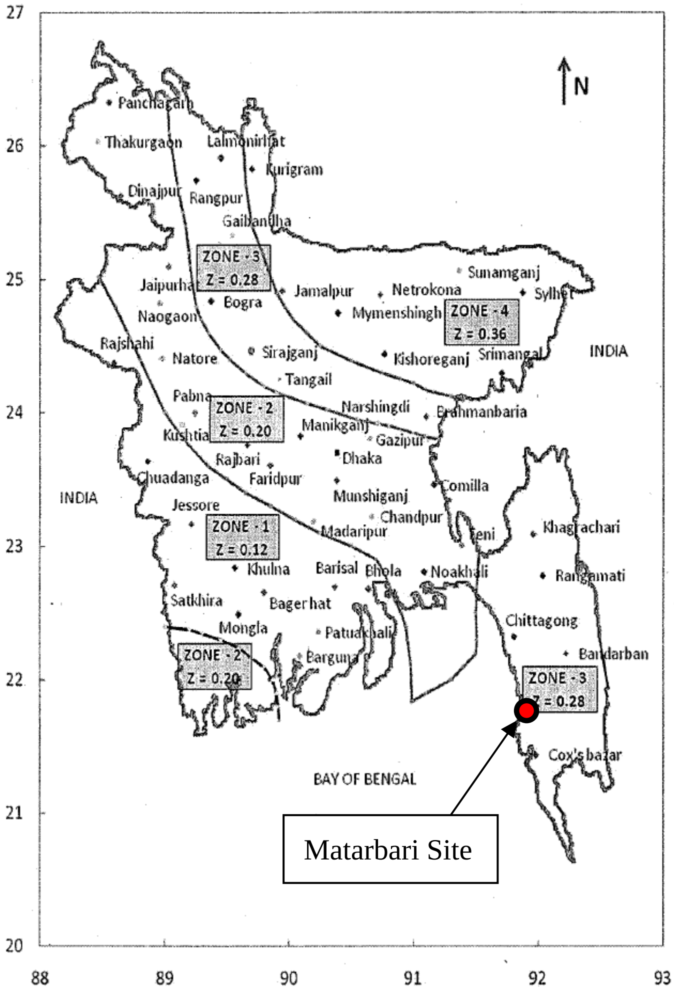
Regarding the intensity of earthquakes as indicated by the Richter Scale, the records of yearly maximums on the Richter scale show that strong earthquakes occurred more often in 2009 and 2011 than in the other 3 years between 2007 and 2011 (Figure 5.9-1).



(Prepared based on the data of Bangladesh Meteorological Department)

Figure 5.9-1 Frequency of Earthquakes and Maximums on the Richter Scale

Bangladesh is divided into four seismic zones, and the design strength of buildings is stipulated in each seismic zone. The project site is located in Zone -3, the same as Chittagong, where moderate levels of strength designs for buildings will be necessary (Figure 5.9-2).



(Source: **BANGLADESH NATIONAL BULDING CODE**)

Figure 5.9-2 Seismic Zone Map of Bangladesh

The seismic coefficient shall be determined from the following relation by the BANGLADESH NATIONAL BULDING CODE 2006.

$$k = k = \frac{Z \cdot I \cdot C}{R}$$

where, k = Seismic coefficient

Z = Seismic zone coefficient given in Table 5.9-1, Matarbari site =0.15

I = Structure importance coefficient given in Table 5.9-2

R = Response modification coefficient for structural systems given in Table 5.9-4

C = Numerical coefficient given by the relation;

$$C = \frac{1.25S}{T^{2/3}}$$

S = Site coefficient for soil characteristics as provided in Table 5.9-3

T = Fundamental period of vibration in seconds

Table 5.9-1 Seismic Zone Coefficients (Z)

Seismic Zone (see Figure5.9-1)	Zone Coefficient
1	0.12
2	0.20
3	0.28
4	0.36

Table 5.9-2 Structure Importance Coefficients (I)

Structure Importance Categories	Structure Importance Coefficients	
	I	I’
Essential facilities	1.25	1.50
Hazardous facilities	1.25	1.50
Special occupancy structures	1.00	1.00
Standard occupancy structures	1.00	1.00
Low-risk structures	1.00	1.00

Table 5.9-3 Site Coefficient (S)

Site Soil Characteristics		Coefficient, S
Type	Description	
S_1	A soil profile with either : a) A rock-like material characterized by a shear-wave velocity greater than 762 m/s or by other suitable means of classification, or b) Stiff or dense soil condition where the soil depth is less than 61 metres	1.0
S_2	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 61 metres	1.2
S_3	A soil profile 21 metres or more in depth and containing more than 6 metres of soft to medium stiff clay but not more than 12 metres of soft clay	1.5
S_4	A soil profile containing more than 12 metres of soft clay characterized by a shear wave velocity less than 152 m/s	2.0

Note : (1) The site coefficient shall be established from properly substantiated geotechnical data. In locations where the soil properties are not known in sufficient detail to determine the soil profile type, soil profile S_3 shall be used. Soil profile S_4 need not be assumed unless the building official determines that soil profile S_4 may be present at the site, or in the event that soil profile S_4 is established by geotechnical data.

Table 5.9-4 Response Modification Coefficient for Structural Systems (R)

Basic Structural System[1]	description of Lateral Force Resisting System	R [2]
a. Bearing Wall System	1. Light framed walls with shear panels	
	i) Plywood walls for structures, 3 storeys or less	8
	ii) All other light framed walls	6
	2. Shear walls	
	i) Concrete	6
	ii) Masonry	6
	3. Light steel framed bearing walls with tension only bracing	4
	4. Braced frames where bracing carries gravity loads	
	i) Steel	6
	ii) Concrete [3]	4
	iii) Heavy timber	4
b. Building Frame System	1. Steel eccentric braced frame (EBF)	10
	2. Light framed walls with shear panels	
	i) Plywood walls for structures 3-storeys or less	9
	ii) All other light framed walls	7
	3. Shear walls	
	i) Concrete	8
	ii) Masonry	8
	4. Concentric braced frames (CBF)	
	i) Steel	8
	ii) Concrete [3]	8
	iii) Heavy timber	8
c. Moment Resisting Frame System	1. Special moment resisting frames (SMRF)	
	i) Steel	12
	ii) Concrete	12
	2. Intermediate moment resisting frames (IMRF), concrete [4]	8
	3. Ordinary moment resisting frames (OMRF)	
	i) Steel	6
	ii) Concrete [5]	5
d. Dual System	1. Shear walls	
	i) Concrete with steel or concrete SMRF	12
	ii) Concrete with steel OMRF	6
	iii) Concrete with concrete IMRF [4]	9
	iv) Masonry with steel or concrete SMRF	8
	v) Masonry with steel OMRF	6
	vi) Masonry with concrete IMRF [3]	7
	2. Steel EBF	
	i) With steel SMRF	12
	ii) With steel OMRF	6
	3. Concentric braced frame (CBF)	
	i) Steel with steel SMRF	10
	ii) Steel with steel OMRF	6
	iii) Concrete with concrete SMRF [3]	9
	iv) Concrete with concrete IMRF [3]	6
e. Special Structural Systems	See Sec 1.3. 2, 1. 3. 3, 1.3.5	

Notes: (1) Basic Structural Systems are defined in Sec 1.3.2, Chapter 1.
(2) See Sec 2.5.6.6 for combination of structural systems, and Sec 1.3.5 for system limitations.
(3) Prohibited in Seismic Zone 3.
(4) Prohibited in Seismic Zone 3 except as permitted in Sec. 2.5.9.3.
(5) Prohibited in seismic Zones 2 and 3. See 1.7.2.6.

A seismic coefficient was calculated using each coefficient above.

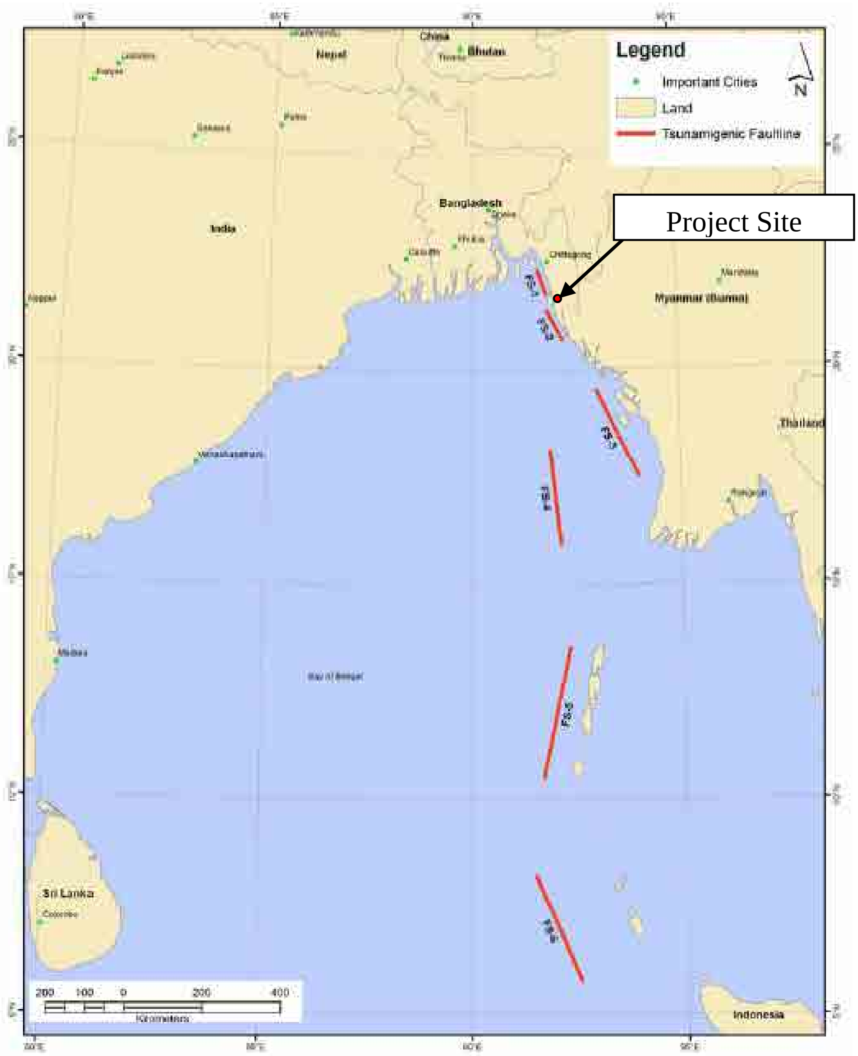
In addition, the shear wave velocity and the natural period of each structure can be calculated as needed.

5.10 Tsunami

A literature survey was carried out on the data concerning Tsunamis.

(1) Tunamigenic Fault Source

Based on a report of the Ministry of Food and Disaster Management, a potential fault source map of the Bay of Bengal has been prepared and presented in Figure 5.10-1.
It shows six potential Tunamigenic fault sources.



Source: Use Existing Data on Available Digital Elevation Models to prepare Useable Tsunami and Storm Surge Inundation Risk Maps for the Entire Coastal Region Final Report 2009

Figure 5.10-1 Potential Tsunamigenic Fault-source Map

(2) Inundation Risk Map

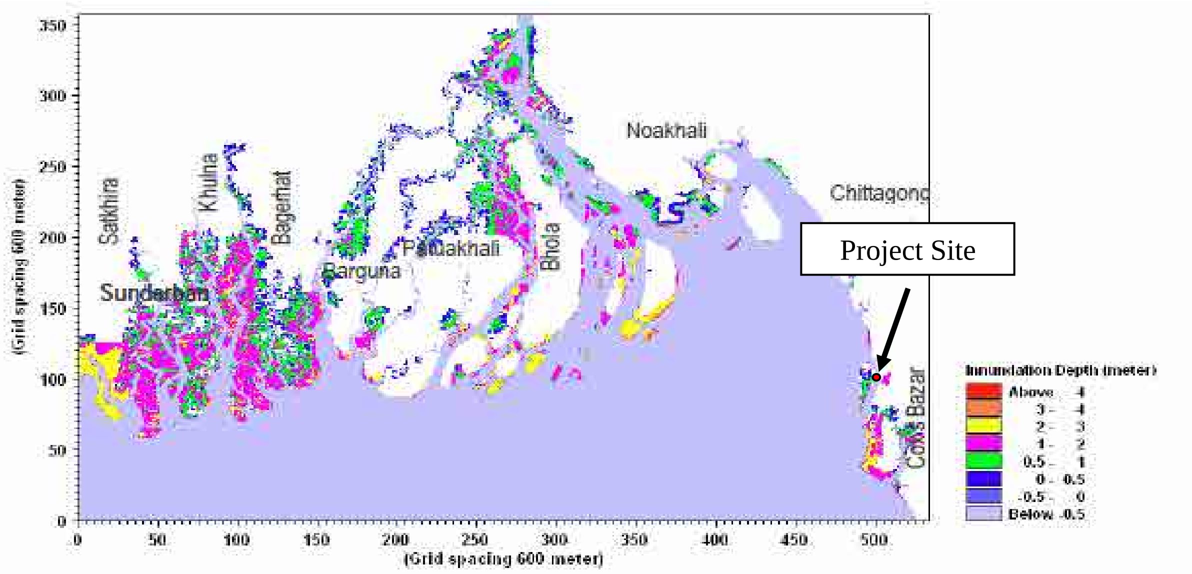
Based on a report of the Ministry of Food and Disaster Management, an Inundation Risk Map has been prepared and presented in Figure 5.10-2.

A tsunami model was developed for the Indian Ocean, the Arabian Sea, the Bay of Bengal and the coastal region of Bangladesh using the MIKE21 model system of DHI (Water Environment Health). The model was calibrated with the tsunami of December 26, 2004, which occurred on the West Coast of Sumatra due to an earthquake. The model was applied to simulate a tsunami propagation and inundation from its sources to the coast of Bangladesh.

An inundation risk map for the coastal region of Bangladesh was prepared based on six scenarios of tsunamis originating from six potential sources of earthquakes in the Bay of Bengal. Initially all the tsunamis generated from the potential sources were simulated using the MIKE 21 model system. Maximum inundation maps for all of the tsunamis were generated from the simulation results under Mean High Water Spring (MHWS) tide conditions. Finally, the inundation risk map was generated based on the maximum inundation maps using GIS tools.

The inundation risk map for tsunamis shows that the Cox's Bazaar coast near the project site would be inundated during a tsunami. Maximum inundations have been found at Cox's Bazar coast near the project site in the range of 1-3 m.

For reference, it was found that in the case of the 2004 Sumatra earthquake, the first tsunami after the earthquake arrived within 2.2 hours, with a maximum height of 31 cm at St. Martin Island.



Source: Use Existing Data on Available Digital Elevation Models to prepare Useable Tsunami and Storm Surge Inundation Risk Maps for the Entire Coastal Region Final Report 2009

Figure 5.10-2 Maximum Inundation Map for Tsunamis

(3) Tsunami Conditions

Based on a report of the Ministry of Food and Disaster Management, which gives detailed descriptions of related Tunamigenic fault sources and tsunami simulations, a tsunami height of 1-3m is predicted.

As a result of this, tsunami height is considerably lower than the storm surge height in the range of 7-9m which is shown Chapter 8.1.2. Therefore, tsunami conditions have not been included in the design of the power plant ground level.

5.11 Flood Types

There are generally four types of floods in Bangladesh[1] (Figure 5.11-1).

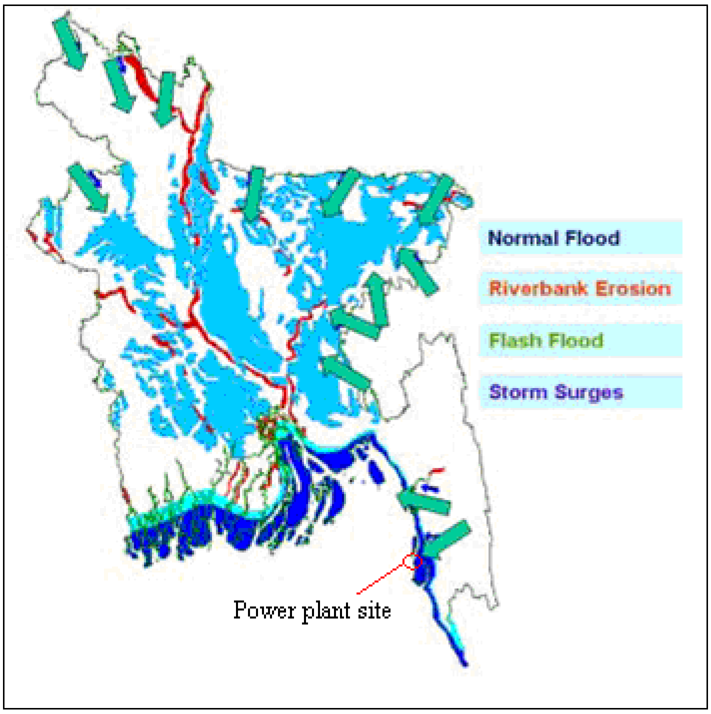
Normal Floods: This type of flood generally occurs in the Gangetic deltas where natural drainage systems are deteriorating due to amounts of rainfall that are larger than drainage capacity. They also occur in towns where natural drainage systems have been disturbed because of human interference, mainly due to construction of unplanned rural roads and illegal occupation of river courses.

Riverbank Erosion: This type of flood is the most common phenomenon in the country from time immemorial. They normally occur in the monsoon season along the river. In the case of extreme floods, 50~70% of the country are inundated extending into areas far beyond the riverbanks.

Flash Floods: This type of flood is characterized by a rapid rise and fall in water levels. Flash floods occur mostly in the northern area, north-central part, northeastern part and southeastern part of the country.

Storm Surges: This kind of flood mostly occurs along the coastal areas of Bangladesh which has a coast line of about 800km along the northern part of the Bay of Bengal. This coastal area is shallow and the coastal line in the eastern portion is conical in shape. Therefore, storm surges are likely to occur due to flood tides from cyclones and southwestern monsoon winds. The power plant site is located in this Storm Surges area.

[1] World Meteorological Organization, 2003: Integrated Flood Management Case Study; BANGLADESH, FLOOD MANAGEMENT



(Source: World Meteorological Organization, 2003)

Figure 5.11-1 Areas of Four Flood Types

Chapter 6

Fuel Supply Plan

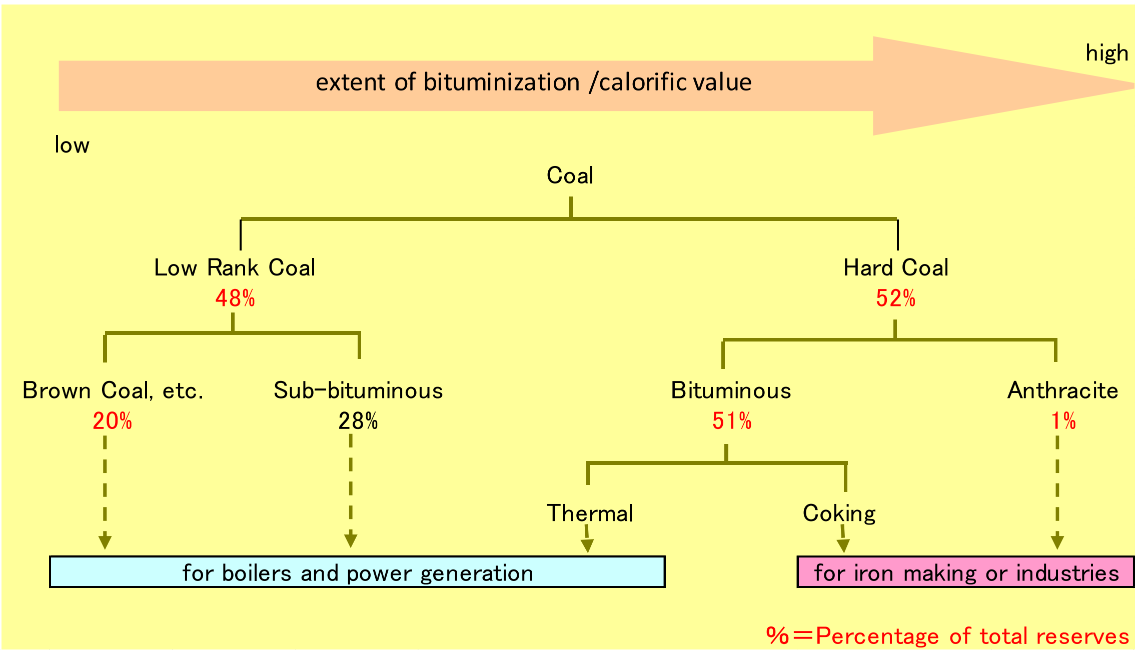
Chapter 6 Fuel Supply Plan

6.1 Amount of Coal Resources, Reserves

6.1.1 Classification of coal

Coal is roughly divided into three types according to the progress of coalification shown in Figure 6.1-1. They are brown coal including peat and lignite, bituminous coal, and anthracite in ascending order according to coalification. Because coalification is the process of the increasing carbon content, the quality of coal rises from brown coal to anthracite. At each intermediate stage in the coalification process, there is matter called peat (the lower grade of lignite), sub-bituminous coal (the lower grade of bituminous) and semi-anthracite etc. Young coal which has high oxygen content requires careful handling due to the likelihood of spontaneous combustion.

In addition, depending on how it is used, coal can be classified as coking coal for iron making and thermal coal for power generation.



Source: The Study Team

Figure 6.1-1 Classification of Coal

6.1.2 Proven reserves of coal in the world

According to BP statistics, the world's proven reserves of coal are 861 billion tones as shown in Table 6.1-1. The reserve-production ratio is about 118 years. Coal has the longer R/P ratio than oil or gas, and has a wider global dispersion rate. The United States has the biggest reserves, Russia the second, and China the third, followed by Australia, India and so on.

Table 6.1-1 Proven Reserves of Coal in the World

(million tonnes)

	Anthracite/ Bituminous	Sub-bituminous/ Brown Coal	Total
USA	108,501	128,794	237,295
Russia	49,088	107,922	157,010
China	62,200	52,300	114,500
Australia	37,100	39,300	76,400
India	56,100	4,500	60,600
Germany	99	40,600	40,699
Ukraine	15,351	18,522	33,873
Kazakhstan	21,500	12,100	33,600
South Africa	30,100	–	30,100
Columbia	6,366	380	6,746
Canada	3,474	3,108	6,582
Indonesia	1,520	4,009	5,529

Source：BP Statistical Review of World Enrgy 2011

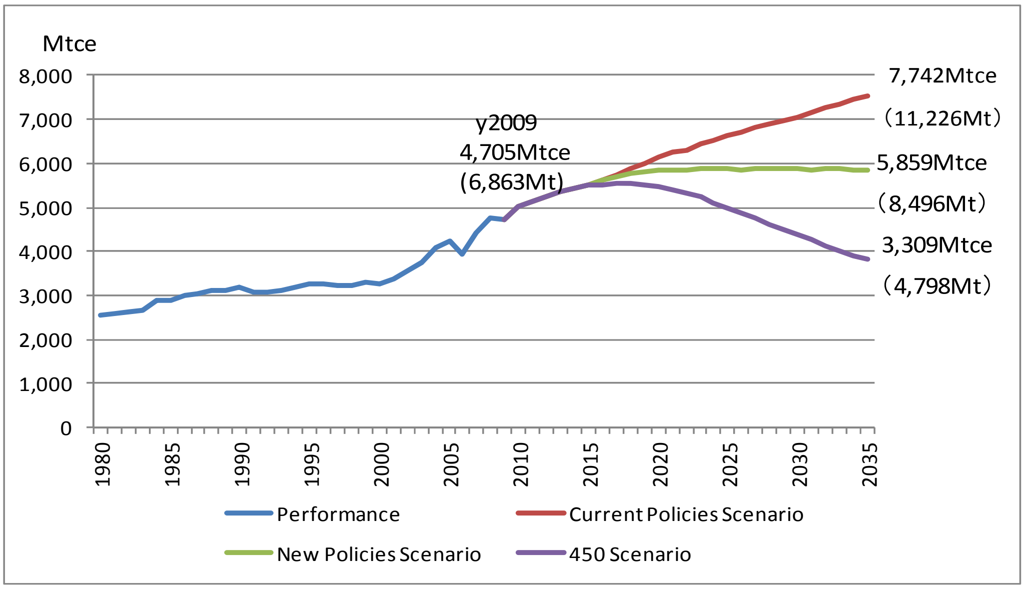
6.2 Demand and Supply Situation of Imported Coal in the International Market

6.2.1 Global coal demand

Figure 6.2-1 shows the result of world coal demand through 2010 and the IEA's prediction until 2035. The predicted scenario shows three via a national approach towards climate change, which are the Current Policies Scenario, New Polices Scenario and the 450 Scenario[1]. World coal production in 2009 was 6.8 billion tons and the demand for coal should continue the current policy remains will reach 11.2 billion tons in 2035. However, it is said that it is possible to reduce the consumption of coal by 8.5 billion tons per the New Polices Scenario and 4.8 billion tons per the 450 Scenario.

Coal demand has been increasing rapidly since 2002 and coal prices have been rising as a result. The period of stable demand applied not only to stable coal prices but also to situations where rapidly increasing coal demand in Non-OECD countries in recent years. The tight supply has caused a coal price increase and uncompetitive coal resources will allow the mining of coal and an increase in coal supply as a result. Therefore, the future price of coal is expected to rise until the balance between supply and demand is stabilized.

[1] 450 scenario is the scenario to hold down CO_2 density to 450ppm



(Sources: IEA World Energy Outlook11)

Figure 6.2-1 World Coal Demand Forecast

About 90% of the world's coal consumption is thermal coal, so global coal demand trends can basically be considered to be global thermal coal demand trends.

According to the "World Energy Outlook 2011" by IEA, global coal demand in 2009 was 4.7 billion tons and occupied a 27% share of primary energy demand. From 2000 to 2010, the estimated global coal demand growth was 4.4% per annum, and that figure was far more than the 1.1% growth in oil demand and 2.7% growth in natural gas demand. As a result, coal contributed to a little less than half the level of primary energy demand growth over the 10- year period. The main use of coal is for power generation. About two-thirds of the demand for coal is for power generation, and 20% is for industrial purposes. During power generation, the proportion of coal is about less than half, so coal can be the main fuel.

In terms of future demand trends, the global coal demand is expected to increase by 1.9% per the annum growth rate from 4.7 billion tones in 2009 to 7.7 billion tones in 2035 under the current policy scenario. Even under the new policy scenario[2,] the demand is expected to remain unchanged from 2020, but reach 5.9 billion tones in 2035.

Concerning regional demand growth, whereas OECD countries are almost flat, non-OECD countries especially China and India are expected to experience large demand growth as shown

[2] New policy scenario is a scenario which is considered the planning and pledge released by the countries for energy security or no environment problems, and it is not a forecast.

in Table 6.2-1. Under the current policy scenario, the growth in coal demand in China and India is expected to account for three quarters of global coal demand growth by 2035. So the growth of coal imports of both countries is projected to have a major impact on the coal trade.

Table 6.2-1 Coal Demand by Region and Scenario

【Coal demand by region and scenario】

(Mtce)

			Current Policies Scenario		New Policies Scenario	
	1980	2009	2020	2035	2020	2035
OECD	1,380	1,476	1,609	1,588	1,494	1,146
United States	*537*	*693*	*751*	*773*	*705*	*599*
Europe	*663*	*415*	*431*	*400*	*383*	*264*
Japan	*85*	*145*	*165*	*156*	*158*	*115*
Non-OECD	1,179	3,229	4,699	6,154	4,339	4,713
China	*446*	*2,179*	*3,069*	*3,709*	*2,863*	*2,820*
India	*75*	*399*	*699*	*1,148*	*619*	*883*
Russia	*NA*	*136*	*173*	*203*	*166*	*168*
World	2,560	4,705	6,308	7,742	5,833	5,859

Source: IEA “World Energy Outlook 2011”

6.2.2 Global coal production

According to BP statistics, global coal production in 2010 was 7.3 billion tons, an increase of 6.3 percent. Per country, production in China is overwhelming in comparison to other countries and its volume accounts for more than 40% of the total world coal production followed by the United States, India, and Australia as shown in Table 6.2-2.

Table 6.2-2 Global Coal Production

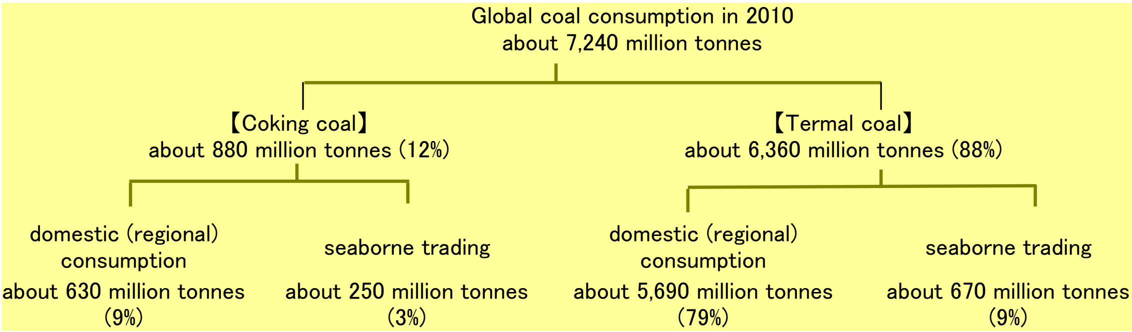
(million tonnes)

China	3,240
USA	985
India	570
Australia	424
Russia	317
Indonesia	306
South Africa	254
Germany	182
Poland	133
Kazakhstan	111

Source: BP Statistical Review of World Enrgy 2011

6.2.3 Seaborne trade in coal

The volume of global seaborne trade in coal is approximately just over 10% of global coal consumption, so most coal is consumed in the country of production as shown in Figure 6.2-2. On the other hand, about 30% of the consumption of coking coal depends on trade and thermal coal trade in terms of global coal consumption reaches just about 10%.



(Sources: IEA World Energy Outlook11)

Figure 6.2-2 Global Coal Consumption

6.2.4 Thermal coal export countries

Countries with a higher export volume of coal are Indonesia, Australia, and then Russia as shown in Table 6.2-3. In high-volume production countries such as China, the United States and India, coal is essentially devoted to domestic consumption and exports are minimal. China has recently become a net importer.

Table 6.2-3 Countries with a Higher Export Volume of Coal

(million tonnes)

Indonesia	285
Australia	143
Russia	95
Columbia	68
South Africa	68
Kazakhstan	33
USA	23
China	19

Source:IEA “Coal Information 2011”

6.2.5 Thermal coal import countries

Top coal importers are mainly East Asian Countries such as Japan, China, Korea, India, and

Taiwan as shown in Table 6.2-4. In addition, European countries are also importers. Although China occupies only about 4 % of the imports in domestic coal production, China is already ranks as one of the top importing counties. Given the significant increase in coal demand in India and China in the future, Chinese and Indian influence is expected to increase in the area of seaborne trade of coal.

Table 6.2-4 Top Coal Importers

(million tonnes)

Japan	135
China	129
Korea	91
India	60
Taiwan	58
Germany	38
Russia	23

Source：IEA "Coal Information 2011"

6.3 Possibility of Coal Supply to the Matarbari CFPP

For coal supply and demand forecasts of countries that can export to Bangladesh, coal production was examined country by country. In order to study the coal supply and demand forecast for 2030, Indonesia, Australia, South Africa and Mozambique will be considered as possible coal-producing countries for the sea transport distances to Bangladesh. Table 6.3-1 shows freight rate and navigation days in 2012.

Table 6.3-1 Freight Rate and Navigation Day

Shipping Country to Chittagong	Loading Port	Freight Rate (US$/t)	Navigation mile	Navigation Days (port to port, 13 knot/hr)
Indonesia (South Sumatra)	Palembang	$13	1,842	6
Indonesia (South Kalimantan)	Taboneo	$14	2,268	8
Indonesia (East Kalimantan)	Bontang	$15	2,963	9
South Africa	Richards Bay	$18	4,979	16
Australia (NSW)	Newcastle	$22	5,767	19
Canada (West coast)	Westshore	$28	8,584	28
USA (West coast)	Long Beach	$31	9,190	30
Colombia (Atlantic coast)	Puerto Bolivar	$33	11,726	38
USA (Gulf)	New Orleans	$38	13,223	42

In addition, in terms of coal reserves and future production possibilities, the neighboring countries of Bangladesh, Myanmar and Laos are being considered. But stable exports would still take time. Thailand has also been producing coal but it cannot be expected that their coal has a high sulfur content, considering the fact that domestic consumption is limited. And, since China becomes an import coal country, China is out of all those countries.

The coal production situation in Australia, Indonesia, South Africa, and Mozambique are described here.

6.3.1 Australia

According to the "Australian energy projections to 2034–35" released by BREE[3] in December, 2011, production of black coal[4] is expected to increase at an annual rate of 2.8% from 300 million tons (9,004 petajoules) in FY2008/09 to 623 million tons in FY2034/35 (18,676 petajoules) as shown in Table 6.3-2 and Figure 6.3-1. Since domestic coal demand is expected to become lower than present levels, the export volume should increase along with the expansion of production. Construction of infrastructure for coal development and coal exports is promoted in the State of New South Wales and the State of Queensland, and it is expected that the volume of coal exports will continue to expand at an annual rate of 3.3% towards FY2034/35 from 247 million tons (7,411 petajoules) to 581 million tons (17,415 petajoules) (black coal alone).

Table 6.3-2 Australian Coal Supply and Demand Outlook

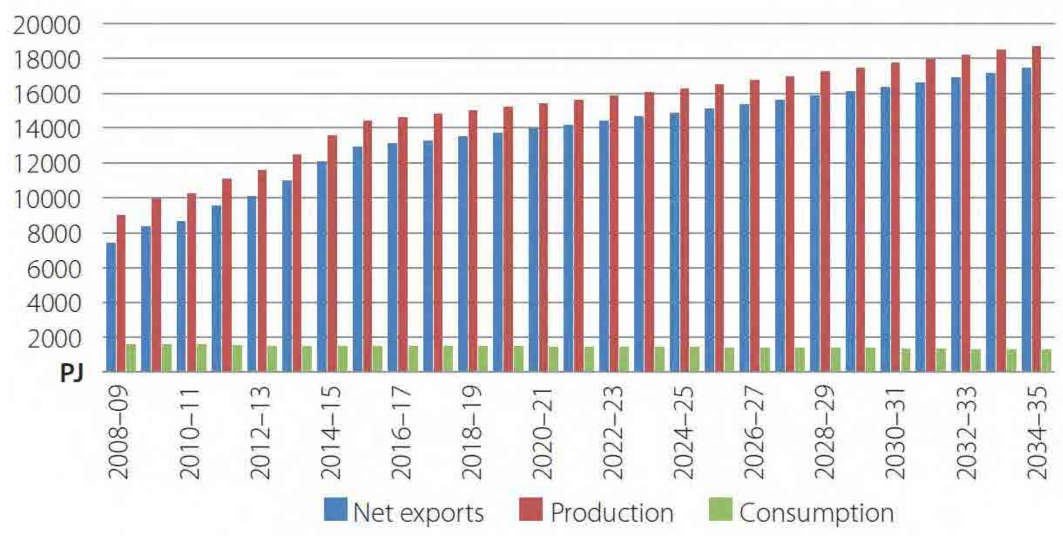
		2008/09		2019/20		2034/35	
		(million tons)	(PJ)	(million tons)	(PJ)	(million tons)	(PJ)
Production	Black Coal	300	(9,004)	506	(15,185)	623	(18,676)
	Brown Coal	66	(647)	66	(647)	29	(281)
		366	(9,651)	572	(15,832)	651	(18,957)
Domesiti Consamption	Black Coal	53	(1,593)	49	(1,460)	42	(1,260)
	Brown Coal	66	(647)	66	(647)	29	(281)
		119	(2,240)	115	(2,107)	71	(1,541)
Exports	Black Coal	247	(7,411)	458	(13,725)	581	(17,415)
	Brown Coal	0	(0)	0	(0)	0	(0)
		247	(7,411)	458	(13,725)	581	(17,415)

Source: Prepared by JICA study team based on the "Australian energy projections to 2034–35, December 2011" of BERR

In the "BREE's list of major minerals and energy projects, April 2012" made public by BREE on its own Web site in April, 2012, 46 projects to expand existing coal mines (16 under

[3] The Bureau of Resources and Energy Economics, a research body of the commonwealth of Australia,
[4] Bituminous coal of both steam and coking coal, etc.

construction) and 48 new development projects (5 under construction), totaling 94 projects (21 under construction), are listed in Table 6.3-3.



Source: The "Australian energy projections to 2034–35, December 2011" of BERR

Figure 6.3-1 Australian Black Coal Supply and Demand Outlook

If the coal supply capacity that can be added by such coal production increase projects listed here in and after 2012 is accumulated, Australia can will be able to add a total of 570 million tons of coal supply capacity in 2017, of which steam coal is 400 million tons and 170 million tons is coking coal as shown in Table 6.3-4. BREE says that 348 million tons of coal (coal products minus lignite) was actually produced in 2011 and the simple addition of this value to added coal supply capacity yields 920 million tons as of 2017. BREE expects coal production (coal products minus lignite) in 2019/20 to be 506 million tons and, if the production increase projects shown in the "BREE's list of major minerals and energy projects, April 2012" are implemented smoothly, it seems that the supply capacity will be sufficient enough to satisfy the expected value even if some of the existing mines are closed due to coal reserve depletion. Since coal production can be expanded as mentioned above, it is assumed to be quite possible to achieve the outlook for 2019/20 coal exports. According to BREE, Australia exported 281 million tons of coal in 2011, of which 133 million tons 47% of this amount was steam coal and 148 million tons or 53% of this amount was coking coal.5 This means that, if the above ratio is applied, as shown in Table 6.3-5, the volume of steam coal exports will swell to 241 million tons in 2019/20 and to 305 million tons in 2034/35, while the volume of coking coal exports will increase to 217 million tons in 2019/20 and to 275 million tons in 2034/35.

[5] BREE's Web site-contained information "Resources and Energy Statistics—December Quarter 2011—Commodity Historical Data Tables"

Table 6.3-3 Number of Australian Coal Projects

	NSW	QLD	West Australia	Total
Expansion	25 (9)	21 (7)	0 (0)	46 (16)
New Project	8 (1)	39 (4)	1 (0)	48 (5)
Total	33 (10)	60 (11)	1 (0)	94 (21)

Source: Prepared by JICA study team based on the “BREE’s list of major minerals and energy projects, April 2012“ of BERR

Table 6.3-4 Australian Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015	2016	2017-
NSW		12.0	33.3	23.6	15.5	14.0	44.4
	Steam Coal	9.0	20.7	16.1	15.5	3.5	41.7
	Coking Coal	3.0	12.7	7.5	0.0	10.5	2.8
QLD		13.2	54.3	146.6	72.6	18.0	120.9
	Steam Coal	3.2	19.2	101.9	70.6	5.0	92.5
	Coking Coal	10.0	35.1	44.7	2.0	13.0	28.5
West Australia		0.0	0.0	2.5	0.0	0.0	0.0
	Steam Coal	0.0	0.0	2.5	0.0	0.0	0.0
	Coking Coal	-	-	-	-	-	-
Total		25.2	87.6	172.7	88.1	32.0	165.3
	Steam Coal	12.2	39.9	120.5	86.1	8.5	134.1
	Coking Coal	13.0	47.8	52.2	2.0	23.5	31.2
Cumulative Total		25.2	112.8	285.5	373.6	405.6	570.9
	Steam Coal	12.2	52.1	172.6	258.7	267.2	401.3
	Coking Coal	13.0	60.8	113.0	115.0	138.5	169.7

(Source: Prepared by JICA study team based on the “BREE’s list of major minerals and energy projects, April 2012“ of BERR)

Table 6.3-5 Australia’s By-Coal Type Coal Exports Outlook

(million tons)

		2011 Actual	2019/20	2034/35
Exports	Steam Coal	148	241	305
	Coking Coal	133	217	275
		281	458	581

Note: Actual values are based on BERR statistics.

(Source: Prepared by JICA study team)

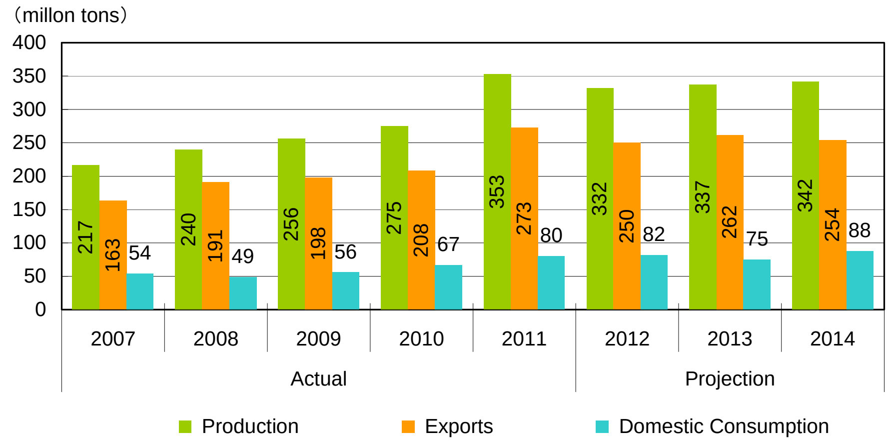
6.3.2 Indonesia

(1) General

According to the presentation[6] made by Mr. Wibowo, Directorate General of Mineral and Coal, the Ministry of Energy and Mineral Resources as shown in Figure 6.3-2, in the medium runs both production volume and export volume of coal fail to maintain such expansion as was achieved before and hit their ceilings. Furthermore, according to the presentation[7] made by Mr. Kamandanu from the Indonesian Coal Mining Association as shown in Figure. 6.3-3, it is expected that, in the long term, coal production will continue to expand. It is, however, assumed that since domestic coal demand is expected to increase, exports will remain in the range from 240 million tons to 260 million tons and fail to maintain such expansion as was achieved before.

Table 6.3-6 shows a compilation[8] of projects for the production increase at existing coal mines and new coal mine development cited in an information magazine[9] between last year and this year, indicating that the supply capacity that can be added between 2012 and 2014 reaches 121 million tons (107 million tons of steam coal and 14 million tons of coking coal). As shown in Figure. 6.3-2, in the medium run, since no increase in coal production is expected between 2011 and 2014, 121 million tons of supply capacity to be added becomes the reserve supply capacity as is. In other words, Indonesia ends up having some 100 million tons-worth reserve coal export capacity.

[6] The "Coal Policy and The New Mining Law No. 4/2009 in Indonesia" at the "Clean Coal Day in Japan 2012 International Symposium" held on September 4 and 5, 2012,
[7] The "Indonesian Coal Mining Outlook" at the IEA workshop "Coal Market's Outlook" held in China on April 14, 2011,
[8] Does not cover all of Indonesia's projects for production increase and new development.
[9] TEX Report (released by The TEX Report Ltd., http://www.texreport.co.jp/xenglish/index.html)

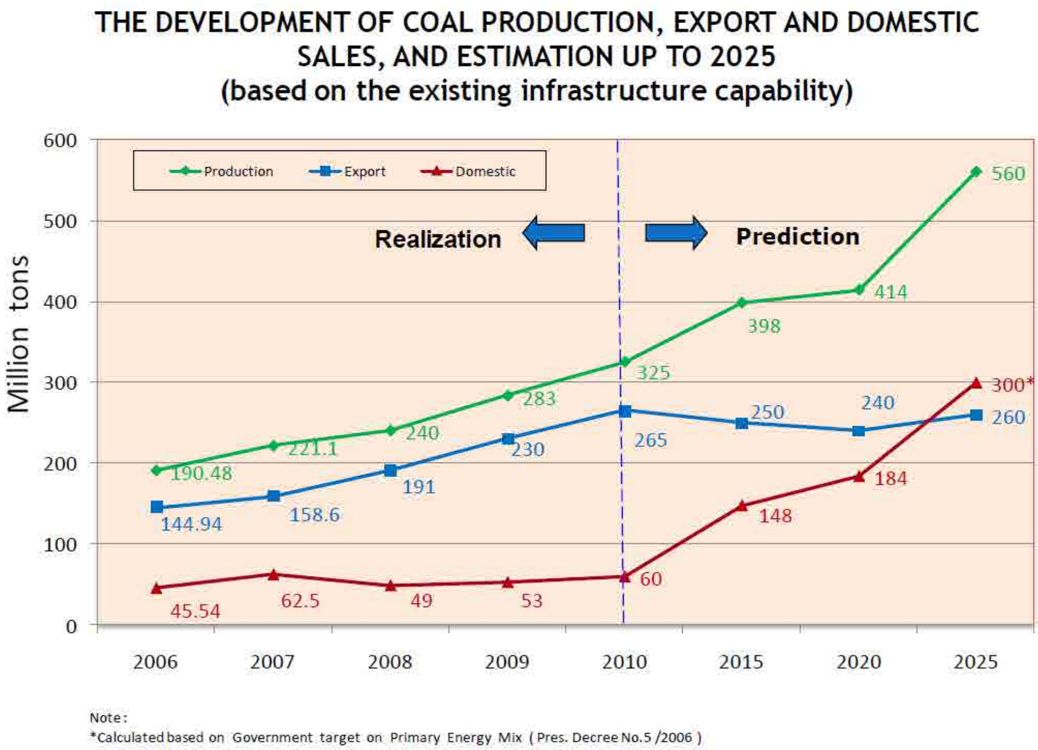


（million tons）

	Actual					Projection		
	2007	2008	2009	2010	2011	2012	2013	2014
Production	217	240	256	275	353	332	337	342
Exports	163	191	198	208	273	250	262	254
Domestic Consumption	54	49	56	67	80	82	75	88

(Source: Prepared by JICA study team based on lecture materials of the “Clean Coal Day in Japan 2012 International Symposium” held on September 4, 2012)

Figure 6.3-2 Indonesian Medium-Term Coal Supply and Demand Outlook



(Source: Lecture materials of IEA workshop “Coal Market’s Outlook” held on April 14, 2011)

Figure 6.3-3 Indonesian Long-Term Coal Supply and Demand Outlook

Table 6.3-6 Indonesia's Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015	2016	2017-
Total		33.8	45.0	42.0	13.5	3.0	6.0
	Steam Coal	29.3	35.5	42.0	0.0	0.0	6.0
	Coking Coal	4.5	9.5	0.0	13.5	3.0	0.0
Cumulative Total		33.8	78.8	120.8	134.3	137.3	143.3
	Steam Coal	29.3	64.8	106.8	106.8	106.8	112.8
	Coking Coal	4.5	14.0	14.0	27.5	30.5	30.5

Note: Does not cover all of Indonesia's projects for production increase at existing coal mines and new coal mine development.

(Source: Prepared by JICA study team)

With regards to the outlook breakdown for coal exports, in Indonesia, the coking coal demand for domestic usage is scarce and it is assumed that the coking coal supply capacity to be added will be all applied to exports. Therefore, although Indonesia exported about 1 to 2 million tons of coking coal in the 2000s[10], it becomes possible to expand this to around 20 million tons in 2015. Assuming that the coking coal supply capacity to be added is entirely applied to exports, the by-coal type outlook for coal exports prepared in line with long-term coal supply and demand outlook (Figure. 6.3-3) will be as shown in Table 6.3-7.

Table 6.3-7 Indonesia's By-Coal Type Coal Exports Outlook

(million tons)

		2011 Actual	2015	2020	2025
Exports	Steam Coal	272	230	220	240
	Coking Coal	1	20	20	20
		273	250	240	260

(Source: Prepared by JICA study team)

(2) Policy challenges

The Indonesian government announced a policy to introduce the DMO[11] to prioritize the domestic supply of coal to cope with the increase of domestic coal demand after 2010 (power generation and cement, 68 million tons in 2009), according to Law No. 4 of 2009 "New Mineral and Coal Mining Law," due to be enacted in late December. The DMO is required to supply coal for the domestic market preference for producers and is intended to prevent an increase in coal export unlimited.

The DMO is expected to decide the domestic coal demand on the basis of the domestic

[10] The "Coal Information 2012" of IEA
[11] Domestic Market obligation

consumer and to allocate to the companies after deciding the minimum percentage of coal production for domestic sales. It is applied to up to 25% from the past as 25% across the board. The DMO is confirmed on a quarterly basis, if the lowest rate of annual sales of domestic coal is not achieved, the production companies will be subject to penalties. In addition, a quota for the domestic market in Indonesia has already mandated a 25% yield to the oil and gas company and DMO is also applied to the coal.

The new Mineral and Coal Law has clearly stated that the adding of value to the mineral resources and low-grade coal export restrictions have emerged as a part of it in the coal fields. This is because the low-grade coal without the coal processing such as the up-grading of its quality should not be exported. Its impact is great for medium and small size mines that have profited by the increasing exports of low-grade coal to China and India. Currently, a critical issue is that the calorific value of low-grade coal is to delineate where the amount of the calorific value, such as 5,100 kcal / kg or 5,500 kcal / kg for example, should be. Meanwhile, despite the details of the coal processing technologies to add value being unknown, whether improved coal technologies are going well in the commercial base is hard to say under the current situation. How this is embodied in this bill has been under question.

Even if the technologies to upgrade low-grade coal will be commercialized in the future, as for the coal, the supply problem does not occur as far as there are resources of the low-grade coal and it becomes the competition with other countries by the calorie price of coal. The issues will become high in fuel cost, but, according to our provisional calculations, the increase of fuel cost becomes approximately within 10% adding increase of fuel efficiency.

(3) Illegal mine

There are many illegal mines in Kalimantan and Sumatra island. An illegal mine has many environmental disruption and non-safe acts. The Indonesian government strengthens the control, too. It is a problem that there is a buyer buying coal from an illegal mine due to cheap coal price. An item forbidding the coal acquisition from an illegal mine is necessary for a purchase contract of the coal to follow it and to prevent this.

6.3.3 South Africa

Regarding South Africa and Mozambique describing later, nothing like the above-given coal supply-demand outlook released such as by a government agency is available but the coal supply capacity that can be added is identified from the projects for production increase at existing coal mines and the new coal mine development contained in an information magazine to infer the volume of coal that can be exported.

First, with regards to South Africa, a compilation[12] of 6 new coal mine development projects placed in an information magazine[13] between last year and this year is shown in Table 6.3-8. During and after 2012, the supply capacity that can be added by 2015 is 36 million tons (18 million tons of steam coal and 18 million tons of coking coal). Since the coal production in 2011 is 253 million tons[14], the supply capacity expands to as much as about 290 million tons in 2015, assuming that the production will not drop due to coal mine closure etc. As for the added coal supply capacity, it is assumed that the coking coal will be entirely applied to exports and, 80% of the steam coal will be applied to the exports. However, the steam coal supply capacity of 10 million tons to be added in 2014 is excluded because it is for domestic use. Table 6.3-9 shows the coal export volume outlook based on this assumption.

Table 6.3-8 South Africa's Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015
Total		0.8	6.2	12.1	0.0
	Steam Coal	0.8	5.2	12.1	0.0
	Coking Coal	0.0	1.0	0.0	0.0
Cumulative Total		0.8	6.9	19.0	19.0
	Steam Coal	0.8	5.9	18.0	18.0
	Coking Coal	0.0	1.0	1.0	1.0

Note: Does not cover all of South Africa's projects for production increase at existing coal mines and new coal mine development.
(Source: Prepared by JICA study team)

Table 6.3-9 South Africa's By-Coal Type Coal Exports Outlook

(million tons)

		Actual					Projection			
		2007	2008	2009	2010	2011*	2012	2013	2014	2015
Exports	Steam Coal	66.1	56.6	51.4	65.6	71.6	72.2	76.3	78.0	78.0
	Coking Coal	0.9	1.3	0.6	0.8	0.2	0.2	1.2	1.2	1.2
		67.0	57.9	52.0	66.4	71.7	72.3	77.4	79.1	79.1

Note: Actual values are based on "Coal Information 2012" of IEA and 2011 values are prospective.
(Source: Prepared by JICA study team)

6.3.4 Mozambique

As for Mozambique, a compilation[15] of 5 new coal mine development projects placed in an information magazine[16] between last year and this year is shown in Table 6.3-10. The supply capacity that can be added between 2012 and 2015 is 44 million tons (14 million tons of steam

[12] Does not cover all of South Africa's projects for production increase and new development.
[13] TEX Report (released by The TEX Report Ltd.)
[14] The "Coal Information 2012"of IEA
[15] Does not cover all of Mozambique's projects for production increase and new development.
[16] TEX Report (released by The TEX Report Ltd.)

coal and 30 million tons of coking coal). Since, according to the “Coal Information 2012” released by IEA, the coal production in 2011 is below 0.1 million tons, the supply capacity of 44 million tons that can be added by 2015 remains as is the amount that can be produced. Assuming that the added coal supply capacity will be entirely applied to coking coal and 70% of steam coal will be applied to exports, the coal exports outlook will be as shown in Table 6.3-11.

Table 6.3-10 Mozambique’s Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015
Total		6.3	10.5	17.4	9.6
	Steam Coal	1.9	3.1	3.4	5.2
	Coking Coal	4.3	7.5	13.9	4.4
Cumulative Total		6.3	16.8	34.1	43.7
	Steam Coal	1.9	5.0	8.4	13.6
	Coking Coal	4.3	11.8	25.7	30.1

Note: Does not cover all of Mozambique’s projects for production increase at existing coal mines and new coal mine development.

(Source: Prepared by JICA study team)

Table 6.3-11 Mozambique’s By-Coal Type Coal Exports Outlook

(million tons)

		Actual					Projection			
		2007	2008	2009	2010	2011*	2012	2013	2014	2015
Exports	Steam Coal	0.02	0.03	0.03	0.03	0.01	1.3	3.5	5.9	9.5
	Coking Coal	0.00	0.00	0.00	0.00	0.00	4.3	11.8	25.7	30.1
		0.02	0.03	0.03	0.03	0.01	5.7	15.3	31.6	39.7

Note: Actual values are based on the “Coal Information 2012” of IEA and 2011 values are prospective.
(Source: Prepared by JICA study team)

6.4 Coal Supply Plan to Matarbari CFPP

6.4.1 The calorific value of import coal and summary of imported coal

(1) Determination of the calorific value

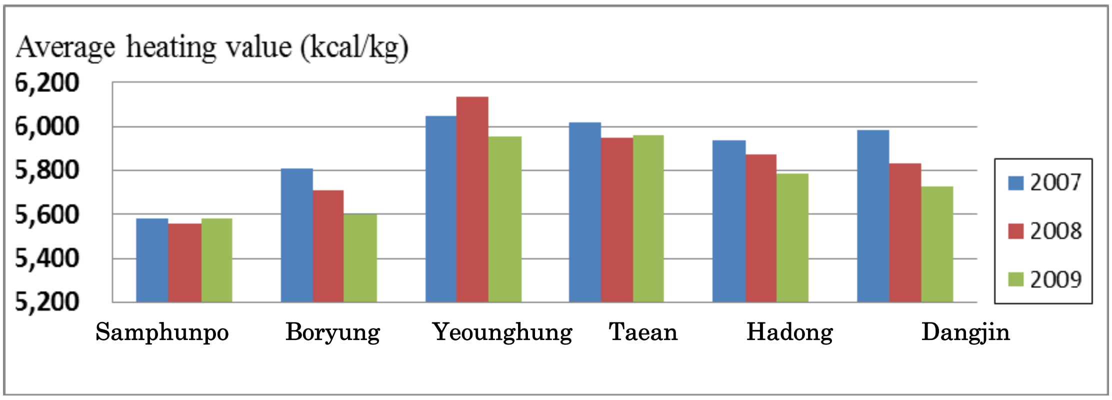
When the calorific value of coal imported by Bangladesh is considered from the viewpoint of the importation of coal available in terms of future stability, the circumstances described below are examined.

- An extra 6,000 kcal/kg for the average demand has already been decided in developed countries and it is difficult to import this high calorie coal to the new market of Bangladesh.
- In terms of the boiler design, to use the higher calorific value becomes a smaller investment amount and better efficient combustion but when calorific value is below the design specifications of the imported coal from the supply problems in the future, it will cause significant operational problems. It is often seen in cases of new power plants in

developing countries. Conversely, if the calorific value is greater than the design specifications, it is a minor problem.

- As an example of the current power plant in Korea in Figure. 6.4-1, the existing power station also tends to degrade the calorific value of coal in terms of securing a stable supply of coal.

From the above situation, the information of Japanese trading companies and the site investigations conducted in Indonesia and Australia, the range and amount of heat from 4,200 kcal/kg to 5,200 kcal/kg and the average calorific value of 4,700 kcal/kg of imported coal is reasonable and determined. It has been confirmed that the quantity of coal in this calorific value necessary for 600Mw x two units is sufficient for long-term stable supply through an investigation as from 3.5 to 4 million tons. In addition, more information about the details of the design coal is described later.



(Source: JICA study team)

Figure 6.4-1 Actual Use of Low-grade Coal at Coal-fired Power Stations in South Korea

(2) Summary of import coal

As a result of this study, Indonesia will be main country of import coal for Matarbari CFPP and 70% of the entire amount of import coal will be from Indonesia. And the rest will be imported from Australia. South Africa and Mozambique will be in addition to Australia in the future. The summary of these coals is as followings.

1) Indonesian coal

- Though Indonesian coal has normally low ash content at around 2% -15%, the range of the total moisture is wide at around 11% - 40%.
- There is much coal with a sulfur content of less than 1%, but, sometimes, there may be much available coal of high calorific value with high sulfur levels.
- In general, the high moisture coal can easily self-ignite. The examination of spontaneous combustion and the adjustment of the coal reserve period in the coal stock pile are

necessary.

- Due to insufficient quality controls at some coal mines, special attention is particularly necessary for the coal from coal mines of small and medium size scale.

2) Australian coal

- Generally, Australian coal has a stable coal quality, and their coal quality control management is thorough.
- Australian coal is available for blend use with Indonesian low grade coal, when high quality coal of Australian coal appears in spot market.
-

3) South African and Mozambican coal

- South African coal is high-grade coal and can be used for blends like Australian coal.
- The Mozambican coal will be expected in the near future, too, but the economic infrastructure situation involving such factors as the port facilities and transportation becomes a problem.

6.4.2 Coal quality of design coal

(1) Candidate for design coal

Based on a determination of the calorific value of imported coal in 6.4.1, the main factor of coal quality of the candidate for design coal that can be supplied stably for the long term in Matarbari CFPP is shown in Table 6.4-1. The coal data painted in blue shows for single brand and coal data painted in yellow shows for blending use in the table.

Table 6.4-1 Candidate for Design Coal

No	Country	Sample No.	total moisture (AR)	Inherent moisture (AD)	Ash (AD)	Sulfur (AD)	GAR (Kcal/kg)
1	South Africa	18	9.0	4.1	15.6	0.82	6,010
2	Indonesia	9	19.0	11.5	8.0	1.00	5,860
3	Australia	13	12.5	7.0	11.5	0.40	5,830
4	Australia	16	17.0	8.0	9.5	0.60	5,800
5	Australia	15	10.5	3.5	21.0	1.00	5,750
6	Indonesia	8	19.0	14.0	5.2	1.60	5,630
7	Australia	14	10.0	2.5	22.0	0.60	5,630
8	South Africa	19	8.0	3.5	23.1	0.74	5,400
9	Indonesia	10	26.0	15.5	7.0	1.00	5,200
10	Indonesia	1	26.0	12.0	6.0	0.60	5,100
11	Indonesia	6	26.0	18.0	4.5	0.99	4,960
12	Indonesia	4	31.0	16.0	6.0	1.00	4,600
13	Indonesia	11	35.0	15.0	6.0	0.80	4,440
14	Indonesia	2	38.0	25.0	7.0	0.60	4,200
15	Indonesia	5	35.0	22.0	4.5	0.10	4,200
16	Indonesia	25	35.0	22.0	3.5	0.10	4,200
17	Indonesia	26	35.0	21.0	4.0	0.15	4,200
18	Indonesia	28	34.0	18.4	7.0	0.60	4,140
19	Indonesia	24	38.0	25.0	3.0	0.15	4,100
20	Indonesia	3	40.0	27.0	2.0	0.15	4,000
21	Indonesia	12	39.0	14.1	4.9	0.13	3,800

(Source: JICA study team)

(2) Summary of single brand

The summary of single brand that is used as only one brand of coal for Matarbari CFPP is shown in table 6.4-2.

Table 6.4-2 Summary of Single Brand

Country	Total moisture (Ar.%)	Inherent moisture (Ad.%)	Ash (Ad.%)	Sulfur (Ad.%)	GAR (Ar.%)
Indonesia	26.0 - 38	12 - 25	3.5 – 7.0	0.1 – 1.0	4,200-5,200

(Source: JICA study team)

(3) Summary of blending coal

When securing of coal of single brand is difficult, use of blending coal is necessary for stabilization of the fueling, the efficiency driving of the boiler, reduction of the fuel cost. In the blend coal, a combination of Australian and South African high calorific coal and Indonesian low calorific coal is examined. They show the coal painted by yellow color in Table 6.4-1. In this case, the calorific value after the blend aims 4,900kcal/kg from 4,500kcal/kg in consideration of fluctuation of the coal quality and Table 6.4-3 shows coal quality of blending coal.

Table 6.4-3 Summary of Blending Coal

Country	Total moisture (Ar.%)	Inherent moisture (Ad.%)	Ash (Ad.%)	Sulfur (Ad.%)	GAR (Ar.%)
Indonesia Australia South Africa	18.3 – 33.7	10.2 – 23.1	3.0 – 15.1	0.23 – 1.0	4,500-4,900

(Source: JICA study team)

6.4.3 Investigation of coal suppliers

The site investigation results of the extracted coal mines in Australia and Indonesia as the main coal supplier from the candidate coal described in the foregoing paragraph is as follows.

(1) Australia

Two coal mines, Moolarben coal mine, Tarrawonga coal mine in NSW and two Newcastle coal loading ports were investigated. The coal mines mentioned above are explained in this clause.

1) MOOLARBEN coal mine

a) General

- Moolarben coal mine located approximately 40km in the north of Mudgee in the western coalfields of NSW.
- They are mining via an open cut mining method at present and now planning to implement an underground mining method in the future.
- All of the produced coal is to be exported and transported by rail to New Castle.

b) Geological condition & recourses

- Coal seam is Ulan seam and thickness is 6 to 13 m.
- The minable coal seam is divided by a rock band called the C-marker, upper seam and bottom seam. The upper seam, 6 to 7 meters is mined via an open cut mining method and the bottom seam, 5 to 6 meters will be mined via an underground mining method in 2014.
- All ROM[17] is washed and the ash content is about 15%.

[17] ROM (Run Of Mine) means raw coal that is mined at site without coal preparation process.

- Minable coal recourses are predicted to be 1,180 million tons .
- Mining cost is cheap due to a low stripping ratio, average stripping ratio; 1:2.2, present stripping ratio; 1:3.6.
- Though the stripping ratio is low, the reason why the bottom seam will be mined using the underground mining method is to be in adherence to the mining approval concerning the environmental impact.

c) Coal preparation plant and coal quality

- Through the put capacity of the coal preparation plant is 1,800t/h using the 1st step and 2nd step process via the Heavy Medium Cyclone, Spiral Concentrator and Flotation. The ash content of the washed coal is 15% and the middling coal is 20% and both coals are blended per customer specifications.
- The capacity is decreased by the volume of the reject in ROM and it was around 800t/h as the oxidation coal was treated at the time of our investigation.
- There were no problems with the quality control at the coal preparation plant.

d) Production capacity

- The Max. production plan is Open cut: 12 million tons per year and Underground: 4.3 million tons per year.

Table 6.4-4 Production of the Moolarben Coal Mine

Projection Summary					
Year	Waste	ROM Coal(t)	SR[18]	Saleable	Recovery
CY2009	899,142				
CY2010	9,272,911	4,906,537	1.89	3,377,368	68.8%
CY2011	15,450,282	7,007,334	2.20	5,011,087	70.4%
CY2012	12,277,292	5,583,666	2.20	3,851,932	70.0%
Project to Date	37,899,627	17,497,537	2.17	12,240,387	70.0%

(Source: Moolarben coal mine)

e) Loading port

The coal of the Moolarben coal mine is exported via NCIG (Newcastle Coal International Group) and PWCS (Port Waratah Coal Services Limited). Both the loading ports have come together to now become the main port.

f) Contract term

[18] SR: Stripping Ratio

The main role of the Japanese business firm here is the introduction of a buyer. A coal procurement contract requires around 12 months because the time requirements may not be able to be met due to the coal sale authorization, arrangement of transportation, the loading and so on.

2) TARRAWONGA coal mine (Whiteheven Coal)

a) General

- Whiteheven Coal company founded in 1999 is a coal producer and located in the northwest of the Gunnedah Basin of New South Wales.
- This company operates four open cut coal mines in this area, Rocglen, Sunnyside. Tarrawonga and Narrabri. Tarrawonga coal mine was investigated at this time.
- Total minable coal resources is 1,771million tons and the marketable coal resources are 426 million tons.
- The stripping ratio of Tarrawonga is high at around 10:1, but other coal mines are from 4:1 to 6:1
- Whiteheven Coal company owns about 427km2 in Gunnedah, Werris, and Ashford coal basin of New South Wales.

b) Tarrawonga coal mine

- Coal production starts from September, 2006. 85% of the coal is semi-soft for coke and the remaining is for steaming coal. The yield of salable clean coal is 95%
- The volume of the coal shipment is 2.6 million tons and the number of employees were approximately 250 people in 2009.
- Whiteheven Coal has an 11% right of NCIG for the present development of a new coal export terminal in New Castle.

c) Geological condition & recourses

- Total coal resources are 89.7 million tons for open cut and 39.5 million tons for the underground mining method.
- The life of the mine will be 20 years.
- The 1:10 stripping ratio is high, but good coal quality of covers 95% of the production and transportation costs.

d) Coal quality control

- ROM from Rocglen, Sunnysde and Tarrawaonga coal mine is treated by a central coal preparation plant with 500t/h having Heavy Dense Medium Cyclone of 1.2m dia. and a Spiral Concentrator. The clean coal ash content is 5.5 % and 12.5 % and 6,800 kcal/kg and 6,200 kcal/kg respectively. The salable coal is blended with ROM and supplied to the market in accordance with customer specifications.

- The ash content of ROM is 22 % and 5,100 kcal/kg, the ROM can be used for Matarbari CFPP directly if available.
- The distances between each coal mine and the preparation plant are 34km, 15km, 45km respectively.

e) Loading port

Whiteheven Coal company holds 11% share of NCIG in New Castle port and is transporting their coal to NCIG by train of 75t x 82wagons taking 8 to 10 hours.

f) Contract term

Same as MOOLARBEN coal mine

(2) Indonesia

The coal mines that have been investigated are KIDECO and BRAU at east Kalimantan as a major Indonesian big coal mine and MME at Sumatra as a typical new middle class coal mine.

1) KIDECO Coal Mine (Pt. Kideco Jaya Agung)

a) General

- KIDECO was established in 1982. The coal production was 35million tons in 2010 and accumulating total production is 200 million tons.
- Coal Contract of Work (CCoW)

  Parties: Between Kideco and Indonesian government in 1982

  Period: 30 years from commercial production (1993 – 2023)

  Royalty: 13.5% of FOB sales amount

  Corporate Tax: 45% of the profit
- KIDECO supplies coal to 16 countries including Indonesia, India, China, Japan and Korea. The main export country is China: 40%, India: 30% followed by Japan, Korea, the Philippines and Thailand.
- Coal resources are 1,376million tons and coal reserves are 651 million tons.

b) Feature of KIDECO coal

- KIDECO coal has around 2.5%, of ash and 0.1% sulfur content is lower than other bituminous coal and the KIDECO coal attracts attention as an eco-friendly energy source. Production levels are shown in the following table.

Table 6.4-5 The Production of Each Pit of KIDECO Coal Mine

Name of pit	Production (million t)	CV(kcal/kg) (GAR)	Stripping ratio	Commence production	Recourses (million t)
Roto-North	2.5	5,400	7.0:1	1993	20.2
Roto-Middle	3.0	4,300		2004	38.4
Roto-South	16.0	4,900	7.2:1	1997	189.2
SM	9.0	4,200	4.3:1	2008	342.1
SSB	0.8			2009	190.0
Total	31.0				

(Source: KIDECO)

- The typical coal quality is shown in the following table.

Table 6.4-6 Coal Quality

Parameter	Roto	SM
Total Moisture (ARB)	27%	35%
Volatile Matter (AD)	42%	40%
Ash (AD)	2.5%	3.5%
Total Sulfur (AD)	0.1%	0.1%
Nitrogen	0.8%	0.8%
Calorific value (GAR)	4800kcal/kg	4200kcal/kg

(Source: KIDECO)

c) Coal transportation

[TMCA] (Barge Loading Terminal)

- The coal is carried with a trailer to TCMA where the coal is transported by three Loading facilities (conveyer type). The capacity of the barge is 12,000 and 8,000 DWT and the capacity of the stock pile of TMCA is 700,000tM.
- The bunkering facility to a barge is 90,000t/Day, ability of 32Mt/year.
- Coal is carried by a barge to the Gulf of Adang which is 58km away from the bunkering facility (TMCA) of KIDECO for 7-8 hours.

[The Gulf of Adang]

- Floating Loading Facility(FLF) ×2 units： 30,000 t/Day
- Conventional Floating Crane(FC)×2units：12,000 t/Day
- In the Gulf of Adang, the size of the ship for the loading from a barge is possible from 100,000 to 150,000 DWT and the Panamax and Capesize of the ship are acceptable.

d) Contract term

- Approximately one year before is desirable for starting the prior negotiations for the contract. And term of a contract is usually around three years from one year.

e) Others

Given their spontaneous combustion characteristics, it is said that KIDECO coal may catch fire within 1.5 months in the coal stock yard.

2) BERAU Coal Mine

a) General

- The Berau coal mine started production from 1994.
- Mining license area is 1,200 km^2 and the coal mine is located in the northern part of east Kalimantan Island and approximately 300km of Samarinda of the state capital.
- Kelai area has the coal seam of 2-6m in thickness extends to approximately 10km, and the estimated deposits to be 1billion t.
- The annual production of Berau coal was 20 million tons in 2011.
- Coal resources are 1,291 million tons and coal reserves are 476 million tons

b) Coal quality and production

The typical coal quality of Berau coal was shown in the following table.

Table 6.4-7 Coal Quality and Production

Parameter	Lati	Binuang Blok 5 & 6	Binuang Blok 7	Sambarata Blok A	Birang
Calorifi Value (ad) (kcal/kg)	5,400	5,900	5,559	6,000	5,550
Total Sulfur (ad) (%)	1	0.6	0.7	0.7	0.99
Ash Content (ad) (%)	5	5	4.3	5	4.43
Total Moisture (ar) (%)	26	18	22.5	15	18

(Source: Berau coal mine)

Within five years, the Berau coal mine is planning to increase the total amount of production to 30 million tons from the 2010 17 million ton level.

c) Coal transportation

[Coal Crushing Plant to barge loading base]

- There is a stock pile in Sambarata (80,000t), Lati (75,000t), Swaran (20,000), each coal mine, and the loading to the barge is loaded by a belt conveyor.
- Conveyer capacity is 5,000t/h and 60,000t/day, the barge capacity is 5,000t to 7,500t
- The distance from the loading place to the offshore loading place of Muara Pantai is from 50 km to 98km.

[The offshore loading place]

- The coal from the three coal mines is carried by a barge to the offshore loading place and it is loaded from the offing onto a ship by the offshore Loading facilities.
- To the offshore loading place with the barge, it takes approximately 18-36 hours of transportation time.
- The loading method of the coal is loaded with the crane of the ship directly by a barge. Loading ability: 12,000t/day

d) Contract term

- It is desirable before one year at the latest to carry out the prior consultation of the contract negotiation. And term of a contract is usually around three years from one year.

e) Others

Spontaneous combustion is a main issue.

3) MME Coal mine (Manabang Muara Enim)

a) General

There is an MME coal mine in the place taking around five hours by car from Palembang and MME is next to the Tanjung Enim coal mine of PTBA . It started operations in 2010. An employee of the MME company is about 100 people and the contractor is 200 people. The coal outport is Lampung.

b) Coal quality and production

The minable coal resources are 140 million tons and the mining costs are significantly low due to the low stripping ratio, such as 1:3. The coal mine will be promising in the future. The following tables show the coal quality and the amount of production.

Table 6.4-8 Coal Quality

Parameter		Av. of Seam A to F
Total Moisture (AR)		30.3 %
Volatile Matter (AD)		38.0 %
Ash (AD)		9.0 %
Total Sulfur (D)		0.8
Calorific value	(AD)	5,800 kcal/kg
	(GAR)	4,750 kcal/kg
	(NAR)	4,350 kcal/kg

(Source: MME coal mine)

Table 6.4-9 Actual and Planned Production (1,000t)

2010 (Actual)	2012 (Actual)	2012 (Forecast)	2012 (Forecast)	2012 (Forecast)
260	850	1,500	2,500	3,500

(Source: MME coal mine)

c) Coal transportation

The MME coal is transported to the new jetty called Bangka Strait by a truck on the coal transportation road inaugurated newly from the MME coal mine. The Bangka Strait has a loading rate of 8,000t/d. The coal is carried by a barge to B. Panjang Port at Lampung.

d) Contract condition

60% has been contracted in 2012 and the remainder has been handled with a spot contract. There it is assumed that cash payment will be given in advance, but LC is possible for certain select customers.

e) Contract term

It is desirable before one year at the latest to carry out the prior consultation of the contract negotiation. In the case of long-term contract, particularly, It will be required to discuss it as possible early. Term of a contract is usually three years from one year, but the longer contract is possible

f) Others

Although the MME Coal mine is a new middle scale coal mine, the coal mine is promising from the perspective of stable production per the long term contract because the economic infrastructure is satisfied, the mining conditions are very good and the mining plan is strong and reliable.

6.4.4 Coal price

(1) Coal price index and forecast of IEA

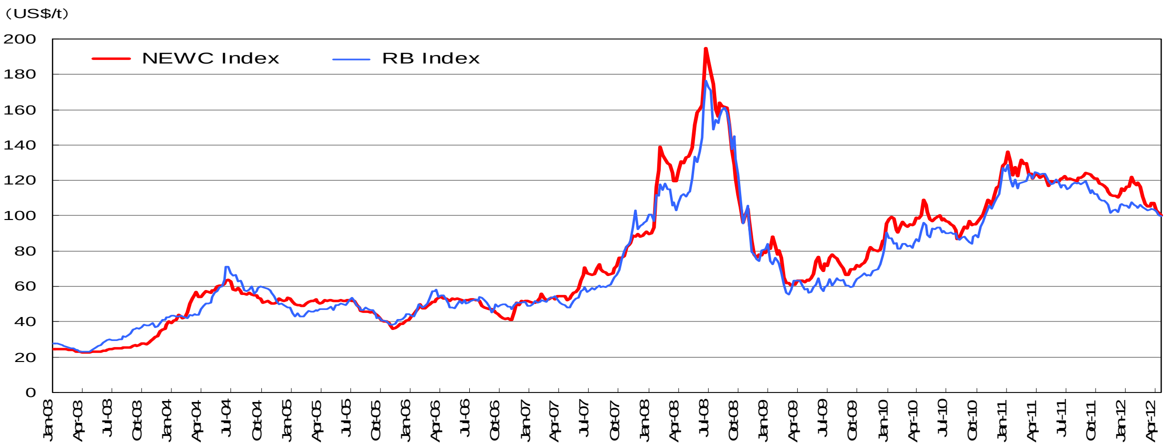
1) Coal price index

The present major price index of steam coal is shown as follows. For reference, the transitions of the NEWC (Newcastle) Index and RB (Richard Bay) Index of globalCOAL[19] are shown in Figure 6.4-3.

- NEWC Index (FOB price of steam coal shipped from Newcastle Port, Australia) : globalCOAL

[19] globalCOAL is one of online coal trading platform and providing the information of coal price as NEWC Index and RB Index. https://www.globalcoal.com/

- RB Index (FOB price of steam coal shipped from Richards Bay Port, South Africa) : globalCOAL
- API4 (FOB price of steam coal shipped from Richards Bay Port, South Africa) : Argus/McCloskey
- API6 (FOB price of steam coal shipped from Newcastle Port, Australia) : Argus/McCloskey
- NEX Spot Index (FOB price of steam coal shipped from Newcastle Port, Australia) : Energy Publishing Inc



(Source: Prepared by JICA study team based on the data contained in the Web site of global COAL)

Figure 6.4-2 NEWC Index and RB Index of Global COAL

2) The IEA Forecast

The long-term coal price scenario of IEA in the World Energy Outlook 2011 stated that the current policy scenario assumes a 110 US$/ton of coal import price of the OECD. Moreover, the long-term coal price forecast of financial institutions are assumed to be approximately 80 to 100 US$/ton units in general.

Table 6.4-10 Long-term Coal Price Scenario for OECD Countries

【OECD steam coal import price】

Real terms (2010 prices) ($/t)

	Current Policies Scenario					New Policies Scenario				
2010	2015	2020	2025	2030	2035	2015	2020	2025	2030	2035
99.2	104.6	109.0	112.8	115.9	118.4	103.7	106.3	108.1	109.3	110.0

Source：IEA “World Energy Outlook 2011”

Looking at price trends over the past 10 years in Figure. 6.4-3, the above price forecasts of the IEA are fairly inexpensive. Considering the needs of the low-grade coal in countries other than OECD, the forecast of the IEA coal price seems to be risky because the coal market, especially in South Asia is presumed to experience rapid coal demand growth in the future.

The Survey team conducted price forecasts in accordance with the following method.

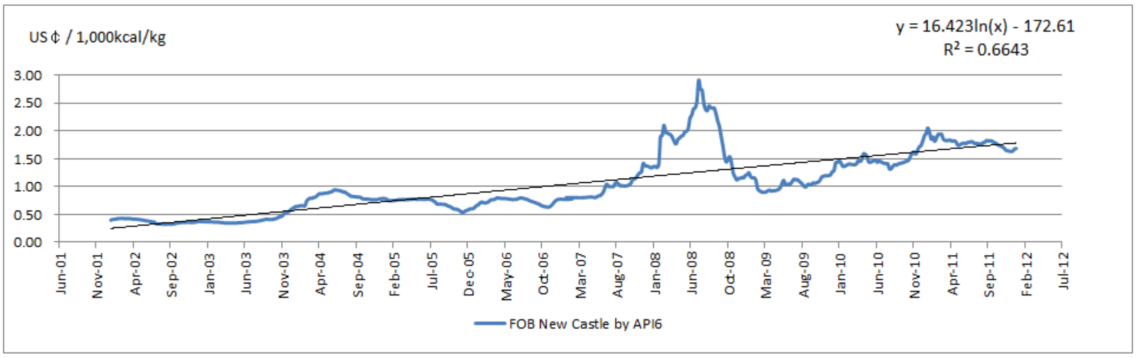
(2) Methodology of Imported Coal Price Forecasts

Methodology of imported coal price forecasts is as follows, a prediction of the FOB Price until 2030

(i) The FOB coal price prediction per 1,000 kcal/kg in 2030 based on actual data for the past 10years of the FOB coal price per 1,000 kcal/kg at the Port of Newcastle in Australia is as shown in Figure. 6.4-4. The calorific value is 6,350kcal/kg in the FOB coal price in these figures.

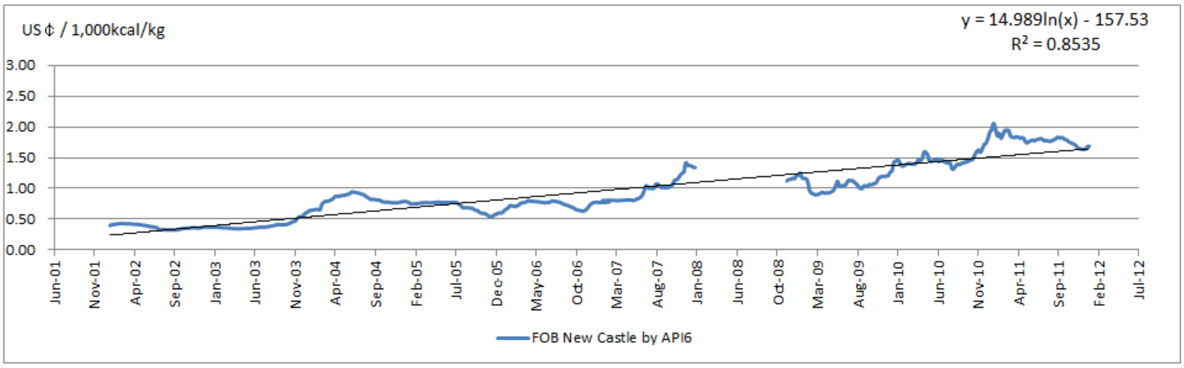
(ii) Examination of correlation per the change of the price index in US¢/1,000 kcal/kg. The rapid rise in price data that appeared from January to October 2008 in the FOB price of the trends in Figure 6-18 is considered inappropriate in order to conduct predictions for 2030 and Figure. 6.4-5 shows the data excluding this period and obtained a correlation curve.

(iii) It is found that the coal unit price per calorific value also changes per the calorific value of the coal from the Indonesian data shown in Figure. 6.4-6 and Figure. 6.4-7. Therefore, the unit price of low grade coal, 4,700kcal/kg is to be 85% of the price index of Port of Newcastle in Figure. 6.4-5. Moreover, they are assumed to b a high case and assumed that the coal unit price reduced to 85% more as a low case.



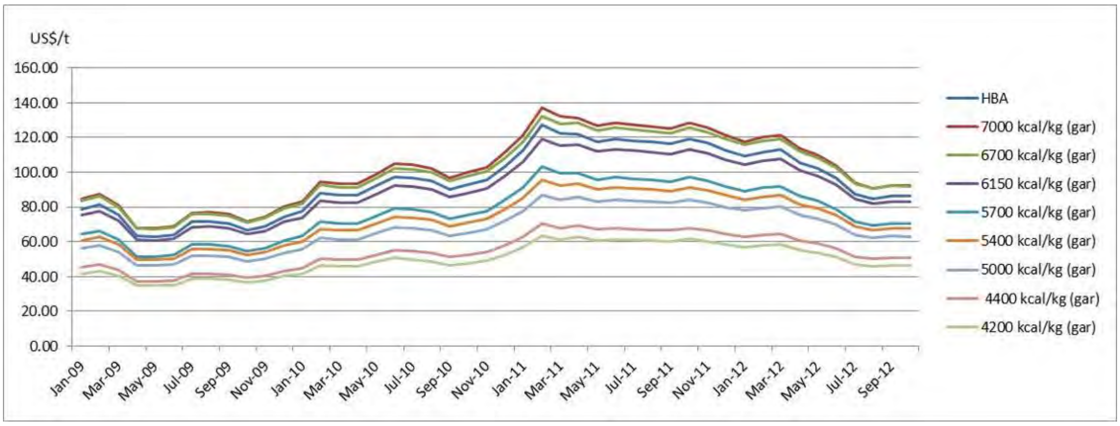
(Source: The Survey team based on Argus/McCloskey's Coal Price Index report API6)

Figure 6.4-3 FOB Price Fluctuations and Correlation Curve per 1,000 kcal / kg at Port of Newcastle in Australia



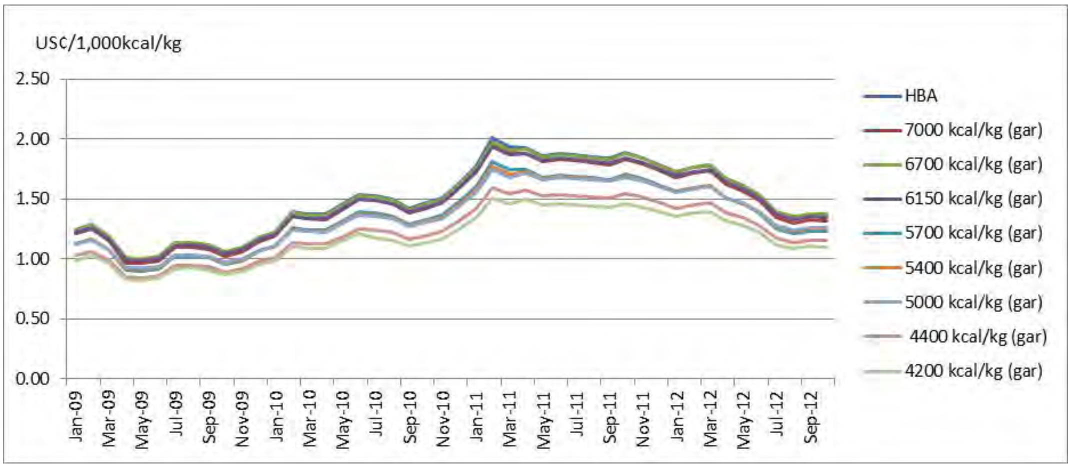
(Source: The Survey team based on Argus/McCloskey's Coal Price Index report API6)

Figure 6.4-4 Correlation Curve Excluded the Data of Jan. to Oct. 2008 in Figure 6.4-4



(Source: The Survey team based on Indonesian Coal Index Report)

Figure 6.4-5 Change of the FOB Price according to the Calorific Value of Indonesian Coal

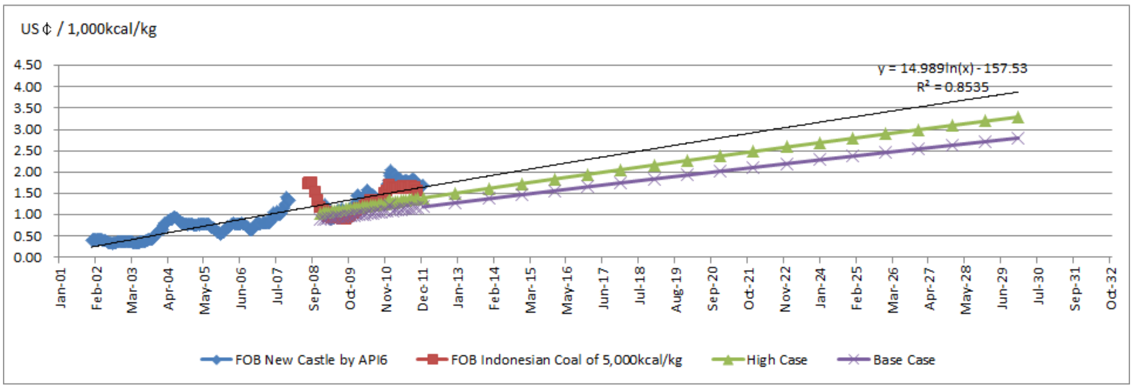


(Source: The Survey team based on Indonesian Coal Index Report)

Figure 6.4-6 Change of the FOB Unit Price per 1,000kacal/kg According to the Calorific Value of Indonesian Coal

(3) Prediction of FOB Price per 1,000 kcal / kg until 2030

Figure. 6.4-8 shows the forecast of the unit price of coal per 1,000kcal/kg with the High Case and Base Case of the low grade coal.



Source: The Survey team based on Argus/McCloskey's Coal Price Index report API6

Figure 6.4-7 The Expected Comparison between the High Case and Based Case on the FOB Coal Unit Price per 1,000kcal/kg of Low Grade Coal Based on the Australia New Castle Port FOB Price

(4) Coal price of FOB and CIF

1) FOB price of high grade coal and low grade coal

Based on the before-mentioned coal unit price, expected the FOB price of Australia as high grade coal and Indonesian coal as low grade coal are shown in Table 6.4-8.

Table 6.4-11 FOB Price Forecast of 6,300kcal/kg & 4,700 kcal/kg

Year	US￠/1,000kcal/kg for high grade coal		US$/t at 6300kcal/kg		US￠/1,000kcal/kg for low grade coal		US$/t at 4,700kcal/kg	
2012	1.64	1.39	103.3	87.8	1.39	1.18	65.5	55.7
2013	1.77	1.51	111.7	95.0	1.51	1.28	70.8	60.2
2014	1.91	1.62	120.0	102.0	1.62	1.38	76.1	64.7
2015	2.04	1.73	128.3	109.0	1.73	1.47	81.3	69.1
2016	2.17	1.84	136.4	116.0	1.84	1.56	86.5	73.5
2017	2.29	1.95	144.6	122.9	1.95	1.66	91.7	77.9
2018	2.42	2.06	152.6	129.7	2.06	1.75	96.8	82.2
2019	2.55	2.17	160.6	136.5	2.17	1.84	101.8	86.5
2020	2.67	2.27	168.5	143.2	2.27	1.93	106.8	90.8
2021	2.80	2.38	176.3	149.9	2.38	2.02	111.8	95.0
2022	2.92	2.48	184.1	156.5	2.48	2.11	116.7	99.2
2023	3.04	2.59	191.8	163.0	2.59	2.20	121.6	103.4
2024	3.17	2.69	199.4	169.5	2.69	2.29	126.5	107.5
2025	3.29	2.79	207.0	176.0	2.79	2.37	131.3	111.6
2026	3.41	2.89	214.5	182.4	2.89	2.46	136.0	115.6
2027	3.52	3.00	222.0	188.7	3.00	2.55	140.8	119.7
2028	3.64	3.10	229.4	195.0	3.10	2.63	145.5	123.6
2029	3.76	3.19	236.8	201.2	3.19	2.72	150.1	127.6
2030	3.87	3.29	244.0	207.4	3.29	2.80	154.8	131.5

Note (1): =(14.989ln(x)−157.53)
Note (2): =(14.989ln(x)−157.53) x 0.85
Note (3): =(14.989ln(x)−157.53) x 0.85
Note (4): =(14.989ln(x)−157.53) x 0.85 x 0.85

(Source: The Survey team)

2) Total price of import coal

Table 6.4-12 shows the total price of Australian import coal and Table 6.4-13 shows the total price of Indonesian coal. Case A includes the handling cost to unload at Matarbari CFPP and Case B shows the case of a no charge on the handling cost at Matarbari CFPP.

Table 6.4-12 Coal Price of Australian Coal to Matarbari CFPP (US$/t)

Year	FOB Price (6,300kcal/kg)		Freight & Insurance (80,000t class)		Case A			Case B		
					(A) Handling Cost	(A) G. Total of Coal Price at Chittagong CFTPP		(B) Handling Cost	(B) Grand Total of Coal Price at Chittagong CFTPP	
	H. Case	B. Case	H. Case	B. Case		H. Case	B. Case		H. Case	B. Case
2012	103.3	87.8	17.8	15.1	13.5	134.6	116.4	0.0	121.1	102.9
2013	111.7	95.0	18.8	15.9	14.3	144.8	125.2	0.0	130.5	110.9
2014	120.0	102.0	19.6	16.7	15.1	154.8	133.9	0.0	139.6	118.7
2015	128.3	109.0	21.0	17.5	16.1	165.3	142.5	0.0	149.2	126.5
2016	136.4	116.0	21.4	18.2	17.0	174.8	151.2	0.0	157.8	134.2
2017	144.6	122.9	22.3	18.8	18.0	184.9	159.7	0.0	166.9	141.7
2018	152.6	129.7	23.1	19.6	19.1	194.8	168.4	0.0	175.7	149.3
2019	160.6	136.5	23.9	20.4	20.3	204.7	177.1	0.0	184.4	156.8
2020	168.5	143.2	24.7	20.9	21.5	214.6	185.6	0.0	193.1	164.1
2021	176.3	149.9	25.4	21.5	22.8	224.5	194.2	0.0	201.7	171.4
2022	184.1	156.5	26.2	22.3	24.1	234.4	202.9	0.0	210.3	178.8
2023	191.8	163.0	27.0	22.9	25.6	244.4	211.5	0.0	218.8	185.9
2024	199.4	169.5	27.8	23.5	27.1	254.3	220.1	0.0	227.2	193.0
2025	207.0	176.0	28.3	24.1	28.8	264.1	228.8	0.0	235.4	200.0
2026	214.5	182.4	29.1	24.8	30.5	274.1	237.7	0.0	243.7	207.2
2027	222.0	188.7	29.9	25.4	32.3	284.2	246.4	0.0	251.9	214.1
2028	229.4	195.0	30.5	26.0	34.3	294.1	255.2	0.0	259.9	221.0
2029	236.8	201.2	31.3	26.6	36.3	304.3	264.1	0.0	268.0	227.8
2030	244.0	207.4	31.8	27.1	38.5	314.4	273.0	0.0	275.9	234.5

(Source: JICA study team)

Table 6.4-13 Coal Price of Indonesian Coal to Matarbari CFPP (US$/t)

Year	FOB Price (4,700kcal/kg)		Freight & Insurance (80,000t class)		Case A			Case B		
					(A) Handling Cost	(A) G. Total of Coal Price at Chittagong CFTPP		(B) Handling Cost	(B) G.Total of Coal Price at Chittagong CFTPP	
	H. Case	B. Case	H. Case	B. Case		H. Case	B. Case		H. Case	B. Case
2012	65.5	55.7	9.2	7.8	13.5	88.2	77.0	0.0	74.7	63.5
2013	70.8	60.2	9.7	8.2	14.3	94.8	82.7	0.0	80.5	68.4
2014	76.1	64.7	10.1	8.6	15.1	101.4	88.4	0.0	86.2	73.3
2015	81.3	69.1	10.8	9.0	16.1	108.2	94.2	0.0	92.1	78.1
2016	86.5	73.5	11.0	9.4	17.0	114.5	100.0	0.0	97.5	82.9
2017	91.7	77.9	11.5	9.7	18.0	121.2	105.7	0.0	103.2	87.6
2018	96.8	82.2	11.9	10.1	19.1	127.8	111.5	0.0	108.7	92.3
2019	101.8	86.5	12.3	10.5	20.3	134.4	117.3	0.0	114.1	97.0
2020	106.8	90.8	12.7	10.8	21.5	141.0	123.1	0.0	119.5	101.6
2021	111.8	95.0	13.1	11.1	22.8	147.7	128.9	0.0	124.9	106.1
2022	116.7	99.2	13.5	11.5	24.1	154.4	134.9	0.0	130.2	110.7
2023	121.6	103.4	13.9	11.8	25.6	161.1	140.8	0.0	135.5	115.2
2024	126.5	107.5	14.3	12.1	27.1	167.9	146.7	0.0	140.8	119.6
2025	131.3	111.6	14.6	12.4	28.8	174.6	152.7	0.0	145.9	124.0
2026	136.0	115.6	15.0	12.8	30.5	181.5	158.9	0.0	151.0	128.4
2027	140.8	119.7	15.4	13.1	32.3	188.5	165.1	0.0	156.2	132.8
2028	145.5	123.6	15.7	13.4	34.3	195.4	171.3	0.0	161.2	137.0
2029	150.1	127.6	16.1	13.7	36.3	202.5	177.6	0.0	166.2	141.3
2030	154.8	131.5	16.4	14.0	38.5	209.6	184.0	0.0	171.2	145.5

(Source: JICA study team)

6.4.5 Transportation and loading port for the coal

This Study shows that from the perspective of transportation and production prospects, Indonesia, Australia, South Africa and Mozambique have the potential to export coal to Bangladesh. Among the countries, Indonesia and Australia have the most potential. The details of the coal transportation system and the shipping port in Indonesia and Australia are described as follows.

(1) Australia: Newcastle Port

Figure 6.4-8 shows the coal distribution map in Australia. A majority of the coal in Australia is located in New South Wales (NSW) and Queensland (QL).

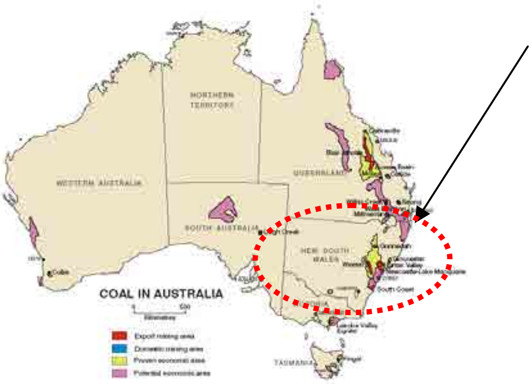
The high quality coal from coal mines in the NSW such as Newcastle, Hunter Valley, Gloucester, Gunnedah and Western Coalfield is exported from Newcastle Port to the world coal market. Figure 6.4-9 describes the coal transportation infrastructure.

Coal shipping in Newcastle Port is managed by two companies, PWCS (Port Waratah Coal Services Ltd.) and NCIG (Newcastle Infrastructure Group).

Newcastle port is one of the major ports for coal shipping in the world. The nominal capacity of coal shipping is 140 million tons per year (as of November 2011).

Importing countries from Newcastle Port and the amount of imported coal are Japan (54%), Korea (13%), China (19%), Mexico (3%) and Taiwan (3%). Table 6.4-14 shows the actual production in Newcastle.

The port belongs to the state government. Management and operations are conducted by Newcastle Port Corporation. PWCS and NCIG lease the coal loading facilities from the state government and manage the accounts and the shares. Figure 6.4-10 describes the coal shipping terminal in Newcastle Port, and Figure 6.4-11 shows the approach route to Newcastle Port.



(Source: Australian Government/Department of Industry, Science & Resources, “Australia’s Export Coal Industry)

Figure 6.4-8 Coal Distribution Map in Australia

Table 6.4-14 Actual Production in Newcastle Port

	Newcastle Port	
	CCT (Carrington Coal Terminal)	KCT (Kooragang Coal Terminal)
Annual Operation Capacity	PWCS: 25 million tons / year	PWCS→105 million tons / year
	NCIC: 53 million tons/ year	
Shipping Capacity (as of 2011)	NCIG: 24.1 million tons/ year	
	PWCS: 97.8 million tons/ year	(increase by 2.9 % from 2010)
	Total: 1,219 million tons/ year	(increase by 12.6 % from 2010)

(Source: PWCS, Annual Report 2011, NCIC General Presentation Aug 2012)

(Source: NSW government “Growth and Development Potential of Coal in New South Wales,” Nov, 2009)

Figure 6.4-9 Coal Export Infrastructure in NSW

(Source: NCIC General Presentation Aug 2012)

Figure 6.4-10 Coal Shipping Terminal in Newcastle Port

(Source: Port Waratah Coal Services Limited Annual Report 2011)

Figure 6.4-11 Approach Route to Newcastle Port

1) PWCS (Port Waratah Coal Services Limited)

PWCS is an unlisted company established in 1976. In 1990, PWCS purchased all of the shares of Kooragang coal Loader, LTD. Regarding the rights and interests of PWCS, one of the coal mining companies in Hunter Valley has 70%. 30% of the rights and interests belong to Japanese companies such as trading companies, steel companies and power companies.

PWCS owns two coal terminals, CCT(Carrington Coal Terminal) and KCT(Kooragang Coal Terminal)). The coal operation capacity is 23 million tons/year in CCT, 105 million tons/year in KCT.

In order to expand the operation capacity in the future, it is planned to have a new berth is constructed and the coal shipping facilities renovated at KCT. The target capacity will be approximately 145 million tons/year by the end of 2015.

The coal is transported by trains from the coal mine near New South Wales to Newcastle Port.

The distance from PWCS to Hunter Valley District is 100km and it takes 9 hours to get there and back. The distance from PWCS to the farthest District of Gunnedah Basin is 364km and it takes 25 hours to get there and back.

In PWCS, coal is transported from many coal mines. Therefore, there is no separate coal stock yard and an empty space is used as the coal stockyard.

In principle, the coal arrives two weeks before the vessels are loaded up. Prior to the loading, the coal is kept in the coal stock yard.

Regarding risks connected to violent meteorological disturbances, following the accident in 2007 when a typhoon drove a vessel ashore as a countermeasure to prevent similar accidents, ships under detention awaiting port entry at some distance from shore will be weighed down with anchors. When a cyclone is approaching, operations are stopped. Such a case occurs for several days every 2-3 years. When there is stormy weather except for cyclones, all procedures minus shipping are kept in operation. Operational rates due to the weather do not worsen.

The work of PWCS is comprised of four phases; 1) Coal Receipt, 2) Coal Stock and Coal Blending, 3) Environmental Management for the Coal Stock Yard, and 4) Coal Loading.

The capacity of the coal terminal at Carrington and Kooragang is described in the following table.

Table 6.4-15 Capacity of PWCS Terminal

Item	PWCS terminal capacity	
	Carrington	KOORAGANG
Annual Operation Capacity	25 million tons /year	108 million tons /year
Coal Transport	(Coal mine to Newcastle: Transported by train)	(Coal mine to Newcastle: Transported by train)
Coal Receive	1 x 4,400 t/h rail capacity 1 x 4,600 t/h rail capacity 1 x 2,200 t/h road capacity	3 x 8,500 t/h rail capacity
Coal Stockpiles	4 x 1.0 km x 40 m 750,000 ton max capacity 400,000 ton working capacity	4 x 2.5 km x 56 m 4,200,000 ton max capacity 2,700,000 ton working capacity
Coal Stacking	4 x 2,500 t/h stacking capacity	6 x 8,500 t/h stacking capacity
Coal Loading	4 x 2,500 t/h reclaiming capacity 2 x 2,500 t/h shiploading capacity 1.4 – 2.4 m wide, 2.75 –5.0m/sec conveyor belts	4 x 8,000 t/h reclaiming capacity 3 x 10,500 t/h shiploading capacity 2.0 – 3.2 m wide, 5.0 – 5.5 m/sec conveyor belts
Berths	Berth space for 2 vessels 16.5 m depth at berth 15.2 m approach to channel	Berth space for 4 vessels 16.5 m depth at berth 15.2 m approach to channel
Vessel Capacity	180,000 dwt max 275 m max length 47 m max beam 30,000 dwt min capacity	210,000 dwt max 300 m max length 50 m max beam 70,000 dwt min capacity

(Source: PWCS Presentation Material 2011)

2) NCIG (Newcastle Infrastructure Group)

NCIG (New Castle International Group) was established and started in 2004 in order to expand the export capacity at Newcastle Port.

The main coal development companies for NCIG are Banpu Public Company Limited, BHP Billiton Group, Idemitsu Kosan Co,Ltd, Peabody Energy Corporation, Rio Tinto Group, Whitehaven Coal Limited, Yankuang Group Co, Ltd.(Sojitsu invests Yankuang). Other companies cannot develop and work with NCIG.

NCIG has an expansion plan whereby NCIG leases the land of 135ha in Kooragang Island for 35 years to construct the coal terminal. The final target capacity of the NCID Coal Terminal is 66 million tons /year.

Table 6.4-16 Capacity of NCIG Terminal

Item	NCIG terminal capacity
	KOORAGANG
Annual Operation Capacity	53 million tons/year (as of 2011)
Coal Transport	(coal mine to Newcastle: transported by train) Train system: composed of two sidetracks, three traverse lines, one loop
Coal Receive	3 x 8,500 t/h rail capacity
Coal Stockpiles	3Pile yard
Coal Stacking	2 x 8,500 t/h stacking capacity
Coal Loading	1 x 10,500 t/h ship loading capacity 2.0 – 3.2 m wide, 5.0 – 5.5 m/sec conveyor belts
Berths	Berth space for 2 vessels 16.5 m depth at berth 15.2 m approach to channel
Vessel Capacity	210,000 dwt max 300 m max length 75 m max beam 70,000 dwt min capacity

(Source: NCIC General Presentation Aug 2012)

(2) Indonesia: Kalimantan Island

Regarding the amount of coal mines in Indonesia in 2010, accessible coal reserves are 104,900 million tons and the estimated amount of coal reserves are 19,000 million tons as described in Table 6.4-17.

The specifications of the Indonesian coal are that most of the coal is thermal coal, not coking coal. The ash content and sulfur content of the Indonesian coal is low so that the calorific value of most of the coal in Indonesia is comparatively low.

In Indonesia, there is abundant coal in Sumatra Island and Kalimantan Island, and a small amount of coal in the Java Island, Sulawesi Island, Maluku Islands and the Papua area.

Coal production in Indonesia was 376 million tons in 2011 (IEA Coal information 2012). Of particular mention is that the proven reserves of coal in Kalimantan Island are approximately 460 million tons. Currently, coal production is conducted primarily in Kalimantan Island.

Table 6.4-17 Proven Reserves in Indonesia

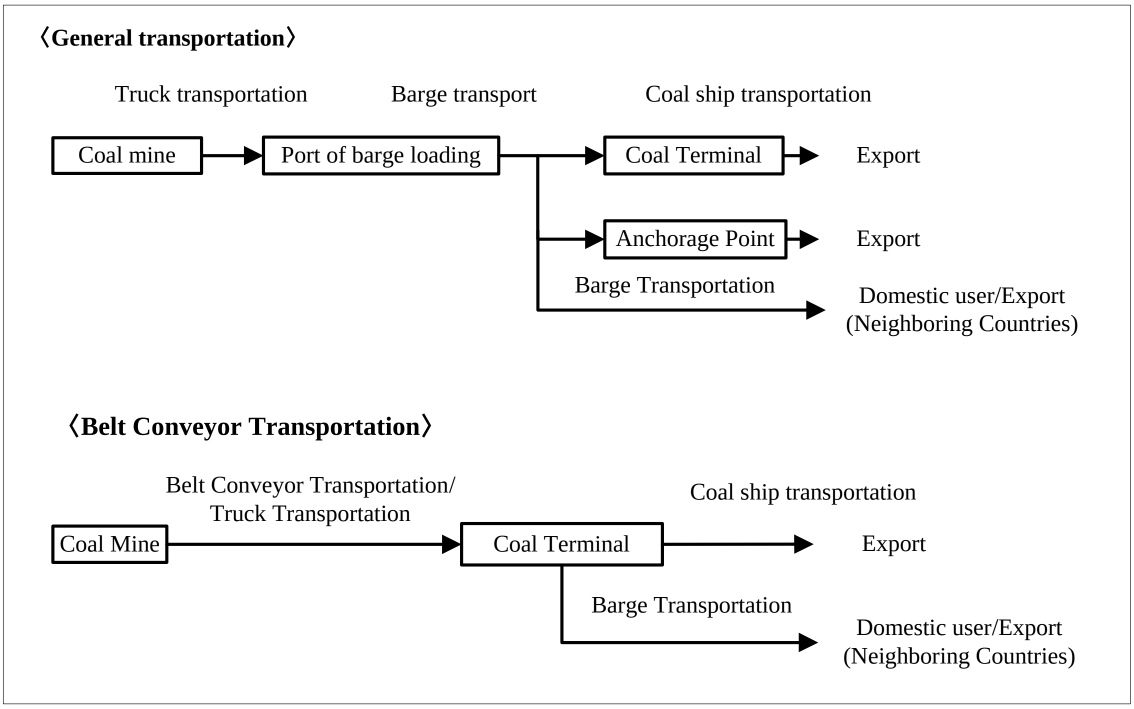
Area	Resources (million tons)	Proven Reserve (million tons)		
		Probable	Proven	Total
Sumatra Island	52,436.57	10,644.45	904.8	11,549.25
Kalimantan Island	52,100.79	2,833.14	4,624.57	7,457.71
Java Island	14.21	0	0	0
Sulawesi Islnad	233.1	0.06	0.06	0.12
Maluku Islands	2.13	0	0	0
Papua New Guinea Island	153.42	0	0	0
Total	104,940.22	13,477.65	5,529.43	19,007.08

(Source: Ministry of Energy and Mineral Resources, 2010)

1) Coal Transportation

In Indonesia, coal production is implemented mainly in Sumatra Island and Kalimantan Island.

Given that there are no train facilities in Sumatra Island and Kalimantan Island and a large river runs nearby the coal mine, two measures for coal transportation are used; one is the truck delivery from the coal mine to the ship, the other is a river barge.



(Source: JICA Study Team)

Figure 6.4-12 Coal Transportation in Indonesia

Figure 6.4-13 shows the image of the trucking, and Figure 6.4-14 describes the image of the loading to the barge ship.

(Source: JICA Study Team)

Figure 6.4-13   Trucking from the Coal Mine to the Barge Ship

(Source: JICA Study Team)

Figure 6.4-14   Loading into Barge Ship

In almost all cases, the method used is TBS (Tug/Barge System) which is the process of a tug boat leading a barge with coal to the reshipment point. The following figure shows the TBS.

(Source: the Study Team)

Figure 6.4-15 Tug/Barge System

In Indonesia, exported coal is loaded onto a large-scale vessel in two ways. One is direct reshipment, and the other is a floating crane or other floating transport facility as shown in the following figure.

(Source: Berau Coal HP)

Figure 6.4-16 Image of Coal Loading into Large-scale Vessel

2) Coal Mines having Export Potential to Bangladesh

In Indonesia, various companies are involved in coal production and coal mine development. The coal mines are concentrated in Kalimantan Island.

Especially, coal development is focused in East Kalimantan and South Kalimantan. The largest coal production company in Indonesia is Bumi Resource. KPC (Kaltim Prima Coal) is the main type of coal developed by Bumi Resorce. The production base is located in East Kalimantan. Its production rate is 40 million tons/ year.

KIDECO which is the number three company in terms of domestic coal production produces 22 million tons of coal a year (Paser Mine).

Berau Mine is located in the northern part of East Kalimantan Island and produces 20 million tons a year.

In South Kalimantan State, Adaro Mine which is number two in terms of domestic coal production produces 40 million tons more than Tutupan Mine which is the largest coal mine in Indonesia.

In Sumatra Island, an Indonesian public company, Bukit Asam is engaged in coal production. BHP Billion which is one of the global major producers of various resources are developed both in the middle and east of Kalimantan.

Among them, Berau Coal Mine and Kideco Coal Mine are interested in exporting to Bangladesh. The following section explains the two coal mines.

(Source: JICA Study Team)

Figure 6.4-17 Location of Coal Mines in Kalimantan Island

a) PT Berau Coal

PT Berau Coal was established in 1983. The coal production base is the Berau area (300 km north of Samarinda State) in East Kalimantan Island. The scale of the coal mine is approximately 1,200 km2.

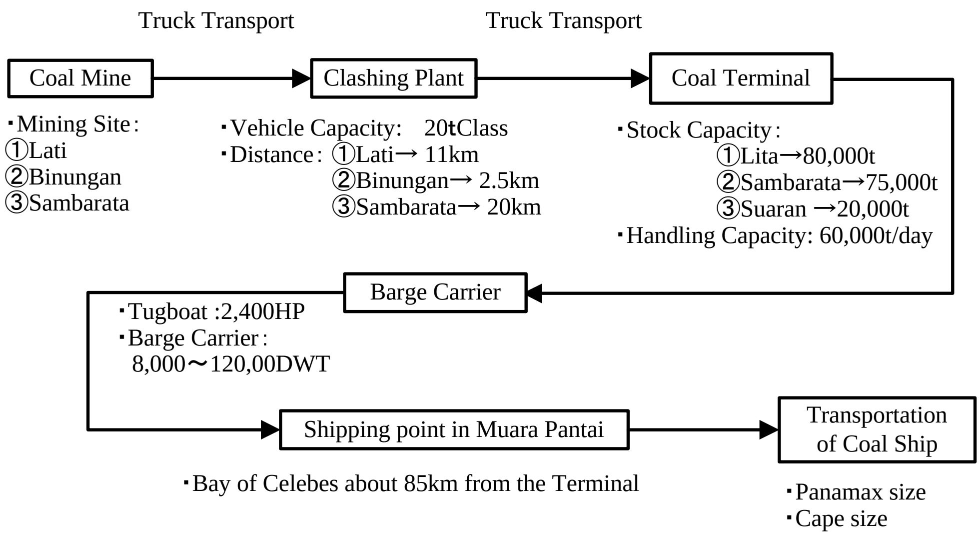
The coal is produced in the three areas of Lati, Binungan and Sambarata, which began commercial production in1994, 1996 and 2001.

The total capacity of annual production in Berau is approximately 20 million tons (as of 2011).

The proven reserves of coal is under investigation in Kelai and Punan, more than 745 million tons in Lati, more than 300 million tons in Binungan, and more than 190 million tons in Sambarata.

The mined coal is transported by truck to three coal terminals in each area. And then, it is grounded up (grading of grains) and blended (grading of quality).

Finally, the coal is transported from the three coal terminals to the reshipping point in Maura Pantai in the Celebes Sea via a barge carrier and transferred to a bulk vessel.



(Source: JICA Study Team)

Figure 6.4-18 Transportation of Berau Mine

b） PT Kideco Jaya Agung

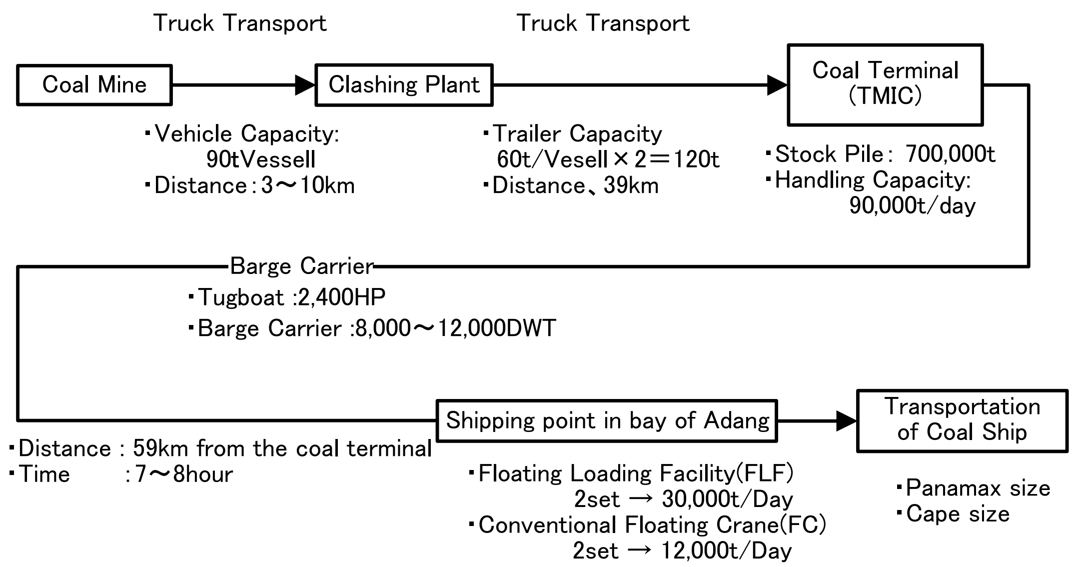
PT KIDECO Jaya Agung (KIDECO） was established in 1982, and q conducted survey for the coal mine from 1983 to 1993. In March 1993, commercial production started in the Roto North area.

The coal mine is located in Paser in East Kalimantan Island. The proven reserves of coal are 979 million tons.

Production began in 1997 in the Roto South area. The production record was 7.5 million tons in 1997, 15 million tons in 2000, 22 million ton s in 2006 and increased to 350 million tons in

2010. The total coal production is 200 million tons.

There are over 16 importing counties from Kideco such as Indonesia, India, China, Japan and Korea. The ratio of exported coal is 40% for China, 30 % for India and the remaining percentage is spread out over Japan, Korea, the Philippines and Thailand.



(Source: JICA Study Team)

Figure 6.4-19 Transportation of Kideco Mine

6.4.6 Allocation plan of ships

In order to operate a coal-fired power station, it is important to secure a stable supply of high-quality coals.

The general process of imported-coal procurement is (i) coal mining, (ii) coal quality control, (iii) coal transportation to the shipment port, (iv) coal loading onto the transport ship, (v) marine transport and (vi) coal unloading to the power station.

In general, the order is repeated based on the contract.

Following commercial operations, the stable procurement of satisfying-quality coal is one of the important contents. There are several kinds of requirements to be discussed towards the finalization of a contract such as the securing of several suppliers, the analysis of a global coal market, grasping of the international market prices and securing transportation ships.

For this section, the practical points of importance in terms of transport from the coal mine to the power station in Bangladesh are described.

(1) Type of contract

1) Type of contract for importing coal

For the contract for coal procurement from overseas, the FOB contract[20] is generally adopted. Therefore, it is necessary for importers to prepare the allocation plan of ships and insurances.

The reason that the FOB contract is selected from the various types of contracts is that it is beneficial for importers to control the efficiency of the allocation of ships and manage production troubles.

Regarding coal procurement costs of the Study, FOB, transport costs and unloading costs are added.

In the case of a long-term contract, generally an FOB contract is used. Coal mine companies do not take ship chartering risks (especially, bunkering risks, the price change risks of bunker fuel oil). The coal importers mostly enter into a one-year contract for ship chartering.

2) Contract Period for Importing Coal

There are two contracts for coal purchases, a term contract and a spot contract.

In terms of securing a stable supply of coal available to procure, the long-term contract is more advantageous. Coal on the market is traded as a general products in a one-year period.

In Japan, the term contract like a one-year contract is also more typical. However, the term contract is adopted so that there is little change in the quantity of the trading coal used for the coal-fired power station.

The procedure of the term contract is that the quantity and the price are decided in the contract,

[20] FOB(Free-on-Board):
FOB is one of the most familiar trading conditions. A seller loads the goods on ships paid by buyers. The seller has responsibility for cost and risk until the goods is transferred from the seller to the buyer on the ship. After loading goods on the ship, the responsibility is transferred to the buyer. Ownership transfer from a seller to a buyer is conducted at the same time of loading at the exporting port. FOB price is calculated with cost of coal production and a seller’s share.

and the supply schedule is managed at the proper timing based on the operation plan.

- One-year contract, three-year contract and five-year contract (basically, one-year contract. For a multi-year contract, the longest term is five years.)
- Combination of a SPOT + one-year contract + three-year contract
- The specific article of extension of the contract period is added in the contract.

A one-year contract is not a contract that is difficult to renew after the one-year period, but it is the type of contract that is normally continuously renewed.

The spot contract is chartering only one ship, which is for a limited situation such as a trial run for the first time that coal is utilized coal at a new coal-fired power plant.

As stated above, it is typical to procure coal with a one-year contract and a multi-year contract. Some are spot contracts or forward contracts such as an index linked contract.

3) Price negotiation for coal procurement

The price negotiation of coal is different from that of oil. The coal contract is generally made bilaterally, not with the market price. In Bangladesh, it is assumed that a price negotiation is conducted with a bilateral contract.

4) Quantity of coal procurement

It is common to decide the quantity of annual trading. If necessary, an option contract is made for additional needs.

A bilaterally option whereby both a seller and a buyer accept should be selected because a buyer has to take the risk if a seller proposes a unilateral contract. If the contract price does not reach an agreement, it is important to enter into some condition where there is not a duty to trade.

5) Tendering system

Most of the power utilities in East Asian countries enter into short/middle-term contracts for importing coal. If the spec requirements are flexible on the power station side, tendering can be considered to be an effective measure.

For this F/S, the flexible spec requirements of imported coal such as the lower calorific value of design coal are proposed. Therefore, it is necessary to establish a coal procurement system with the advantage of being able to enter into a flexible contract.

6) Methods of settlement

Regarding coal procurement, it is usual to make a settlement with an L/C (Letter of Credit)[21].

Some major banks which are approved by a mediator issue an L/C to a buyer on the condition that a seller has to pay for issuing the L/C until one week before arrival in the loading port, others do not require the initial payment.

(2) Risks of coal procurement

The following items are assumed as risks for coal procurement in Bangladesh.

(i) Risk for allocation of ships,

(ii) Risk for trouble caused by coal mines,

(iii) Risk of power plant shutdowns

- In the case of a change of the necessary quantity of coal due to the operation plan for the power plan and the timing of maintenance,
- In the case of long-term shutdown due to trouble,
- In the case of a change (degradation) in the coal quality.

(3) Countermeasures against coal procurement risks

Countermeasures against coal procurement risks is the creation of an optimal mixed contract comprised of both a “Long-term contract” and “Short-term contract” as a proposed contract which can secure the proper quality and quantity of coal in consideration supply stability.

A countermeasures for the stable allocation of ships are (i) Securing of ships, (ii) Securing of a fixed amount of imported coal. Therefore, it is necessary to enter into long-term contracts with several shipping companies.

In addition, it is also necessary to ensure that the contractors for coal procurement promise to supply alternative coal in the event of an accident that could prevents the normal means of coal procurement as stated in the contract.

Given that coal production depends on the climate, it is necessary to consider the risk of procuring coal in the same area if it comes from different coal mines.

[21] L/C, Letter of Credit:
The written commitment to pay that an importer’s bank guarantees the credit based on the importer’s request. It is written by an importer’s bank in the importing country and an exporter’s bank in the exporting country.

In addition, although it rarely happens recently, it is necessary to trade coal with several companies whose locations are spread out over various areas because there is possibility of a coal miners' strike and interference by local residents that could halt coal production.

As an example of power utilities in Japan, most of the power station use similar kinds of coals, while the procurement system is integrated due to risk reduction.

(4) Standard price of coal

In general, the standard price of steam coal for the power station is decided on a yearly basis. Regarding the other coal price, it is typical to make a decision every six months, quarterly or based on an Index-linked system.

(5) Guarantee

Bangladesh has no experience importing coal, but for the Matarbari Power Station, it is necessary to deal with a large amount of imported coal and a large amount of money. The supplier may request payment in advance or an L/C settlement as a credit enhancement. This will happen not only in Bangladesh, but also in Japan.

At the Matarbari Power Station, there is the possibility to enhance the credit that will prompt the government to take a hand in the organizational structure of coal procurement.

In other words, the government as a higher institution will take responsibility for the credit enhancement when the CPGCBL (public power utility) enters into long-term contracts with coal suppliers.

In this case, the government's credit enhancement is assumed to be as follows;

- CPGCBL fulfills the contract,
- If the contract is not fulfilled, the government covers the CPGCBL' s debt.

Without any trouble, CPGCBL undertakes the payment obligation. The government has no financial burdens.

There are alternative guarantees outside of the above-mentioned government guarantee such as a Performance Guarantee of CPGCBL' s long-term contract which is issued from major banks, and a Letter of Guarantee of the joint liability of guarantee in the event that CPGCBL defaults.

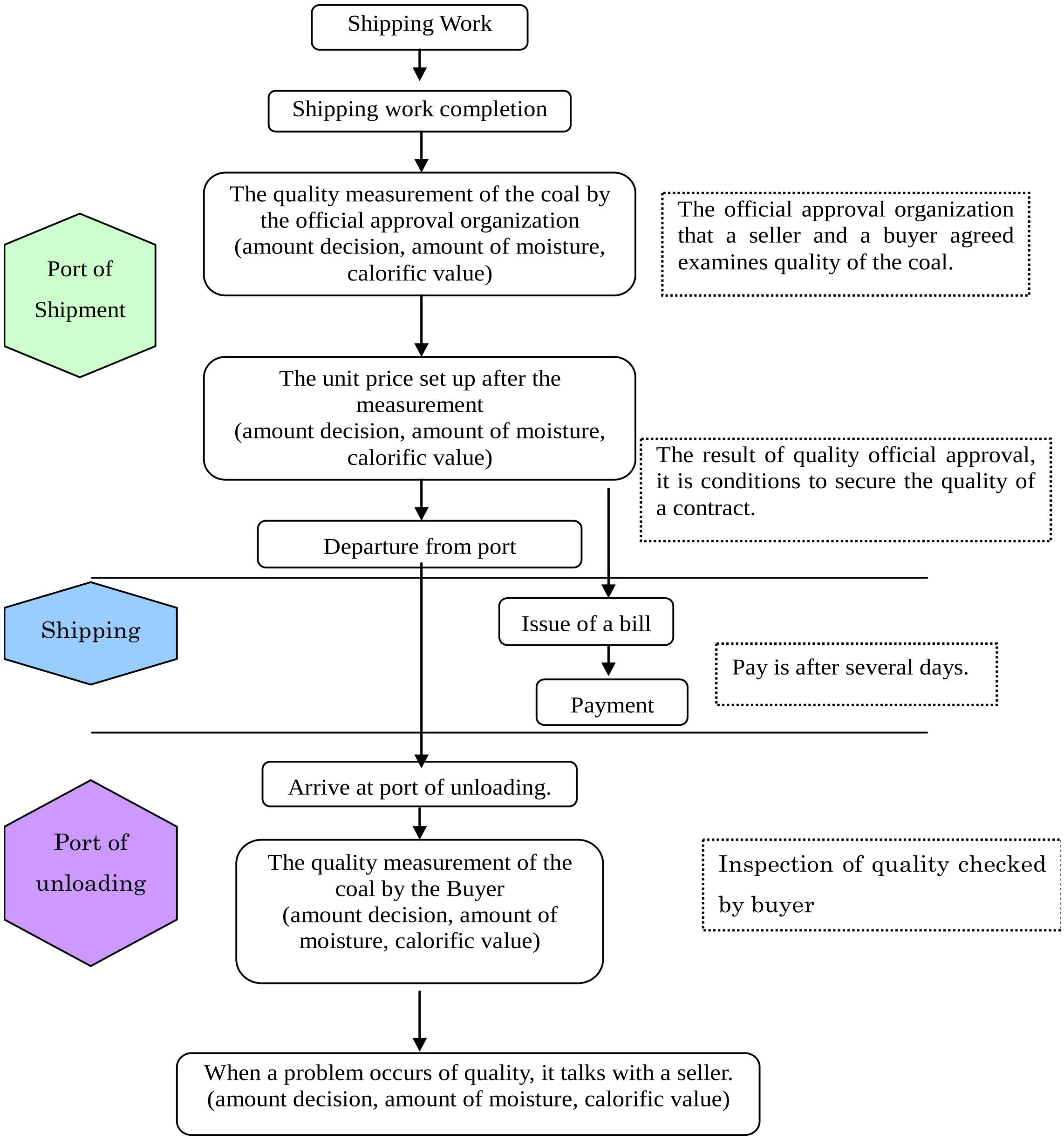
However, a long-term bank guarantee is typically not practical.

(6) Coal quality management at coal mine

The general workflow from coal shipping to coal loading in Australia is shown in the following figure.

The quality management of the calorific value and the amount of moisture after the coal loading at the shipping port is implemented by a third-party examination agency after loading on the ship. According to the results of the measurement (confirmation of quantity, quality and calorific value), the unit price is divided and the bill is made following the quality article written on the contract.

The amount billed is calculated with the confirmed quantity multiplied by the unit price (calories of loading coal), and upon arrival of a ship, the buyer verifies the quantity, quality and calorific value of the coal. After the verification, if there is any difference, it is negotiated between a buyer and a supplier.



(Source: JICA Study Team)

Figure 6.4-20 Work Flow of Coal Shipping

(7) Type of transport ships

In Japan, power utilities for coal transportation enter into a special shipping vessel contract with the shipping companies.

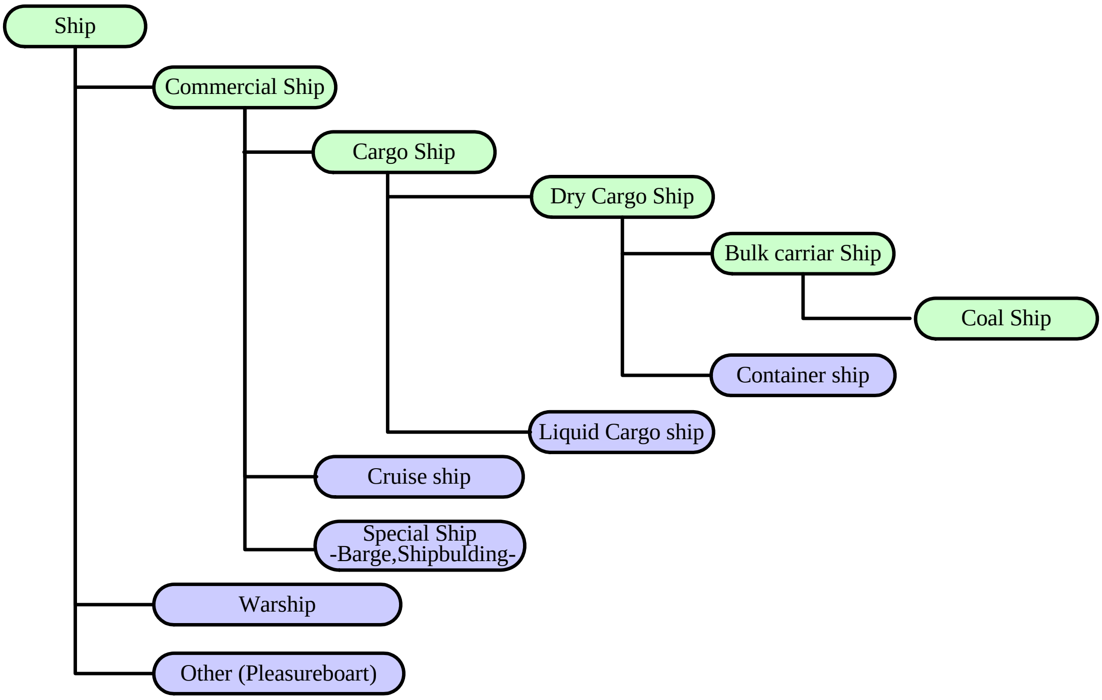
In consideration of the coal procurement risks and quantity change, it is necessary to decide a proper transportation mode and contract amongst the long/short-term contracts or spot chartering.

Most of the steel manufacturing companies use special shipping vessels. For example, 60-70% of steel factories in China consign their special vessels to Japanese shipping companies, and the others enter into spot contracts.

(8) Type of ships

1) Types of ships by cargo

The following figure shows the types of ships by cargo.



(Source: JICA Study Team)

Figure 6.4-21 Types of Ships by Cargo

The types of ships by cargo are divided into three types: Dry Cargo, Liquid Cargo and the others. Dry Cargo can be classified into bulk carriers and container ships.

The bulk carrier ships deal with general merchandise, machineries and steel materials. The container ships carry the container freight 20 feet by 40.

The bulk carrier ships are classified into standard bulk carrier and special bulk carrier. The distinguishing characteristics of standard bulk carrier ships are their handy size, panamax size and cape size.

The various special ships are bulk coal carriers, ore coal carriers, chip carriers, car carriers and reefer carriers.

Liquid cargo ships are divided into oil tankers, product carriers, chemical tankers, and liquefied natural gas carriers.

The oil tankers are for oil, product carriers are for petroleum products (naphtha, diesel oil, heavy oil, kerosene, gasoline), chemical tankers are for liquid chemical products(benzene, toluene, wine, milk and others), and liquefied natural gas carriers are for LNG and LPG.

In the above figure, the “Others (Pleasure boat)” refer to passenger boats, cruise passenger boats, ferry boats, fishing boats, tugboats and naval escort ships.

2) Size of bulk carriers

The size of carriers depends on the weight of the freight such as the fuel, lubricating oil, passengers and food items.

The loading capacity of a carrier is shown in tons. The unit of the “DWT (deadweight)” is used as tonnages in explanation of the number of cargo ships and tankers.

The size of the bulk carriers are specified into 4 types such as a (i) Small Handy, (ii) Supramax Handy, (iii) Panamax and (iv) Cape Size. The typical size of the bulk carriers is described in the following table.

Table 6.4-18 Typical Size of Bulk Carriers

Item	Small Handy	Supermax Handy	Panamax	Cape size
DWT(Dead weight)	32,000	55,000	70,000	170,000
LOA(Length over all)	170	190	225	280
Beam(m)	27	32.2	32.2	47
Full draft(m)	12.5	12.5	13.7	17.8
Number of Hold	5	5	7	9
Hold Capacity (m^3)	41,000	69,000	102,000	195,000

(Source: NYK Presentation material)

The Handy size vessels are those bulk carriers whose loading capacity is 18,000-55,000DWT. Their fairly compact size allows for easy entry and departure at most of the world’s ports.

Among the various Handy sizes, the Small Handy are those bulk carriers whose loading capacity is less than 28,000DWT, and the Super Max are those bulk carriers whose loading capacity is 45,000DWT-55,000DWT.

The word “Panamax” is a compound word combining “Panama” and “maximum”. The size of the ship is the maximum size that would allow for passage through the Panama Canal. The length is 900 feet (approximately 274m) or less, and the width is 106 feet (approximately 32.31 ｍ) or less. The loading capacity is a 70,000DWT-75,000DWT class. The Panamax is utilized for not only tankers, but also bulk carriers, or carriers and container ships.

For the coal transportation at the Matarbari coal-fired power station it is recommended that Panamax-size ships be used. These Panamax size ships will raise the efficiency of coal procurement.

The Cape size is larger than the Panamax size. The Cape size ships whose loading capacity is 150,000DWT-170,000DWT class are too large to allow for easy passage through the Panama Canal, so they need to go around the Cape of Good Hope in the African Continent.

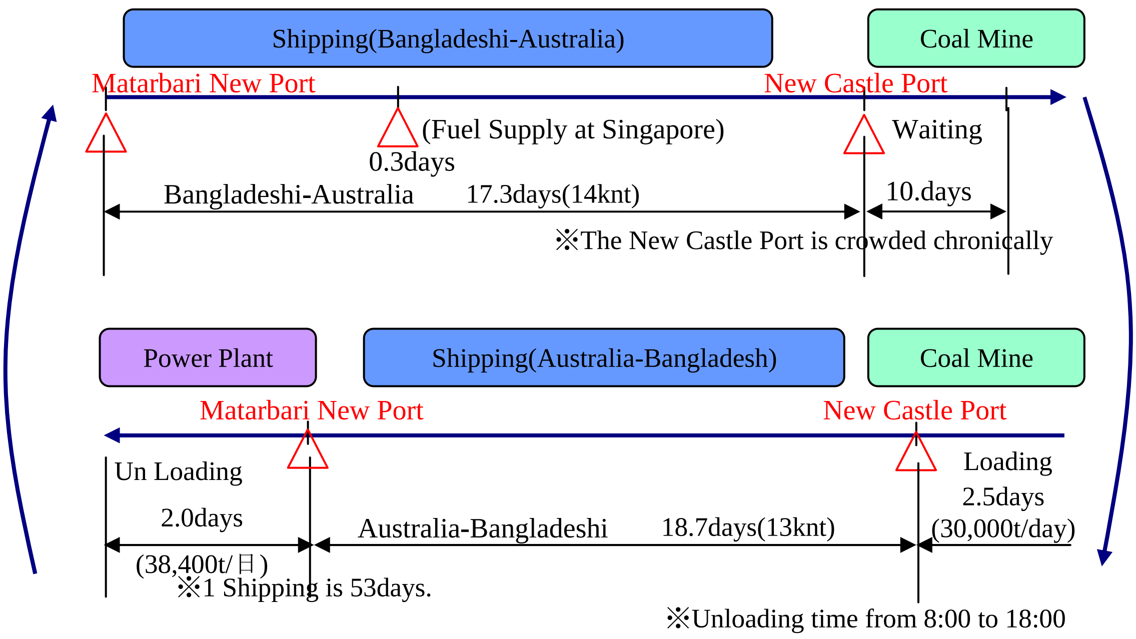
3) Transportation from Australia to Matarbari in Bangladesh

The navigation period from New Castle Port in Australia to the newly developed Matarbari Port in Bangladesh is estimated in Table 6.4-19.

The transportation route from Australia to Matarbari is shown in Figure 6.4-22.

The conditions of the transportation are the estimated loading capacity of 75,000 tons, an estimated distance of 5,824 miles, a transportation speed of 13knt(25.3km/h). In the route via Australia, refueling is planned to take place at the Singapore Port due to passage through the Strait of Malacca.

The navigation period from New Castle Port in Australia to Matarbari Port in Bangladesh is 53 days. According to past data, if 20 days are to be regarded as non-operation days due to bad weather, the remaining days in the year for operation will be 345 days, and coal transportation can be conducted 7 times a year.



(Source: JICA Study Team)

Figure 6.4-22 Transportation Route of Australia to Matarbari in Bangladesh

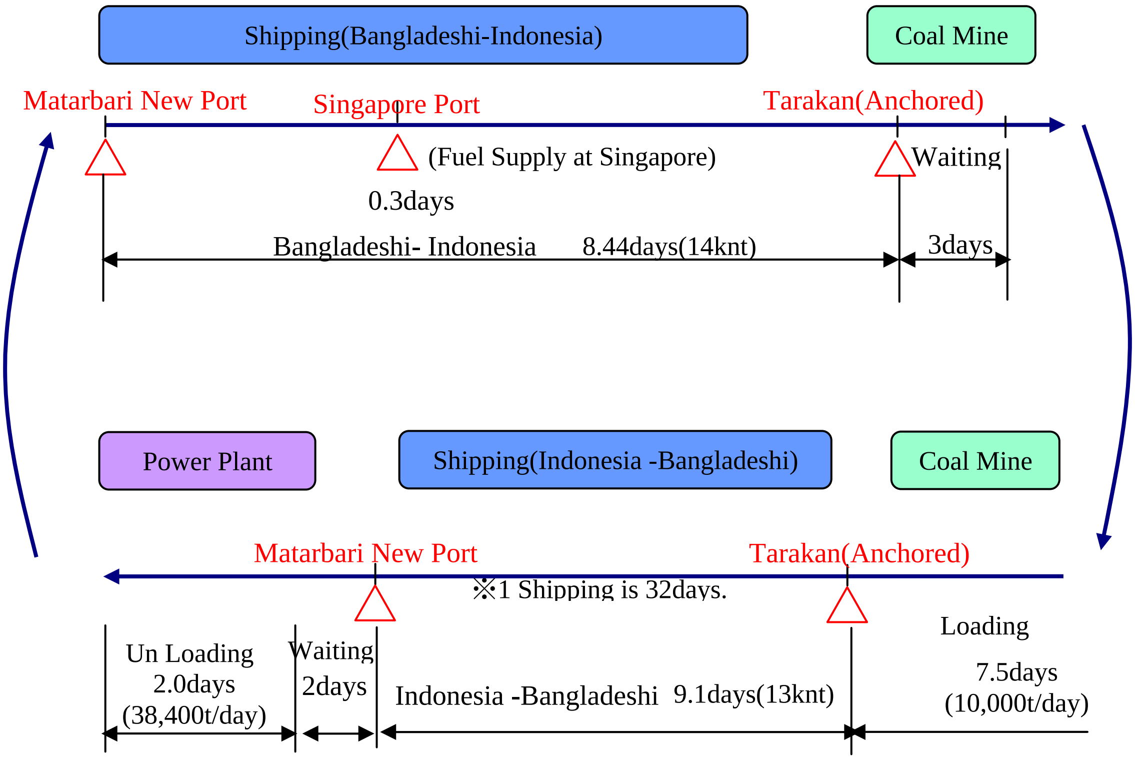
4) Transportation from Indonesia to Matarbari Port in Bangladesh

The navigation period from Tarakan Port of East Kalimantan Island in Indonesia to the newly developed Matarbari Port in Bangladesh is estimated in Table 6.4-19.

The transportation route is shown in Figure 6.4-23.

The conditions of the transportation is the estimated loading capacity of 75,000 tons, an estimated distance of 2,837 miles, a transportation speed of 13knt (25.3km/h). In the route via Australia, refueling is planned to take place at the Singapore Port due to passage through the Strait of Malacca.

The navigation period from Tarakan Port in Indonesia(Anchored type port) to Matarbari Port in Bangladesh is 32 days, and coal transportation can be conducted 11 times a year.



(Source: JICA Study Team)

Figure 6.4-23 Transportation Route from Tarakan in Indonesia to Matarbari Port in Bangladesh

Table 6.4-19 Navigation Days from the Main Port in Australia and Indonesia

Estimation of navigation days from the main port in Australia and Indonesia to Matarbari in Bangladesh

【Review Conditions】

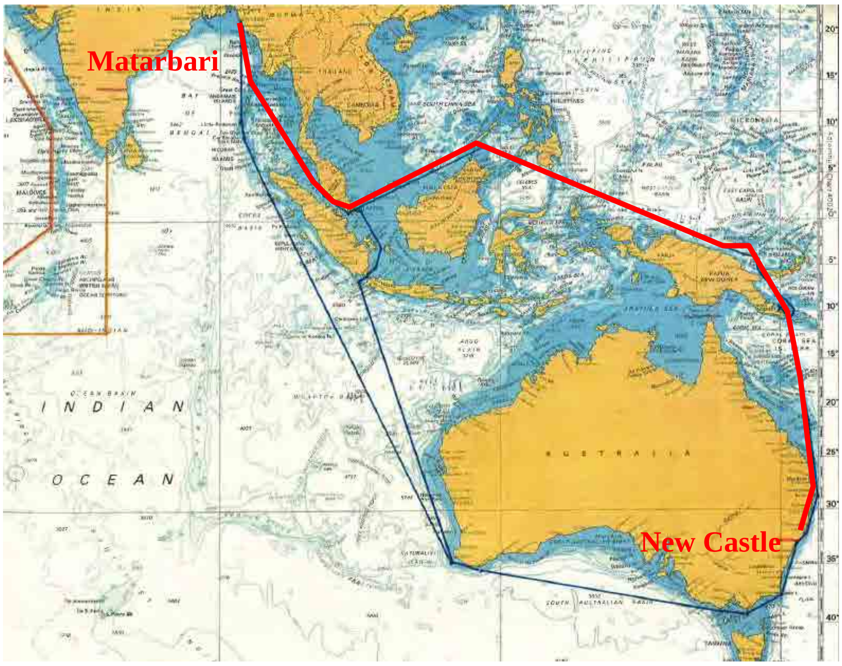
- ●Target vessel: PANAMAX type (DWT76,000)
- ●Precondition of sailing speed
  - ・Outward: 14knt, (27.2km/h)
  - ・Homeward: 13knt, (25.3km/h)
- ●Shipping port
  - ・Australia: New Castle Port in NSW
  - ・Indonesia: East Kalimantan Island

Item	Representative Port			
	Australia	Indonesia		
Loading Port	NEWCASTLE (Jetty)	TARAKAN (Anchored)	SAMARINDA (Anchored)	TANJUNG BARA(Jetty)
Expectation of cargo Weight (t)	75,000	74,500	75,000	75,000
【Bound】				
Distance of Shipping (Mile)Via Singapore	5,824	2,837	2,647	2,716
Navigation Days（day）	17.33	8.44	7.88	8.08
Time of Fuel Supply at Singapore (day)	0.3	0.3	0.3	0.3
Waiting days of Loading on offing(day)	10	3	3	3
Loading Capacity of one day (t/day)	30,000	10,000	17,000	35,000
The total number of loading days (day)	2.5	7.5	4.4	2.1
【Return】				
Distance of Shipping (Mile)Via Singapore	5,824	2,837	2,647	2,716
Navigation Days（day）	18.67	9.09	8.48	8.71
Waiting days of Unloading(day)	2	2	2	2
Unloading Capacity of One day (t/day)	38,400	38,400	38,400	38,400
The total number of Unloading days (day)	2.0	2.0	2.0	2.0
The total number of navigation days(day）	52.8	32.2	28.0	26.2
The number the annual shipping (Shipping/year)	7	11	12	13
●Annual Operation Days:345days ●It is 20th non-operation days by bad weather				
【Reference】Quantity of annual procurement coal (t/year)	490,500	797,895	923,250	998,600

Source: JICA Study Team

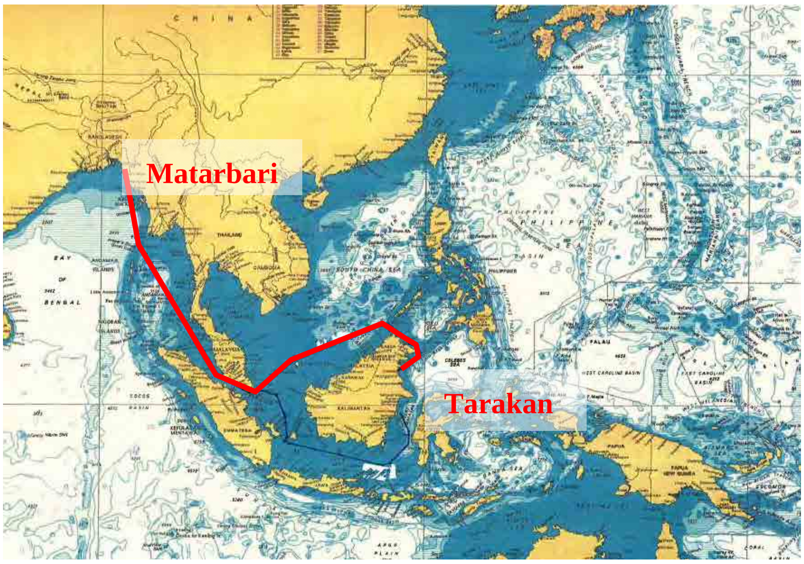
5) Marine Transportation Route

The marine transportation route between Matarbari area in Bangladesh and New Castle Port in Australia is shown in Figure 6-4.24, and the route between the Matarbari area and Tarakan Port in Kalimantan Island, Indonesia is shown in Figure 6-4.25.



(Source: JICA Study Team)

Figure 6.4-24 Transportation Route from Australia



(Source: JICA Study Team)

Figure 6.4-25 Transportation Route from East Kalimantan Island, Indonesia

Chapter 7

Conceptual Design

Chapter 7 Conceptual Design

7.1 Outline of the Project

This project is for the development of CPGCBL Matarbari Coal-Fired Power Plant (2 x 600MW) (hereinafter referred to as “Matarbari CFPP”) located in the South East of Bangladesh and designed to deliver 1,200 MW to the PGCB power grid through a 400kV transmission line that will also be constructed.

The project will utilize “Ultra Super Critical Technology” (hereinafter referred as to “USC”). In order to obtain sufficient fuel to operate the power plant in a stable manner, a vast amount of coal has to be transported in from the sea. Therefore, the construction of an excavated port, including a fuel berth and a fuel transportation facility to the power plant, will be needed for the unloading of coal for the operation of Matarbari CFPP.

An overall picture of the plant is the construction of all of the facilities for Matarbari CFPP, from the pier facilities for fuel transportation to and including the switch yard connecting to the 400kV transmission line for Matarbari CFPP.

This Preparatory Survey report, which considers the feasibility of constructing Matarbari CFPP, also addresses the systems and basic design options for the project.

7.2 Basic Study of the Plant System

7.2.1 Candidate steam cycles

Three types of steam cycles, i.e., subcritical pressure, supercritical (SC) pressure and ultra supercritical pressure, can be used for large capacity thermal power plants. In order to select the steam cycle of the power plant for this project, expected performance comparisons and economic evaluations are carried out for the following cases.

Table 7.2-1 Typical Steam Cycles for Large Capacity Thermal Power Plants

Type of Steam Cycle	Main Steam Pressure	Main / Reheat Steam Temperature
Subcritical	16.6 MPa(g)	538/538°C
Supercritical (SC)	24.1 MPa(g)	538/566°C
Ultra Supercritical (USC)	24.5 MPa(g)	600/600°C

(Source: JICA Study Team)

7.2.2 Materials of main components

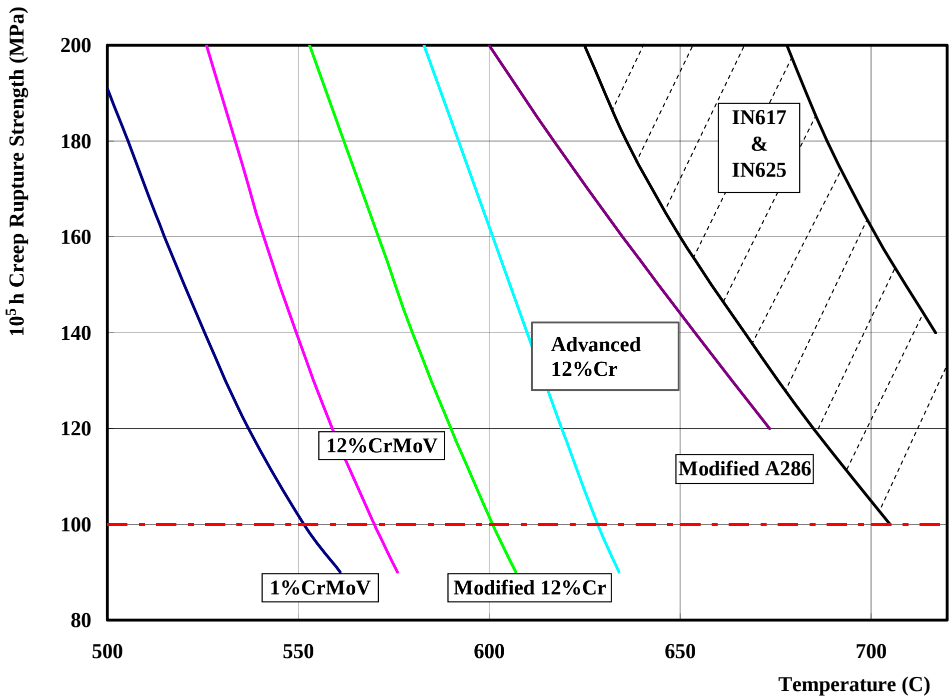
It is clear that the development of high temperature resistant materials for boilers and steam turbines have enabled the commercialization of SC and USC plants. Heat transfer surfaces of boiler tube elements must be increasingly augmented because the temperature difference between the working fluid and the combustion gas is reduced. As a result, high chromium content Ferrite steels were commercialized for SC and conventional USC boilers. However, for further high level steam conditions of advanced USC (collectively A-USC) boilers, Ferrite steel cannot be used for high temperature thick elements, such as super heater tubes, tube headers at re-heater outlets and main steam pipes, because of lower strength at high temperatures. Austenitic steels, Nickel base alloys, and Fe-Ni base alloys with high creep rupture strength, must be applied for these parts. Figure 7.2-1 illustrates the materials to be applied for parts of boilers with the advance of steam conditions.

Type of Unit	Conventional Type			Advanced Type	
Pressure (MPa)	25	25	25	30	30~35
SH Temp (^{o}C)	540	566	600	650	700~720
RH Temp (^{o}C)	540	566	600	650	700~750
Water Cooled Wall	Low-alloy Steel			Modified Low-alloy Steel	
Heat Transfer Tube High Temp Parts	2.25 ~ 9 % Cr Alloy Steel			Stainless Steel	Fe-Ni Base Ni Base
Main Steam Pipe Steam Header	9 ~ 12 % Cr Alloy Steel			Modified 9 % Cr	Fe-Ni Base Ni Base

(Source) Journal of Thermal and Nuclear Power Generation (Vol.58, No.8)

Figure 7.2-1 Relationship between Boiler Materials and Steam Conditions

Rotor material of steam turbines can be commonly evaluated by whether the temperature which maintains the creep rupture time of 10^5 h under stress of 100MPa is higher than its working temperature or not. Figure 7.2-2 illustrates the relationship between 10^5 h creep rupture strength of materials and their temperatures. For a USC plant with 600/600°C steam conditions, modified 12% Cr ferrite steel or higher grade materials can be used as the material of steam turbine rotors.



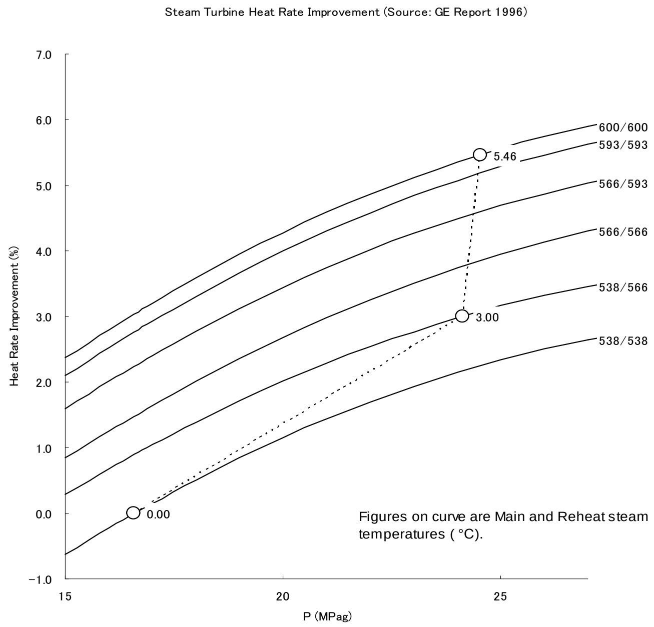
(Source) Journal of Thermal and Nuclear Power Generation (Vol.58, No.8)

Figure 7.2-2 10^5 h Creep Rupture Strength of Various Materials

7.2.3 Expected performance of each steam cycle

(1) Steam turbine efficiency (ηt)

Figure 7.2-4 shows steam turbine heat rate (or thermal efficiency) improvements for various steam cycles for a subcritical power plant. Steam turbine efficiency (ηt) is improved by adopting higher steam pressure and higher steam temperature conditions. Based on a Subcritical (16.6MPag, 538/538°C, 84.7hPa) power plant of which estimated efficiency is 45.00% at the rated load condition, the efficiencies of Supercritical (24.1MPag, 538/566°C, 84.7hPa) and Ultra Supercritical (24.5MPag, 600/600°C, 84.7hPa) power plants will be improved by 3.00% to 46.35% and by 5.46% to 47.46% respectively.



(Source) Report of GE Power Systems in 1998

Figure 7.2-3 Steam Turbine Plant Heat Rate Improvement

(2) Boiler efficiency (ηb)

Boiler efficiency (ηb) based on gross calorific value will be 87.0%. The same parameter for boiler efficiency is commonly applied for all cases of Subcritical, Supercritical and Ultra -Supercritical power plants.

The major parameters, which affect the boiler efficiency, are assumed as follows.

- Gross caloric value of coal: 4700 kcal/kg as received.
- Ambient air temperature: 30°C
- Ambient air relative humidity: 80%
- Flue gas temperature at air heater outlet: 130°C
- Excess air at economizer outlet: 15.0%
- Excess air ratio at air heater outlet: 21.4%

(3) Plant efficiency (ηpg)

Plant efficiency based on gross calorific value and generator output (ηpg) can be calculated using the following formula.

$$\eta pg = \eta t \times \eta b / 100\ (\%)$$

Where:

ηpg: Plant efficiency (%)

ηt: Steam turbine efficiency (%)
ηb: Boiler efficiency (%)

The calculation result of plant efficiency is 39.15% (base) for Subcritical, 40.32% (3.00% better) for Supercritical, and 41.29% (5.47% better) for Ultra Supercritical.

(4) Auxiliary power consumption (α %)

Auxiliary power consumption (α %) at the rated load condition for the power plants with each steam cycle is examined in general. The result is as shown below. The power plant with the USC steam cycle has slightly lower auxiliary power consumption than that of the other cycles because of its higher thermal efficiency.

- USC: 6.48%
- Supercritical: 6.64%
- Subcritical: 6.78%

The auxiliary power consumption is the sum of auxiliary power and power losses of the following facilities and equipment. Auxiliary power for common facilities such as desalination plants, demineralization plants, and water treatment plants, etc. are not included.

i) Auxiliary power required for electric power generation plants such as steam turbine generators, boilers, electrostatic precipitators, flue gas desulfurization systems, their auxiliaries, and lighting and HVAC for power plant buildings.
ii) Auxiliary power and loss for main and auxiliary transformers, buses and power cables.
iii) Auxiliary power of the following common facilities/equipment:
   a. Coal handling system
   b. Reagent preparation and waste water treatment system for flue gas desulfurization system (if necessary)
   c. Ash handling facilities

(5) Coal consumption and CO_2 emission

Coal consumption (C_C) and CO_2 emission (E_{CO2}) can be calculated with the following formulas.

- Coal Consumption:

$$CC = (MWg \times 860 \times 10^3) \times (100/\eta pg) / (GAR \times 1000) \times 8760 \times (CF/100) \text{ (ton/year)}$$

Where:

CC : Annual Coal Consumption (t/year)
MWg : Generator Output at rated load (MW)

860×10^3	: Conversion factor of electric power from MW to kcal/h (kcal/MWh)
ηpg	: Power plant gross thermal efficiency (%)
GAR	: Gross calorific value of coal, as received basis (kcal/kg)
8760	: Calendar hours per year (h/year)
CF	: Plant capacity factor, 80 (%)

・ CO_2 emission:

$$E_{CO2} = C_C \times M_{CO2}/C_A \times (c / 100)$$

Where:

E_{CO2}	: Annual CO_2 emission (t/year)
C_C	: Annual coal consumption, as received basis (t/year)
M_{CO2}	: Molecular weight of CO_2, 44 (kg/kg mol)
C_A	: Atomic weight of carbon, 12 (kg/kg atom)
c	: Carbon content in coal, as received basis（weight %）

The results of calculating the coal consumptions and CO_2 emissions for the three steam cycles are as shown in Table 7.2-2.

In regards to the economic performance, coal consumption of USC is roughly 5.49% less than that of sub-critical steam cycles.

Simultaneously, the equivalent amount of boiler flue gas can also be reduced.

Namely, where the power units are to be operated under the output condition of 2 x 600MW for one year (where the capacity factor is assumed to be 80%), 2 x 600MW USC power plants will be able to reduce 216,400 ton/year of coal consumption and 396,600 ton/year of carbon dioxides emissions into the atmosphere compared to those of a sub-critical power plant.

To conclude, the JICA Study Team has selected the USC steam cycle for the Project because it has better fuel economy and thereby an increased amount of CO_2 emission reduction compared to the subcritical pressure and the supercritical pressure steam cycles.

Table 7.2-2 Comparison of Expected Performance between Sub-critical, Supercritical and USC Power Plants

	Subcritical (16.6MPag, 538/538°C)	Supercritical (24.1MPag, 538/566°C)	USC (24.5MPag, 600/600°C)	Remarks
Generator output (kW)	1,203,862	1,202,057	1,200,000	At rated load
Auxiliary power ratio (%)	6.78	6.64	6.48	
Net electric power output (kW)	1,122,240	1,122,240	1,122,240	At substation
Turbine efficiency (%)	45	46.35	47.46	
Boiler efficiency (%)	87.0	87.0	87.0	HHV base
Plant efficiency (%)	39.15	40.32	41.29	Generator output and HHV base
	Base	3.00% better	5.47% better	
Fuel heat input, HHV (10^6kcal/h)	2,644	2,564	2,499	As received basis
Gross calorific value of coal (kcal/kg)	4,700	4,700	4,700	As received
Coal consumption (t/h)	562.66	545.45	531.78	(ditto)
Plant capacity factor, %	80	80	80	
Coal consumption (t/year)	3,943,100	3,822,500	3,726,700	
	Base	120,600 less	216,400 less	
Carbon content in coal, wt. %	50	50	50	As received basis (tentative value)
CO_2 gas emission (t/year)	7,229,000	7,008,000	6,832,400	
	Base	221,000 less	396,600 less	
		(3.06% better)	(5.49% better)	

(Source: JICA Study Team)

Note: The above performance results are expected based on the coal properties typical for this project.

7.2.4 Economic evaluation on steam cycles

Because of its higher thermal efficiency, a USC thermal power plant can reduce coal consumption by a greater amount than a Subcritical plant. However, construction a USC plant is more expensive than a Subcritical power plant.

From an economic viewpoint in regards to both construction costs and operation costs, an economic evaluation is carried out between Subcritical, Supercritical and USC power plants for this project with some given assumptions.

(1) Methodology

Power generation efficiencies of USC and Subcritical power plants are the same as the expected performances predicted in Table 7.2-2, and the net present values of fuel costs and construction cost are compared between a Subcritical power plant and a USC power plant.

If the total construction costs and the net present value of coal costs for a power plant are lower than those of another power plant, the power plant can be evaluated as being more economical than the other power plant.

(2) Evaluation criteria

- Gross power output of power plant : 1,200,000 kW
- Auxiliary power ratio : 6.48%
- Plant operating period (m) : 25 years
- Capacity factor : 80％
- Discount rate (i) : 10%/year
- Fuel cost escalation rate (e) : 4.7%/year (Note-1)
- Modified annuity present value factor : 14.0 (Note-2)
- Gross calorific value of coal : 4700kcal/kg as received basis
- Unit price of coal : 63.5USD/t (4700kcal/kg) (Note-3)

Note:

1. The fuel cost escalation rate is estimated from the increase of Indonesian coal prices from 2012 to 2030 in Section 6.4.6.
2. The modified annuity present value factor is derived by the following formula.
   Modified annuity present value factor = $(1+e)\{(1+i)^m-(1+e)^m\}/(i-e)/(1+i)^m$
3. Unit price of coal refers to the Indonesian coal price of 2012 in Section 6.4.6.

(3) Net present value of fuel costs

Net present value of coal costs is calculated by the following formula:

NPV of coal cost = annual coal consumption (t/year) x unit price of coal (USD/t)
x modified annuity present value factor (-)

The calculation result is as shown in Table 7.2-3.

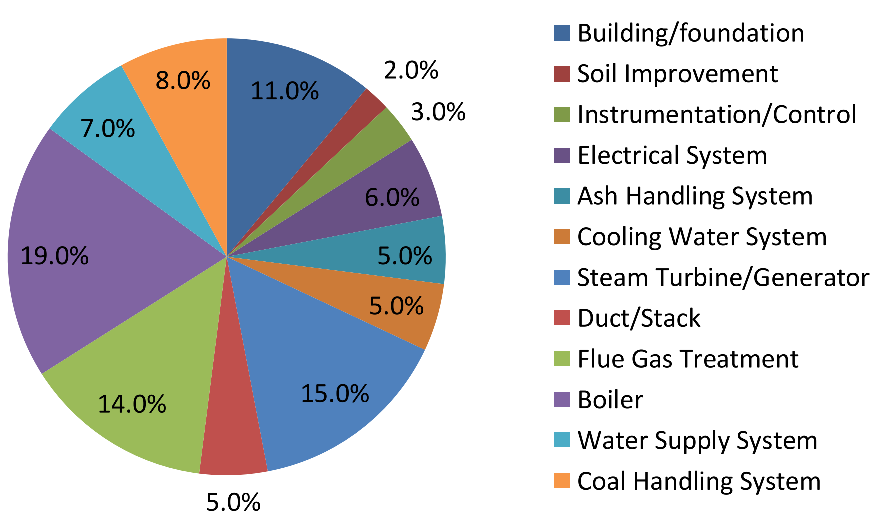
Table 7.2-3 Net Present Value of Coal Costs

	Subcritical	Supercritical	USC
Annual Coal Consumption (t/year)	3,970,000	3,848,000	3,752,000
	Base	-120,600	-216,400
Unit Price of coal (USD/t)	63.5	63.5	63.5
Annual coal cost (million USD/year)	250	243	237
	Base	-7	-13
Modified annuity present value factor	14.0	14.0	14.0
NPV of fuel cost (million USD)	Base	-107	-193

(Source: JICA Study Team)

(4) Construction costs of power plants

Figure 7.2-4 shows a cost breakdown by percent of USC Coal Fired Power Plants. To evaluate the difference of construction costs between a Subcritical power plant and a USC power plant, the construction costs of a Subcritical power plant were estimated based on the cost breakdown of USC power plants in Figure 7.2-4.



(Source) CCT Workshop 2008 in Japan

Figure 7.2-4 Cost Breakdown by Percent of USC Coal Fired Power Plants

The results for the Project are shown in Table 7.2-4. The construction cost of each item of a Subcritical power plant (Ab) can be obtained from those for a USC power plant (At) divided by the factor (At/Ab).

Each factor (At/Ab) is estimated as the following:

i) Construction costs of building/foundation, instrumentation/control and water supply system are considered to be the same as for a Subcritical power plant. Therefore, At/Ab=1.00 is applied.

ii) The capacities of soil improvement, ash handling system, flue gas duct/stack and coal handling system for a USC power plant are 5.5% less than that of a Subcritical power plant because of its higher thermal efficiency. Applying the 2/3 power law, the construction costs are estimated to be 3.7% lower, i.e. At/Ab = 0.963.

iii) For steam turbines/ generators, the capacity of a USC power plant is the same as a Subcritical power plant. However, the effects of higher main and reheat steam temperatures and of higher feed water pressure on the materials and components of the steam turbine proper, and the feed water heating system, are taken into consideration. An approximate 3.5% to 7% increase of the construction cost is expected.

iv) For the boiler for a USC power plant, the operating pressure in the steam and feed water portions is 1.5 times higher than that of a Subcritical power plant and the steam temperatures at the superheater outlet and reheater outlet are around 60°C higher than those of a Subcritical power plant. An increase of tube and pipe wall thicknesses, grade up / improvement of the material specifications, and an increase of heat surfaces of superheaters and reheaters may push up the construction costs to 20% to 30% higher than those of a Subcritical power plant, i.e., At/Ab = 1.20 to 1.30.

Table 7.2-4 Breakdown of Construction Costs of Power Plants

Item		Const. Costs of USC (At)	Ratio of At/Ab	Const. Costs of Subcritical (Ab)
Building/ Foundation	%	11.0	1	11.0
Soil Improvement	%	2.0	0.96	2.1
Instrumentation/ Control	%	3.0	1	3.0
Electrical System	%	6.0	1	6.0
Ash Handling System	%	5.0	0.96	5.2
Cooling Water System	%	5.0	0.94	5.3
Steam Turbine/ Generator	%	15.0	1.035-1.07	14.0-14.5
Duct/ Stack	%	5.0	0.96	5.2
Flue Gas Treatment	%	14.0	0.96	14.5
Boiler	%	19.0	1.20-1.30	14.6-15.8

Item		Const. Costs of USC (At)	Ratio of At/Ab	Const. Costs of Subcritical (Ab)
Water Supply System	%	7.0	1	7.0
Coal Handling System	%	8.0	0.96	8.3
Total	%	100	-	96.3-98.0

(Source: JICA Study Team)

(5) Economic Evaluation

As a result of the above examination, the net present value of coal cost for a USC power plant is 193 million USD less than a Subcritical power plant.

On the other hand, the construction costs of a USC power plant are 2% to 4% higher than a Subcritical power plant. When the construction costs per gross power generation capacity of a Subcritical power plant are in the range of 1,500 USD/kW to 2000 USD/kW, the construction costs of a USC power plant are 36 to 96 million USD higher than a Subcritical power plant. (1,200,000 kW x 1,500 to 2000 USD/kW x 0.02 to 0.04 = 36 to 96 million USD)

Therefore, the total estimated amount of the plant construction costs and the net present value of annual coal costs for a USC power plant is 98 to 158 million USD less than a Subcritical power plant, which means that a USC power plant is more economical than a Subcritical power plant for the Project.

Table 7.2-5 Economic Evaluation Comparing Subcritical and USC Power Plants

Item	Unit	Subcritical	USC
Net Present Value of Coal Costs	Million USD	Base	193 less
Construction Costs	Million USD	Base	36 to 96 more expensive
NPV of Coal Costs + Const. Costs	Million USD	Base	97 to 157 more economical

(Source: JICA Study Team)

7.3 Scope of Works

7.3.1 General

This Project basically consists of 2 x 600MW Coal-fired Thermal Power Generation Facilities and 400kV Transmission Lines and the Anowara Substation Facilities (only 400kV switching equipment for two incoming 400kV transmission lines), and includes designing, furnishing, constructing, installing, checking, starting-up and testing of complete operable systems and facilities.

The EPC Contract requires all of the works for engineering and management, whenever in these specifications the terms "provide", "furnish", "supply", "furnish and/or install", etc., are used, it is intended that the Contractor shall supply and install all systems and facilities unless specific notation is made that the equipment, device, or system is to be installed by others.

The Contract shall also include all works in place from the initial site construction to start-up and testing as required for complete operable systems and facilities with Contractor's and Contractor's Vendors services of technical direction as required for placing the systems and facilities into successful operation, and for training the Employer's plant personnel in the operation and maintenance of the systems and facilities.

The Contractor shall execute checkout, start-up and perform initial operation of systems and facilities in coordination with the Employer's plant operation staff. The Employer’s plant operating staff will be supervised by the Contractor. The Contractor shall work with the Employer to develop and perform a technology transition from engineering, construction and start-up to the operation of all systems and facilities.

7.3.2 Works and services to be provided by the Contractor

The Works include the complete project management, design, engineering, necessary studies to collect input data for design, liaisoning with third parties regarding the Employer's permitting and licensing, progress monitoring and reporting materials and equipment procurement, construction and erection, transportation, importing of goods, compliance with all relevant statutory legislation and requirements of start-up, commissioning, trial run and performance testing, training of Employer's personnel and contractor’s documents including as-built documents, and other necessary facilities and services for a fully operational plant within the boundaries as defined in the specification.

(1) Boiler and Auxiliaries / Materials

The Works include, but are not limited to, the following equipment / materials:

1) Boiler
2) Coal Bunker
3) Coal Pulverizer
4) Coal Feeder
5) Coal Burner
6) Ignition lighter
7) Start-up Oil Burner
8) Forced Draft Fan
9) Primary Air Fan

10) Soot Blower System
11) Air Heater
12) Induced Draft Fan
13) Electrostatic Precipitator
14) Flue Gas Desulfurizer
15) Stack
16) Fuel Oil Service Tank
17) Fuel Oil Pump
18) Essential Spare Parts as a minimum
19) Tools and Test Equipment
20) Consumable Parts and Material for Commissioning and Initial Operation for 3 Months (Recorder Chart and others)

(2) Coal and Ash Handling Equipment / Materials

The Works include, but are not limited to, the following equipment / materials:

1) Coal handling equipment
   a. Coal Unloader
   b. Coal Conveyor
   c. Stacker / Reclaimer
   d. Coal Yard
   e. Coal Discharging Conveyer
   f. Coal Shifting Conveyor
   h. Essential Spare Parts as a minimum
   i. Tools and Test Equipment
   j. Consumable Parts and Material for Commissioning and Initial Operation for 3 Months (Recorder Chart and others)

2) Ash Handling Equipment
   a. Furnace Bottom Clinker Handling Equipment
   b. Fly Ash Collection Equipment
   c. Fly Ash Storage Silo
   d. Ash Discharging Conveyor
   e. Essential Spare Parts as a minimum
   f. Tools and Test Equipment
   g. Consumable Parts and Material for Commissioning and Initial Operation

(3) Steam Turbine and Auxiliaries / Materials

The Works include, but are not limited to, the following equipment / materials:

1) Steam Turbine
2) Condenser
3) Steam Turbine Bypass System (High Pressure Bypass)
4) Steam Turbine Bypass System (Low Pressure Bypass)
5) Condenser Cathodic Protection Equipment
6) Condenser Tube Cleaning Equipment
7) Motor-driven Condenser Vacuum Pump
8) Condensate Pump
9) Grand Steam Condenser
10) Condensate Demineralizer
11) Low Pressure Feed Water Heaters
12) Deaerator
13) Turbine-driven Boiler Feed Pump
14) Motor-driven Boiler Feed Pump
15) High Pressure Feed Water Heaters
16) Cooling Water Pump
17) Cooling Water Heat Exchanger
18) Auxiliary Oil Pump
19) Emergency Bearing Oil Pump
20) Oil Cooler
21) Turning Gears
22) Turning Gear Oil Pump
23) Steam Turbine Supervisory Instrument
24) Essential Spare Parts as the minimum
25) Tools and Test Equipment
26) Consumable Parts and Material for Commissioning and Initial Operation

(4) BOP (Balance of Plant) / Materials

The Works include, but are not limited to, the following equipment / materials:

1) Auxiliary Boiler
2) Circulating Water Supply System including Screen, Pump and Piping
3) Desalination Plant including Service Water Supply Facilities and Service Water Tank
4) Demineralization Plant
5) Make Up Water Tank
6) Chemical Injection / Sampling Facilities

7) Hydrogen Generation System
8) Nitrogen and Oxygen generation System
9) Carbon Dioxide and Nitrogen Supply System
10) Compressed Air Supply System
11) Waste Water Treatment Facilities
12) Fire Protection System
13) Chemical Laboratory Equipment

(5) Electrical Equipment / Materials

The Works include, but are not limited to, the following equipment / materials:

1) Generator and Auxiliaries including Excitation System
2) Generator Circuit System including IPB, VT/ SA and NGR
3) Generator Circuit Switching Devices (GCB and DS with Earthing switch)
4) Generator Step-up Transformer with Auxiliaries
5) Unit Auxiliary Transformer with Auxiliaries
6) Station Auxiliary Transformer with Auxiliaries
7) 6.6kV Medium Voltage Switchgears with Meters and Protection Relays
8) 415V Unit and Common Switchgears
9) 415V Essential Switchgear
10) Motor Control Center (MCC)
11) Uninterruptable Power Supply Facilities (UPS)
12) Emergency Power Supply Facilities
13) DC Power System
14) Generator and Transformer Protection Relays
15) Cathodic Protection System
16) Power Cables and Wiring Materials
17) Control Cables and Wiring Materials
18) Cable Trays and Fitting Materials
19) Grounding Materials
20) Plant Lighting System
21) Communication System

(6) Instrumentation and Control Equipment / Materials

The Works include, but are not limited to, the following equipment / materials:

1) Plant Interlock System
2) Boiler Control System

3) Burner Control System
4) Turbine Control System
5) Plant Auxiliary Interlock and Sequence Control System
6) Data Acquisition Historical Storage and Retrieval System
7) Local Control System
8) Remote Monitoring System
9) Plant Emission Monitoring System
10) Fuel Coal Analyzing System
11) Rotating Machine Vibration Monitors
12) Water / Steam Analyzing System
13) Instrumentation and Control Cables

(7) 400kV Switchyard Equipment / Materials (air insulated switchgear)

The Works include, but are not limited to, the following equipment / materials:

1) 400kV Circuit Breakers
2) 400kV Disconnecting Switches including Earthing Switches
3) Current Transformers
4) Voltage Transformers
5) Lightning Arresters
6) Buss and Conductors
7) Bay Control Unit (BCU)
8) Station Control System (SCS)
9) SCADA
10) Protection Relay System with Metering System
11) AC and DC Auxiliary Power System including Battery and UPS
12) Communication and Data Transmission System, Cabling and Cable Ways
13) Steel Structures
14) Field Equipment

(8) Port and Harbor

The Works include, but are not limited to, the following port facilities/ works:

1) Channel
2) Turning Basin
3) Coal Unloading Berth
4) Oil Unloading Berth
5) Shallow Draft Wharf
6) Revetment

7) Stone Cladding Work
8) Preparation Work
9) Dredging Work
10) Excavating Work
11) Piling Work for the Berth

(9) Civil, Structures and Buildings

The Works include, but are not limited to, the following civil, structures and buildings:

1) Site preparation works
2) General leveling and earthworks
3) Embankment works and slope protection works for embankment
4) Piling and Foundations for all Equipment / Facilities in the Power Plant
5) Piling and Foundations for all Equipment /Facilities in the Coal Storage Yard
6) Piling and Foundations for all Equipment / Facilities in the Ash Disposal Area
7) Piling and Foundations for all Equipment/Facilities of the Coal and Ash Handling Facilities
8) Banking works with slope protection works
9) Temporary site services (fire protection, first aid and medical services, lighting, site security)
10) Temporary buildings
11) Laydown and Contractor's areas
12) Preliminary works
13) Site strip and grading
14) Temporary roads, drainage and services
15) Permanent ducts/draw pits /pipework
16) Underground utilities
17) Landscaping
18) Security fencing and access control
19) Roads, car parks and paved areas
20) Pipe trenches and channels
21) Cable trenches and ducts
22) Drainage
23) Foundations for pipe racks and pipe support
24) Foul water drainage
25) Industrial sewage water system
26) Wastewater storage pond, coagulation and sedimentation tank
27) Boiler structures, cladding and stack foundations

28) Turbine building and foundations
29) Electrical building
30) Control room/ office building
31) Workshop and warehouse building, standard equipment and tools for daily maintenance
32) Transformer compounds
33) 400 kV Switchyard control building
34) Water treatment plant building and associated tank foundations
35) Civil works for cooling water system, cooling water intake structures, cooling water pump house, underground inlet cooling water culvert, underground cooling water discharge culvert and discharge structures
36) HVAC systems
37) Fire detection system for the Plant
38) Electrical installations of the buildings, small power systems, indoor normal, emergency and exit lighting for the Plant's buildings
39) Outdoor lighting for roads, buildings and structures of the Plant
40) Lightning protection for the Plant buildings and areas
41) Service platforms and structures, lifting beams and lifting devices for Plant equipment in order to facilitate daily operation and maintenance
42) Offices and Facilities for the Employer’s Engineer at Site as specified by the Employer
43) Countermeasure works for ground settlement
44) Community roads construction works

(10) Construction Works

The Works for the Plant, Port and Harbor include, but are not limited to, the following Construction and start-up / commissioning services:

1) Construction Management including Scheduling, Expediting and Supervision of the Works concerned maintaining Security and Safety
2) Provision, implementation and management of a fully compliant Quality Assurance/ Quality Control programme covering all aspects of the works
3) Provision of all Documents/Drawings necessary for Erection/Installation, Piping, Cabling and Commissioning
4) Provision of all Facilities, Consumables and Tools necessary for Erection and Commissioning
5) Provision of Site Office/Housing with necessary Equipment including Drinking / Service Water, Lightings and Drainage /Sanitary Facilities
6) Provision of Storage/Housing for all Equipment / Materials
7) Shipping and Custom Clearance with necessary processing of Notices and Documents

8) Obtaining and Securing all required Local, State and Government Permissions
9) Transportation, Storage and Handling of all Equipment/Materials maintaining due Quality
10) Fuel cost during Start-up to successful initial synchronization
11) Provision of Construction Utilities including Electricity, Water, Gas and Compressed Air
12) Erection, Installation, Adjustment and Fixing of all Equipment / Facilities
13) Plumbing / Piping and Cabling / Wiring of all Equipment and Facilities
14) Testing and Commissioning of all Equipment and Facilities
15) Performance Test including Verification of Guaranteed / Required Data / Characteristics
16) Cleaning all Equipment/Facilities and Clearing out all unnecessary materials after construction at Site
17) Construction management
18) Hydrological, bathymetric, recirculation studies needed to clarify cooling water conditions
19) Site topographic geotechnical investigation /Boring
20) Site soil investigations
21) Construction labor and tools
22) Construction equipment
23) Safety and loss control program
24) Quality assurance program
25) Procurement expediting
26) Manufacturer’s field services
27) Reception of equipment and materials (including custom clearance), handling and storage
28) Preoperational checkout, testing, and start-up
29) Construction closeout and site finishing
30) Construction of storage area
31) First aid and security (during construction)
32) Participate in coordination conferences and other meeting as the Employer may request

(11) Engineering Works

The Works for the Plant, Port and Harbor include, but are not limited to, the following works:

1) Project Management including Scheduling and Expediting of all Works concerned with the resolution of unexpected difficulties and obstacles
2) Quality Assurance of all Works / Equipment concerned including Periodical Reports to Employer
3) Design of all Systems and Equipment, and Provision of Documents and Drawings to the Employer and Consultant

4) Procurement/Production of all Equipment/Facilities with the disclosure of Purchasing Documents if required
5) Workshop Test with Submission of Documents in advance and of the Results afterward to the Employer
6) Workshop Training with effective Facilities/Materials for the Employer's Staff
7) Field Training including Deskwork and Examination
8) Provision of Protection Relays Setting Plan
9) Participation in Meetings for Design Review, Progress and Project Coordination
10) Provision of Operation and Maintenance Manual
11) Provision of additionally required Drawings and Documents during Project Execution

7.3.3 400 kV transmission lines and substation facilities

(1) Transmission Lines Equipment/Materials

The Works include, but are not limited to, the following equipment /materials:

1) Double-circuit 400 kV overhead transmission line towers
2) Foundations
3) Insulators and fittings
4) Conductors and their accessories
5) Ground wire, OPGW and their accessories

(2) Transmission Lines Construction

The Works include, but are not limited to, the following items:

1) Transmission Lines routing design, supported by the Employer
2) Site preparation and temporary works including any demolition and relocation of the existing services, if needed
3) Soil investigations
4) Site topographic investigations
5) General leveling and earthworks
6) Piling, if needed
7) Security fencing and access control
8) Roads
9) Temporary buildings, drainage and services
10) Any civil and construction works, including towers and tower foundations
11) Landscaping

(3) Transmission Lines Engineering Works

These operations include project management concerned with the transmission line, such as the design, construction, and testing at site, etc.

(4) Substation Engineering Equipment/Materials

The Works include, but are not limited to, the following equipment / materials:

Extension of the 400kV Anowara Substation: 2 x 400 kV feeder bays for the previously mentioned transmission lines, as instructed in the attached single line diagram which will be provided.

1) 400kV Double Busbar
2) 400kV Circuit breakers
3) 400kV Disconnectors
4) 400kV Earthing Switch
5) Voltage Transformers
6) Current Transformers
7) Surge Arresters
8) Protection Systems
9) Control and monitoring systems with modification of SCADA system
10) Power and Control Cables
11) Communication and Data Transmission System, Power Line Carriers (PLC) at site end of HV lines
12) LVAC Equipment
13) DC Power

(5) Substation Construction Works

The Works will include, but are not limited to, the following items:

1) Investigation work of actual situation at present of the 400kV Anowara substation
2) Civil work (earthing, basement, steel structure, etc.)
3) Installation work of equipment
4) Connection work of protection and control system
5) Testing

(6) Substation Engineering Works

The Works include complete project management concerned with the substation, such as design, construction, testing at site, etc.

7.3.4 Works and services to be provided by Employer

The following work associated with the plant will be provided by the Employer and/or others:

1) Provide the Contractor with the Site
2) Fuel coal and light oil after successful initial synchronization
3) Environmental Impact Assessment (EIA)
4) All necessary environmental permits for the construction and operation of the plant (Contractor shall provide all necessary information regarding the plant equipment and services in his supply to assist the Employer and/or others in obtaining required environmental permits)
5) Providing operators and maintenance personnel for site-specific hands-on training by the Contractor and for Plant start-up, initial operation, and performance testing under the Contractor's technical directions in accordance with a mutually agreeable schedule of activities, taking into account the other obligations of such personnel

7.4 Plant Design Consideration

7.4.1 Design criteria

In accordance with data from several metrological data sources, the Plant shall be designed according to Table 7.4-1 Design Criteria. The Minimum Ambient Dry Bulb Temperature was obtained by statistical treatment of daily minimum temperatures of January from 1992 to 2011 at the Kutubdia observation station. The Maximum Ambient Dry Bulb Temperature was obtained by statistical treatment of daily minimum temperatures of April and May from 1992 to 2011 at the Kutubdia observation station. The Design Ambient Dry Bulb Temperature was obtained using the above 20 years data as typical conditions. The Annual Rainfall was obtained from the above 10 years data (from 2002 to 2011) at the Kutubdia observation station. Design Ambient Dry Bulb Temperature, Relative Humidity and Design Sea Water Temperature at Economic Continuous Rating (ECR) conditions are 30^{o}C, 80% and 30^{o}C, respectively. The design conditions were determined tentatively according to the limited metrological data in order that these could be revised during the design stage.

Table 7.4-1 Tentative Design Criteria

Design Ambient Dry Bulb Temperature /Relative Humidity for Performance Guarantee	30^{o}C / 80%
Design Sea Water Temperature	30^{o}C / 32^{o}C

(ECR / Turbine Capability)	
Minimum / Maximum Relative Humidity	20% / 100%
Minimum Ambient Dry BulbTemp. / Maximum Ambient Dry Bulb	15^oC / 35^oC
Barometric Pressure	0.1013 MPa
Elevation	10m+ MSL for power block area
Sea Water Level	High Water Level = +2.2m M.S.L. Low Water Level = -2.2m M.S.L.
Seismic Criteria*	0.15 (Zone 2)
Wind Design*	72.2 m/s (Chittagong)
Annual Rainfall	4877 mm
Maximum Rainfall Rate (1 hour) *	85 mm/hr
Snow Load	0 kg/m^2

(Source: *: Bangladesh National Building Code 2006, Other: JICA Study Team)

Table 7.4-2 summarizes tentative specification of Design Coal. The average caloric value of imported coal is 4,700 kcal/kg and it is used for each evaluation in this study. Detail of coal quality is described in Chapter 6.

Table 7.4-2 Tentative Specification of Design Coal

Total moisture (Air dry.%)	18.3 – 38.0
Inherent moisture (Air dry.%)	10.2 – 25.0
Ash (Air dry.%)	3.0 – 15.1
Sulfur (Air dry.%)	0.1 – 1.0
Gross Caloric Value (As received kcal/kg)	4,200 - 5200

7.4.2 Expected plant performance

The expected plant performance at ECR conditions of Matarbali CFPP are summarized in Table 7.4-3.

Table 7.4-3 Expected Plant Performance

Generator output (kW) at ECR	2 x 600,000
Auxiliary power ratio (%)	6.48
Net electric power output (kW)	2 x 561,120
Turbine efficiency (%)	47.46
Boiler efficiency (%)	87.0

Plant efficiency (%)	41.29

(Source: JICA Study Team)

Note) Design Ambient Dry Bulb Temperature / Relative Humidity: $30^{o}C$ / 80%
Design Sea Water Temperature / Condenser Vacuum: $30^{o}C$ / 84.7 hPa
Steam Condition: 24.5MPag, 600/600ºC
Gross calorific value of coal : 4700kcal/kg (as received basis)

7.4.3 Codes and standards

(1) **General**

The power plant components, systems, and equipment shall be designed, manufactured, assembled and tested at the workplaces of the manufacturers, installed and, after installation at the site, shall be tested and commissioned, in accordance with applicable internationally recognized codes and standards which are adopted and published in the latest revision of the following organizations, and shall be applied in order to confirm the safety of the power plant.

(2) **List of internationally recognized codes and standards**

The full name of the referenced codes and standards are;

Abbreviation	Name
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute, Inc.
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
HEI	Heat Exchange Institute
HIS	Hydraulic Institute Standard
IEC	International Electrotechnical Commission
IEE	Institute of Electrical Engineers
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
JIS	Japan Industrial Standard
MSS	Manufacturer’s Standardization Society of the Valve and Fittings Industry
NACE	National Association of Corrosion Engineers

NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
SSPC	Steel Structures Painting Council
TEMA	Tubular Exchanger Manufacturers Association

7.4.4 Site layout

(1) Circumstances of Site

A reconnaissance survey was conducted in the 2nd half of September 2012, in order to construct the proposed CPCG Matarbari Coal-Fired Power Plant (2 x 600MW) at Cox’s Bazaar (“Matarbari CFPP”).

The Proposed Power Plant Project site is situated in Matarbari island of Maheskhali Upazila of Cox’s Bazar district. It is located at 91052’58”E and 21042’15”N. The proposed site is surrounded by the Bay of Bengal on the West, Kohelia river on the East, the homestead of Matarbari union on the north and the homestead of Dhalghata union on the south.

The general features of the project site are described as follows.

- The total project area was found to be nearly flat.
- There were no major differences in levels found.
- Some khal, ditches, depressions or heaps were observed in the project area.
- No significant physical features were observed.
- There were no structures in the project area.
- There were fish and salt cultivation land in the project area. Some temporary housing was found in the project area.
- There were many water courses in the project area, manually cut for the purpose of fish and salt cultivation.
- There were no features like electric poles, roads, etc., located anywhere in the boundary line.

Photographs of the project area are shown in Figures 7.4.3-1 and 7.4.3-2

Figure 7.4-1 Photograph of Project Area (fish and salt cultivation land)

Figure 7.4-2 Photograph of Project Area (living conditions)

(2) Required Area of the Total Power Plant

The required total area for the power plant is as follows.

1) Port Facilities

The area of the channel and port, including common facilities, is assumed to be approximately 770,000 m2 = 77 ha.

For details , please refer to 8.2.4 Comparison of Layout Planning ,(3) Layout Plan .

2) Power Block

The size of the power block, including common facilities, is assumed to be 520m x 530m = 275,000m^2 = 28ha, referring to the same scale of coal-fired power plants in foreign countries. However, since the systems or specifications of the common facilities are not decided at present, it is a comparatively bigger size for the 600MW x 2 units.

3) Switch Yard

The switch yard is assumed to be 220m×200m = 44,000 m^2 = 4.4ha ,based on previous results.

4) Coal Stock Yard

The area of the coal stock yard is assumed to be approximately 334,800 m2 = 34 ha.

For details , please refer to 7.4.8 Coal and Handling Facilities .

5) Ash Disposal Pond

The area of the ash disposal pond is assumed to be approximately 200 ha.

For details , please refer to 7.4.8.2 Ash Handling System .

(2) Site Layout

1) The arrangement of the whole area

The layout planning of the whole area was arranged as follows based on the circumstantial conditions, and is provided in Figure7.4-3.

- The northwest side

The boundary of the north-western limit is fixed under the constraint that it does not go over the homestead of the Matarbari Union.

- The east side

The boundary of the eastern limit is fixed under the constraint of the exiting road and river.

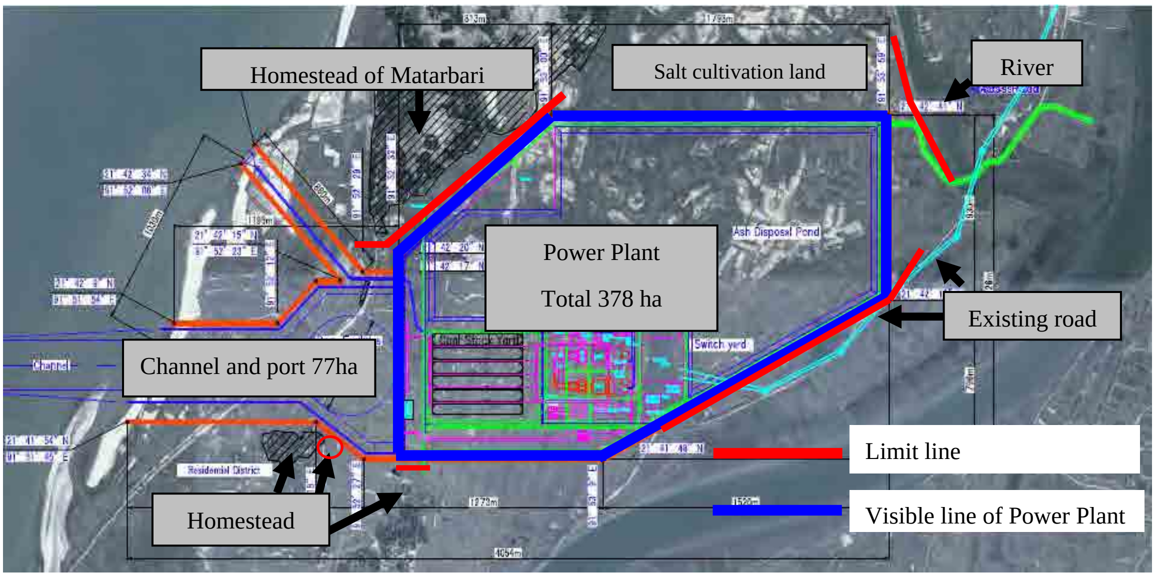
- The south side

The boundary of the southern limit is fixed under the constraint that it does not go over the homestead.

Based on the required area of the total power plant area and restrictive conditions, the data is arranged in list form as following.

Table 7.4-4 Location and Required Area

Location data (GPS)	East longitude : 91°51′45″E～91°53′59″E North latitude : 21°41′48″N～21°42′39″N
Required Area	Total: 455 ha - Port facility 77 ha - Port, Revetment 20 ha - Coal stock yard 33 ha (for 60 days stock) - Power block 40 ha (including Switch yard) - Ash disposal pond 183 ha (for 25 years operation) - Township 10 ha - Intake tunnel area 17 ha -Embankment 75 ha



(Source: JICA Study Team)

Figure 7.4-3 Overall Power Plant

2) The location of the power plant

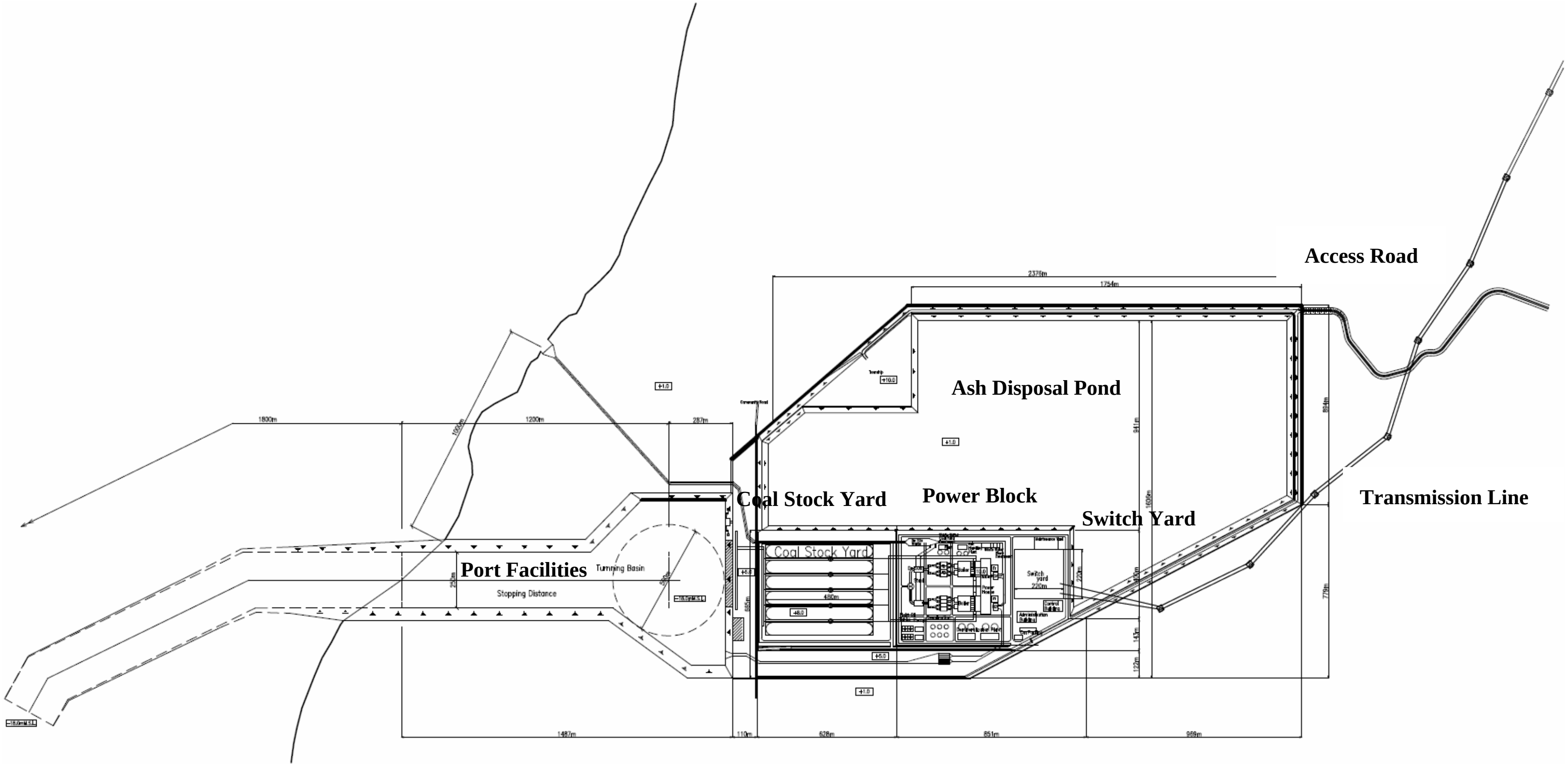
There shall be optimized allocation for each energy flow, such as fuel (coal and ash), cooling water and electric power (transmission line). Also, allocation for each energy flow shall not interfere with each other at the points of transportation, construction, operation and maintenance.

The power block shall be located at the center of the power plant.

The coal stock yard will be located on the west side of the power block and beside the port.

The ash disposal pond will be located on the northeast side of power block in light of the wind direction.

A concept drawing of the power plant is shown in Figure 7.4-4. This plant layout is designed so as not to inhibit the construction of two additional units and a coal center.



(Source: JICA Study Team)

Figure 7.4-4 Overall Power Plant

7.4.5 Environmental requirements

The environmental requirements of the Plant shall be in accordance with the applicable Bangladesh standards, regulations and laws as well as the Environmental, Health and Safety Guidelines of the International Finance Corporation (IFC Guidelines).

(1) Airborne Emissions

The plant exhaust emissions shall not exceed the emission limit of pollutants shown on Table 7.4-5. EP and FGD shall be installed to meet such limitation. The proposed requirement in the bidding document comes from the result of numerical simulation carried out in Chapter 15.

Table 7.4-5 Emission Limits of Pollutants

Pollutant	Unit	IFC Guidelines	Bangladesh Standards	Proposed Requirement
NOx	mg/m^3N	510	600	460
SO_2	mg/m^3N	850	- [a]	820
Particulate Matter	mg/m^3N	50	150	50

(Source) Environmental, Health, and Safety Guidelines for Thermal Power Plants, IFC 2008

Schedule 11and 12, Rule 13, Environment Conservation Rules, 1997

(Note) The above are based on 6% O_2 dry conditions.

a) At least a 275m height stack is required for dispersion of sulfuric acid.

Regarding the SO_2 emission limit, IFC Guidelines state that selection of the emission level in the range is to be determined by EIA considering the project's sustainability, development impact, and cost-benefit of the pollution control performance.

(2) Noise Emission

The noise levels shall not exceed the standard noise levels mentioned in Table 7.4-6. At this stage, the noise limit at the plant boundary can not be established. It should be established considering that the noise level of the nearest village shall be kept within 50 dBA during daytime and 45 dBA during night time.

Table 7.4-6 Noise Standards for Industrial Areas

	Unit	IFC Guidelines	Bangladesh Standards	
			Residential area	Industrial area
Day time	dBA	70 (7:00 – 22:00)	55 (6:00 – 21:00)	75 (6:00 – 21:00)

	Unit	IFC Guidelines	Bangladesh Standards	
			Residential area	Industrial area
Night time	dBA	70 (22:00 – 7:00)	45 (21:00 – 6:00)	70 (21:00 – 6:00)

(Source) General Environmental, Health, and Safety Guidelines, IFC 2007

Schedule 4, Rule 12, Environment Conservation Rules, 1997

All measurement of noise and testing shall be done in accordance with ANSI B133.8.
To comply with the above stated noise criteria, any modifications necessary, including the installation of additional and/or improved sound attenuation equipment, shall be implemented.

(3) Industrial Wastewater Quality
The treated wastewater discharge quality shall meet the standards in Table 7.4-7. A wastewater treatment system shall be installed to meet such limits.

Table 7.4-7 Industrial Effluent Standards

Sl. No.	Parameter	Unit	IFC Guidelines	Bangladesh Standards
1.	Ammoniacal Nitrogen (N molecule)	mg/l	-	50
2.	Ammonia (free ammonia)	mg/1	-	5
3.	Arsenic (As)	mg/1	0.5	0.2
4.	BOD_5 20°C	mg/1	-	50
5.	Boron	mg/1	-	2
6.	Cadmium (Cd)	mg/1	0.1	0.50
7.	Chloride	mg/1	-	600
8.	Chromium (total Cr)	mg/1	0.5	0.5
9.	COD	mg/1	-	200
10.	Chromium (hexavalent Cr)	mg/1	0.5	0.1
11.	Copper (Cu)	mg/1	0.5	0.5
12.	Dissolved Oxygen (DO)	mg/1	-	4.5-8
13.	Electrical Conductivity	mho/cm	-	1200
14.	Total Dissolved Solids (TDS)	mg/l	-	2,100

<table>
<tr><th>Sl. No.</th><th colspan="2">Parameter</th><th>Unit</th><th>IFC Guidelines</th><th>Bangladesh Standards</th></tr>
<tr><td>15.</td><td colspan="2">Fluoride (F)</td><td>mg/1</td><td>-</td><td>2</td></tr>
<tr><td>16.</td><td colspan="2">Sulfide (S)</td><td>mg/1</td><td>-</td><td>1</td></tr>
<tr><td>17.</td><td colspan="2">Iron (Fe)</td><td>mg/1</td><td>1.0</td><td>2</td></tr>
<tr><td>18.</td><td colspan="2">Total Kjeldahl Nitrogen (N)</td><td>mg/1</td><td>-</td><td>100</td></tr>
<tr><td>19.</td><td colspan="2">Lead (Pb)</td><td>mg/1</td><td>0.5</td><td>0.1</td></tr>
<tr><td>20.</td><td colspan="2">Mangaense (Mn)</td><td>mg/1</td><td>-</td><td>5</td></tr>
<tr><td>21.</td><td colspan="2">Mercury (Hg)</td><td>mg/1</td><td>0.005</td><td>0.01</td></tr>
<tr><td>22.</td><td colspan="2">Nickel (Ni)</td><td>mg/1</td><td>-</td><td>1.0</td></tr>
<tr><td>23.</td><td colspan="2">Nitrate (N molecule)</td><td>mg/1</td><td>-</td><td>10.0</td></tr>
<tr><td>24.</td><td colspan="2">Oil & grease</td><td>mg/1</td><td>10</td><td>10</td></tr>
<tr><td>25.</td><td colspan="2">Phenol compounds(C_6H_5OH)</td><td>mg/1</td><td>-</td><td>1.0</td></tr>
<tr><td>26.</td><td colspan="2">Dissolved Phosphorus (P)</td><td>mg/1</td><td>-</td><td>8</td></tr>
<tr><td>27.</td><td colspan="2">Radioactive Materials</td><td colspan="3">As determined by Bangladesh Atomic Energy Commission</td></tr>
<tr><td>28.</td><td colspan="2">pH</td><td>mg/1</td><td>6-9</td><td>6-9</td></tr>
<tr><td>29.</td><td colspan="2">Selenium</td><td>mg/1</td><td>-</td><td>0.05</td></tr>
<tr><td>30.</td><td colspan="2">Zn (Zn)</td><td>mg/1</td><td>1.0</td><td>5</td></tr>
<tr><td>31.</td><td colspan="2">Total Dissolved Solids</td><td>mg/1</td><td>-</td><td>2,100</td></tr>
<tr><td rowspan="2">32.</td><td rowspan="2">Temperature</td><td>Summer</td><td>^{O}C</td><td>-</td><td>40</td></tr>
<tr><td>Winter</td><td>^{O}C</td><td>-</td><td>45</td></tr>
<tr><td>33.</td><td colspan="2">Total Suspended Solid (TSS)</td><td>mg/1</td><td>50</td><td>150</td></tr>
<tr><td>34.</td><td colspan="2">Cyanide (CN)</td><td>mg/1</td><td>-</td><td>0.1</td></tr>
<tr><td>35.</td><td colspan="2">Total Residual Chlorine</td><td>mg/1</td><td>0.2</td><td>-</td></tr>
<tr><td>36.</td><td colspan="2">Temperature increase</td><td>^{O}C</td><td>*</td><td>-</td></tr>
</table>

(Source) Environmental, Health, and Safety Guidelines for Thermal Power Plants, IFC 2008

Schedule 10, Rule 13, Environment Conservation Rules, 1997. Place for determination of standard is Inland Surface Water.

(Note) * Site specific requirement to be established by the EA. Elevated temperature areas due to the discharge of once-through cooling water (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.

(4) Sanitary Wastewater Quality

The treated sanitary wastewater quality shall meet Bangladesh standards in Table 7.4-8. Septic tanks shall be installed to meet such limitations.

The listed IFC Guidelines are for reference purposes only because the IFC Guidelines state that they are applicable in the case of the absence of national or local standards for sanitary wastewater discharges. Septic tanks shall be installed to meet such limitations.

Table 7.4-8 Sanitary Effluent Standards

Parameter	Unit	IFC Guidelines (reference)	Bangladesh Standards
pH	-	6 - 9	-
BOD	mg/1	30	40
COD	mg/1	125	
Total nitrogen	mg/1	10	250
Total phosphorus	mg/1	2	35
Oil and grease	mg/1	10	
Total suspended solids	mg/1	50	100
Total coliform bacteria	MPN / 100ml	400	1000
Temperature	^{O}C	-	30

(Source) Environmental, Health, and Safety Guidelines for Thermal Power Plants, IFC 2008

Schedule 9, Rule 12, Environment Conservation Rules, 1997

(Notes) MPN = Most Probable Number

(5) Environmental Monitoring Facilities

The Continuous Emission Monitoring System (hereinafter called “CEMS”) shall be installed to monitor flue gas from the Plant. CEMS shall be required to monitor the amount of the flue gas and its concentrations of NOx, SO2, and Particulate Matter.

The continuous monitoring system for the amount of the effluent from the wastewater treatment system and its pH value and turbidity shall be monitored. The monitoring shall be conducted at the treated water pit of the wastewater treatment system in the Plant.

7.4.6 Boilers and flue gas treatment facilities

Boilers and flue gas treatment facilities for this project shall be composed of two boilers, two electrostatic precipitators, and a flue gas desulfurization system, and their auxiliary equipment, each of which is associated with each of the two condensing type steam turbines of 600 MW generation capacities.

(1) Boilers

The two boilers shall both be pulverized coal firing, radiant reheat, and variable pressure once-through boilers for outdoor installation. Each boiler will be designed as a balanced draft furnace with low NOx burners and over fire (two stage firing) system and pulverized coal from vertical shaft roller type mills shall be fired directly in the boiler. The design criteria of the boilers are shown in Table 7.4-9.

Table 7.4-9 Boiler Design Criteria

Type	Radiant Reheat, Variable Pressure, Once-through Boiler (Outdoor Installation)
Steam Flow Rate at B-MCR; Main steam: Reheat steam:	 1,760 t/h 1,490 t/h
Steam Pressure at B-MCR; Superheater outlet: Reheater outlet:	 25.4 MPa (g) 4.75 MPa (g)
Steam temperature; Superheater outlet: Reheater outlet:	 604 ºCº 602 ºC
Firing system	Pulverized coal firing with Low NOx burners and over fire air (two stage firing) Light oil or high speed diesel oil (30% capacity) for unit start up, and ignition and stabilization of coal burners
Drafting System	Balanced draft with forced draft fans and induced draft fans
Primary air system	Cold primary air fan
Steam temperature control method	Feed water/fuel flow ratio and spray water for main steam and flue gas damper and spray water (emergency) for reheat steam

(Source: JICA Study Team)

Note: B-MCR means Boiler Maximum Continuous Rating.

The boiler will be designed for pulverized coal firing and light oil will be used for igniters and initial warm up for unit starting up. The boiler shall have corner or opposite fired, water cooled furnace, radiant- and convection- heat transfer superheaters and reheaters, attemperators, economizers, regenerative air heaters, and a HP/LP turbine bypass system.

(2) Primary Air Fan, Forced Air Fans

Each boiler has 2 x 50% capacity primary air fans (PAF) and 2 x 50% capacity forced draft fans (FDF) for supplying the required primary/secondary air for the boiler. These fans will be of axial flow type with variable pitch moving blades.

(3) Induced Draft Fans

Each boiler will be equipped with 2 x 50% capacity induced draft fans for keeping the draft of the furnace at slightly reduced pressure to prevent flue gas leakage. These fans will be of axial flow type with variable pitch moving blades.

(4) Boiler Circulation Pumps

There will be 1 x 25% boiler circulation pump with glandless submerged motor. The purpose of this pump is to return water drained from the water separator to the inlet of the economizer and recover the heat during the operation at 25% or lower load. In the case of a base load unit as with this project, installation of this pump might not be necessary.

(5) Soot Blowing System

The boiler shall be provided with dozens of long retractable soot blowers and wall blowers. The entire soot blower operations shall be carried out from the DCS of the plant control system. An intelligent automatically controlled operation system will be applied for the soot blower system.

(6) Burner Management & Automatic Plant Control Systems

The boiler will be equipped with a complete burner management system including mill automation and secondary air control with all required accessories as detailed in the DCS System (Control and Instrumentation).

(7) Mills & Milling System

Each boiler shall be installed with six vertical shaft roller type mills, including one standby for the pulverized coal firing system. Each mill has a gravimetric raw coal feeder. The pulverized coal from each mill is transported through several pulverized coal pipes to the burners. The burners are arranged for tangential firing or opposite firing. Five pulverizes would meet the normal rating of B-MCR with designed coal while one will be for maintenance or stand by.

(8) Electrostatic Precipitators

The flue gas dust collection system for each boiler shall consist of a two pass electrostatic precipitator (ESP). The electrostatic precipitator ash collection hoppers will have a capacity sufficient for twelve hours operations at the maximum collection rate in any section of the electrostatic precipitator. The ESPs will be provided complete with motorized rapping mechanisms, rectifier transformers, hoppers and their heaters and all associated auxiliaries. The hopper outlet shall be provided with a diversion gate for Dry Fly Ash collection System. The

ESP will be capable to limit dust emission to 100 mg/Nm^3 with one ESP Field series out of service at MCR, with the worst coal having the maximum ash content.

Since the FGD system in the downstream of ESP is capable of a minimum of 50% removal efficiency, the dust emission will be reduced to $50mg/Nm^3$ or less at the stack.

(9) Flue Gas Desulfurization System (FGD)

a) Type of FGD

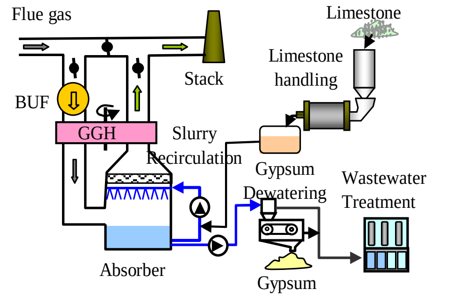
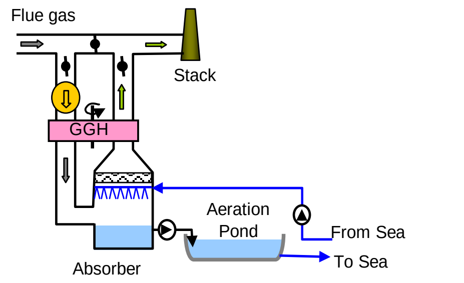
Two types of FGD systems are applicable for this project. One is the Limestone/Gypsum FGD and the other one is Seawater FGD. A comparison of both systems is shown in Table 7.4-10. Seawater FGD is recommended for this project with the following reasons:

(i) Since Seawater FGD uses seawater as an absorbent of SO_2, a handling system and pulverizing system of limestone are not required.

(ii) Since no byproducts such as gypsum is produced, a dewatering, storage and delivery system and disposal area are not required.

(iii) Because of the above reasons, project costs and land area will be extremely reduced.

Table 7.4-10 Comparison between Limestone/Gypsum FGD and Seawater FGD

Process	Limestone/Gypsum FGD	Seawater FGD
Outline		
Chemical Reaction	Sulfur dioxide + Calcium carbonate + Water + Oxygen ⇒Gypsum + Carbon dioxide $SO_2+CaCO_3+2H_2O+1/2O_2$ $\Rightarrow CaSO_4 \cdot 2H_2O+CO_2$	Sulfur dioxide + Seawater ⇒ Sulfite ion, Sulfite ion + Oxygen ⇒ Sulfate ion $SO_2+H_2O \Rightarrow SO_3^{-}+2H$, $SO_3^{-}+1/2O_2 \Rightarrow SO_4^{--}$
FGD efficiency	90~99%	90~95%
Absorbent	Limestone	Seawater
Byproduct	Gypsum (utilized as cement/plaster material)	Effluent (discharged back to the sea)
Waste water treatment	Wastewater treatment by WWT plant	Oxidation in Seawater aeration pond
Plant space	Larger (limestone/gypsum facilities & gypsum disposal pond)	Smaller (seawater aeration pond)
Water consumption	Service water	(Seawater)
Availability	Very high	Higher (no limestone/gypsum handling)
Levelized cost	Base	Cheaper (better)
Unit capacity	~1000 MWe	~1000 MWe
Application for Utility	Since 1970s, world share 83%	Since 1990s, world share 3%
Manufacturer	Many manufacturers	A few manufacturers

(Source: JICA Study Team)

b) Configuration of Seawater FGD

Seawater FGD for each boiler of this project shall consist of the following equipment/facilities:

- One set of sulfur dioxide absorbers
- One set of regenerative gas-gas heaters (GGH)
- A few sets of seawater boost up pumps
- Seawater pipes and valves
- Two sets of FGD boost up fans
- One flue gas bypass system (one bypass duct and one bypass damper)
- Inlet and outlet flue gas ducts

- Air blowers for aeration
- One aeration pond (common use for two boilers)
- Electrical power supply system
- Instrumentation and control system

c) Required Performance of FGD system

FGD shall reduce SO_2 in flue gas to 820 mg/Nm^3 or less to satisfy Bangladesh regulations and the international standards, including the WHO. Since SO_2 concentration in flue gas entering FGD is estimated as 2,958 mg/Nm^3 for the worst coal condition (sulphur content of 1.0%), the SO_2 removal efficiency is required to be higher than 73%.

FGD shall also be capable of reducing the dust in flue gas with 50% or higher removal efficiency.

According to the result of an air dispersion simulation, the flue gas is required to be higher than 75°C at the stack to get a sufficient dispersion. Each FGD shall be equipped with a regenerative type gas-gas heater.

The required performances for the boiler flue gas treatment facilities are as shown in Table 7.4-11.

Table 7.4-11 Required Performance for Flue Gas Treatment Facilities

	Unit	ESP Inlet	FGD inlet	Stack	Remarks
Wet Gas Flow	Nm^3/h	1,916,900	1,916,900	1,819,500	per unit
Dry Gas Flow	Nm^3/h	1,660,400	1,660,400	1,660,400	per unit
Flue Gas Temperature	ºC	130	130	75	
Oxygen in flue gas	dry vol. %	3.89	3.89	3.89	
Stack height	m	-	-	275	
Stack ID	m	-	-	7.3	
Stack Velocity	m/s	-	-	15.4	
Pollutant Concentrations (dry, 6%O_2)					IFC Standard
NOx (as NO_2)	mg/Nm^3	460	460	460	510
SO_2	mg/Nm^3	2,958	820	820	850
PM	mg/Nm^3	9,015	100	50	50
Pollutant Emissions					
NOx (as NO2)	kg/h	872	872	872	per unit
SO2	kg/h	5,605	1,554	1,554	per unit
PM	kg/h	17,083	189	95	per unit

7.4.7 Steam turbine and auxiliaries

The steam turbine plant will be comprised of a steam turbine, condenser, condensate equipment, feed water heaters, boiler feed pumps and condenser circulating cooling water system as the fundamental configuration.

(1) Steam Turbine

a) Type;

The steam cycle system will be a single reheat, ultra supercritical, condensing type required for high efficiency and a large-size power plant. The steam cycle is of ultra supercritical pressure considering that the unit size is 600 MW class.

b) Shaft Configuration

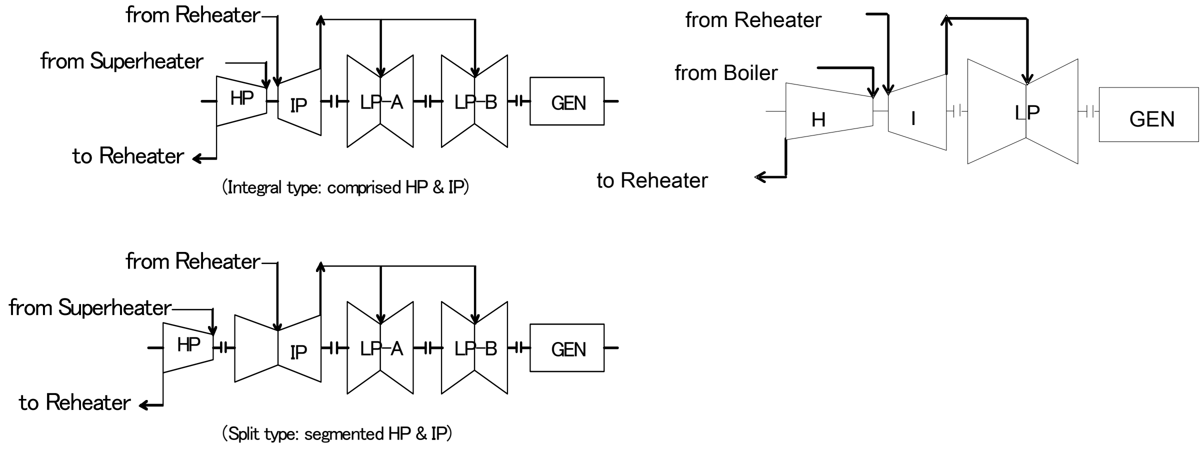
There are two types of shaft configuration, which are the tandem compound (hereinafter referred to as “TC”) and cross compound (hereinafter referred to as “CC”).

For the TC shaft configuration, high pressure (HP), intermediate pressure (IP) and low pressure (LP) steam turbines are connected in the same shaft. For the CC shaft configuration, the shafts of HP, IP and LP steam turbines are separated. The shaft of the HP steam turbine is called the primary shaft, the other one is called the secondary shaft. Figure 7.4-5 shows the TC shaft configuration, while Figure 7.4-6 shows the CC type.

In the case of the CC type, the secondary axial side runs at half speed (1,500 rpm) and is referred to as a two speed compound machine.

In the latest design of TC configuration for the 600MW class, a single outer casing HP/IP turbine and one double flow LP turbine type has been developed by introduction of 48 inch blades for the last stage of the LP turbine. Applying such latest design contributes to high efficiency and decreasing investment costs.

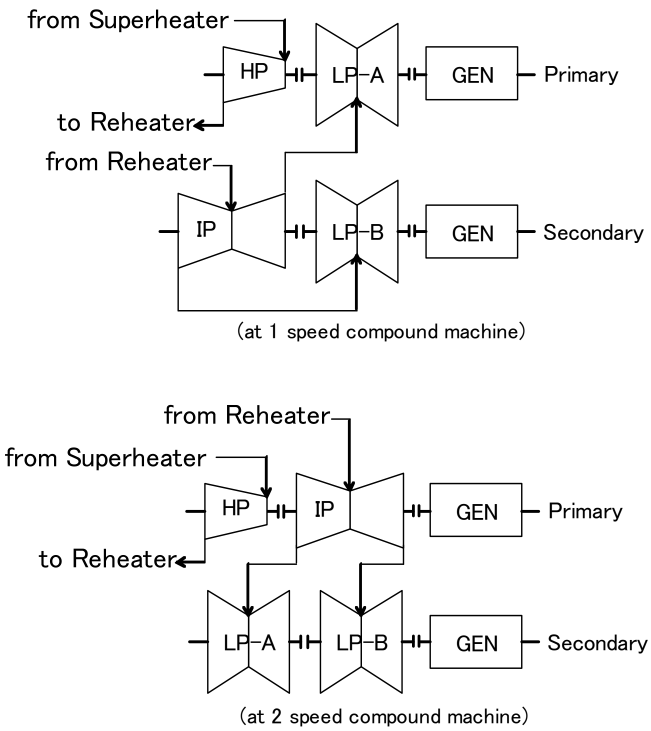
Both types of TC and CC have individual specific features illustrated in the next sub-section.



(Integral type: comprised HP & IP and one LP)

(Source: JICA Study Team)

Figure 7.4-5 Tandem Compound Shaft Configuration



(Source: JICA Study Team)

Figure 7.4-6 Cross Compound Shaft Configuration

C) Comparison of Specific Features of TC and CC Shaft Configurations

The CC shaft configuration is applied to large scale units, of which the secondary shaft runs at half the speed of the primary shaft to reduce the centrifugal force imposed on the root section of the longer blades of the LP steam turbine.

The TC is also applied to the 600MW class steam turbine units as the result of development of the LP turbine longer blades to withstand the centrifugal force under the same speed as the primary speed.

Table 7.4-12 shows the comparison results between TC and CC shaft configurations of 600MW class steam turbines.

The TC shaft configuration is preferable for the Project considering advantages such as “Installation space is smaller”, “Operability is simpler” and “Maintainability is easier”.

Table 7.4-12 Comparison between TC and CC Shaft Configurations

Comparison Item	TC	CC
Number of axis	1	2
Shaft length	Longer	Base
Operating reliability	Similar	Base
Turbine efficiency	Same	Base
Installation space	Smaller	Base
Operability	Simpler	Base
Maintainability	Easier	Base
Construction cost	Less	Base
Running cost	Same	Base

(2) Condenser

a) Design Concept

In thermal power plants, the purpose of a surface condenser is to condense the exhaust steam from a steam turbine into cycle water (steam condensate) so that it is reused in the boiler as boiler feed water.

There are many fabrication design variations depending on the manufacturer, the size of the steam turbine, and other site-specific conditions.
A single pass-one division of tube and shell circuit schematics is preferable, even for condenser types for large-sized turbines, being based on the HEI (Heat Exchange Institute) standard.

b) Required amount of cooling water

The required amount of cooling water (G_w) for the condenser is calculated by the following formula.

$$G_w = Q/(\delta td \times cp \times \rho)$$

Q: Incoming heat to condenser（kcal/h）

δ td: temperature difference of cooling water between inlet and outlet of condenser (°C)

cp: specific heat of cooling water (kcal/kg °C)

ρ : specific gravity of cooling water (kg/m^3)

Based on the data of a similar power plant with the same capacity and same steam conditions, and adding an amount of bearing cooling water, etc., the total required amount of cooling water was estimated at 50 m^3/s for two units.

c) Condenser Vacuum

The estimate for a condenser vacuum such as 8.47 kPa (a) (saturated temperature 42.6°C) is done on the basis of the method provided in the HEI standard. The following example is provided for reference.

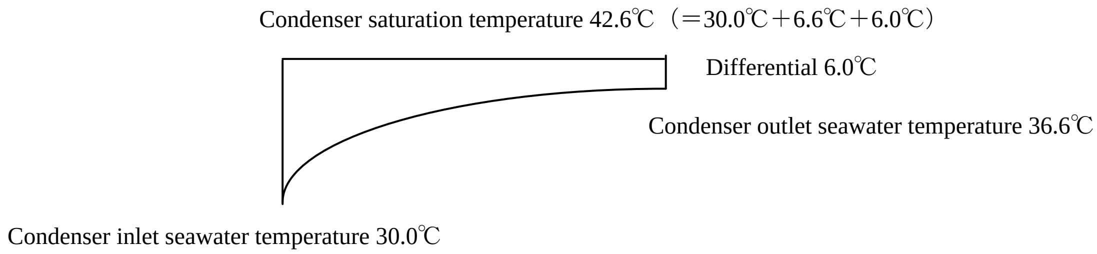
On the one hand, the condenser vacuum depends on the actual measurement data of seawater temperature, and the vacuum has been studied on the basis of a design seawater temperature of 30.0°C at the condenser inlet in accordance with Table 7.4-13 Rated Condition of steam/water cycle conditions of Clause 7.4.7 (7).

The cooling water facilities will be designed so that discharged water temperature will be 37°C, which is not considered problematic since the temperature is not higher than 40°C which is the maximum temperature allowed in the waste water quality standards of Bangladesh.

Therefore, the temperature has been set to 36.6°C, which is a lower value than the above standard. By adding the seawater temperature rise of 6.6°C in the condenser, and the estimated temperature difference of 6.0°C between the saturated temperature of condenser and condenser outlet seawater temperature, to the condenser inlet seawater temperature, the saturated temperature of condenser has been set at 42.6°C.

The saturated condenser pressure of 2.50 inch Hg abs. = 8.47 kPa (abs) equivalent to the above saturated temperature has been adopted as the design condenser vacuum.

It will sometimes be necessary to review the seawater temperature of the condenser outlet to a certain extent depending upon the conditions of yearly seawater temperature change at the power plant construction site.



(Source: JICA Study Team)

Figure 7.4-7 Relationship between Saturated Temperature of Condenser and Sea Water Temperature

d) Tube material

In general, tubes are made of stainless steel, copper alloys such as brass or bronze, cupro nickel, or titanium depending on several selection criteria. The use of copper bearing alloys, such as brass or cuprous nickel, is rare in new plants, due to environmental concerns of toxic copper alloys. Also, depending on the steam cycle water treatment for the boiler, it may be desirable to avoid tube materials containing copper. From the viewpoint of reliability and anti-corrosion, titanium is the best technical choice for the Project.

(3) Vacuum system

For water-cooled surface condensers, the shell’s internal vacuum is most commonly supplied and maintained by two types of vacuum systems, such as steam jet type air ejectors and motor driven vacuum pumps.

The motor driven vacuum pumps are preferable on the basis that they are more serviceable.

(4) Condensate demineralizer

A USC plant does not have function of boiler water blow and however it requires high quality of boiler feed water so that a condensate demineralizer shall be installed after the condensate extraction pumps. Contaminants in the condensate water are colloidal matters of iron and cupper etc, sodium ion and chloride ion. In some case the condensate demineralizer is to equip filters to remove colloidal matters. After the filters the condensate demineralizer has ion exchangers for dissolved matters.

(5) Feedwater heater

Feedwater heaters are applied to improve thermal efficiency. The source of heating is the extracted steam from the turbine. The number of heaters is determined considering economic benefits such as improved efficiency and additional investment costs, etc. In general, six to eight heaters are installed for large scale power plants over 200MW.

a) Heat exchanger;

A heat exchanger is a device built for efficient heat transfer from one fluid to another. The fluid may be separated by a solid wall, so that they are never mixed, or they may be in direct contact. Heat exchangers may be classified according to their flow arrangement.

In parallel-flow heat exchangers, two fluids enter the exchanger at the same end, and travel in parallel to the other side. In counter-flow heat exchangers the fluids enter the exchanger from opposite ends. The counter-flow design is more efficient, in that it can transfer the most heat from the heat (transfer) fluid.

① Types of heat exchangers:

The shell and tube heat exchanger is the most common type of heat exchanger in large coal fired power plants, and is suitable for higher-pressure applications.

This type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside of the shell. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids.

② Shell and tube heat exchanger:

Feed water is at a high pressure so that a shell and tube heat exchanger is applied. In this case, feed water flows inside of the tube and extracted steam and its condensate flows outside of the tube. There can be many variations on the shell and tube design. Typically, the tubes are bent in the shape of a U (called U-tubes) and the ends of each tube are connected to water boxes divided by a partition sheet.

U-tube heat exchangers are the most common type of heat exchanger in coal fired power plants.

③ Selection of tube material

To be able to transfer heat well, the tube material should have good thermal conductivity. Because heat is transferred from the hot to cold side through the tubes walls, there is a temperature difference through the width of the tubes. Because of the tendency of the tube material to thermally expand differently at various temperatures, thermal stress occurs during operation. This is in addition to any stress from high pressures from the fluids themselves. The tube material should also be compatible with both the shell and tube side fluids for long periods under the operating conditions (temperatures, pressures, pH, etc.) to minimize deterioration of the tubes, such as corrosion.

All of these requirements call for a careful selection of strong, thermally-conductive, corrosion-resistant, high quality tube materials, typically metals, including copper alloy, stainless steel, carbon steel, non-ferrous copper alloy, Inconel, nickel, hastelloy and titanium. An inadequate selection of tube material might result in a leak in the tube between the shell and tube sides causing fluid cross-contamination and possibly loss of pressure.

b) Deaerator

A deaerator is a device that is widely used for the removal of air and other dissolved gases from the feed water to steam-generating boilers. In particular, dissolved oxygen in boiler feedwaters will cause serious corrosion damage in steam systems by the oxidizing of surfaces of metal piping and other metallic equipment. Water also combines with any dissolved carbon dioxide to form carbonic acid that causes further corrosion. Most deaerators are designed to remove oxygen down to levels of 7 ppb by weight (0.0005 cm^3/L) or less.

From technical (efficiency and operation, etc.) aspects and cost aspects, tray-type and spray-type deaerators are considered the main options for selection.

(6) Pumps

Pumps such as condensate extraction/condensate booster pumps, boiler feed /feed water booster pumps, closed cycle cooling water pumps, seawater booster pumps and circulating water pumps are installed in the plant.

a) Condensate pump

A condensate pump is a specific type of pump used to extract the condensate (water) in the hot-well of a condenser.

Condensate pumps, as used in hydraulic systems, are usually motor-driven centrifugal pumps.

In a thermal power plant, the condensate pump is normally located adjacent to the main condenser hot-well, often directly below it.

These pumps are used in succession to provide sufficient Net Positive Suction Head (NPSH) to prevent cavitation and the subsequent damage associated with it.

b) Boiler feed pump

A boiler feed pump is a specific type of pump used to pump feedwater into a steam boiler. The water may be freshly supplied or returning condensate produced as a result of the condensation of the steam produced by the boiler.

These pumps are normally high pressure units that use suction from a condensate return system and can be of the centrifugal pump type.

(7) Specifications

The specifications of the Steam Turbine and Auxiliaries are shown in Table 7.4-13.

Table 7.4-13 Specifications of Steam Turbine and Auxiliaries

Item	Specifications
Turbine	
Type	Tandem compound, single reheat, ultra supercritical, two-flow, condensing type
Power Output at generator terminals	600 MW
Rated Speed	3,000 rpm
Number of Casings	one (1) HP・ IP & one (1) LP
Steam Pressure at MSV	24.5 MPa (g)
Steam Temperature at MSV	600ºC
Steam Temperature at RSV	600ºC
Number of Extractions	8
Control System	Digital Electro-hydraulic Controller (D-EHC)
Condenser	
Type	Surface cooling, single pass-one division, shell and tube type
Condenser Vacuum	Approx. 8.47 kPa (abs)
Design Inlet CW Temperature	30.0ºC
CW Temperature Rise	7 ºC and below
Tube Cleanliness Factor	0.9
Cleaning Equipment	Ball Cleaning System
Tube Material	Titanium
Feedwater Heater	
Type	Surface cooling, shell & tube type
Number of Heaters	8 including Deaerator
Condensate Extraction Pump (CP)	
Type	Vertical Barrel, Multistage Diffuser Type (Motor driven)
Number	3 x 50%
Boiler Feed Pump (BFP)	
Type	Turbine driven (T-BFP) plus Motor driven (M-BFP) Horizontal, Multistage Diffuser Type
Number	Option 1: 3 x 50% (T-BFP) plus 1 x 30% (M-BFP) Option 2: 2 x 50% (T-BFP) plus 2 x 30% (M-BFP)
BFP Booster Pump	

Item	Specifications
Type	Horizontal, Multistage Diffuser Type (Motor driven)
Number	Option 1: 3 x 50% Option 2: 2 x 50%
Circulating Water Pump (CWP)	
Type	Vertical, Single Stage Type (Motor driven)
Number	3 × 50%

(Source: JICA Study Team)

(8) Boiler Feed water treatment

There are three treatments for once-through boilers as shown in Table 7.4-14.

Historically AVT was a major method in which pH was controlled using ammonia, and oxygen in the feed water was removed using hydrazine. Thus dissolved oxygen was kept at a quite low level (less than 7μg/l) and pH was kept on the alkali side to form a protective film of magnetite (Fe_3O_4). The formation speed of such oxide scale was fast so that periodical (every two – three years) chemical cleaning of boilers and heaters was required.

On the other hand, in NWT and CWT, low concentration oxygen is injected and hematite (Fe_2O_3) scale is formed. The solubility of hematite is quite low and the surface of film is smooth compared with magnetite. Consequently, the application of CWT/NWT has the advantage of reducing chemical cleaning and power consumption of boiler feed water pumps.

In Japan, the first CWT application to a large once-through boiler was in 1990. CWT is now applied to 53 thermal power plants with satisfactory results. Therefore applying CWT to boiler feed water treatment is suitable because of the advantages and sufficient results mentioned above.

Table 7.4-14 Boiler Feed-Water Treatments for Once-Through Boilers

Water Treatment Type	All Volatile Treatment (AVT)	Neutral Water Treatment (NWT)	Combined Water Treatment (CWT)
pH (at 25 °C)	9.0-9.7	≒7	8.0-9.3
Cation conductivity (mS/m)	≦0.025	≦0.02	≦0.02
Dissolved oxygen (μg/l)	less than 7	20-200	20-200
Chemicals	Ammonia	Oxygen	Ammonia

Water Treatment Type	All Volatile Treatment (AVT)	Neutral Water Treatment (NWT)	Combined Water Treatment (CWT)
	Hydrazine		Oxygen

(Source) Mitsubishi Heavy Industries Technical Review Vol. 49 No. 1 (March 2012)

7.4.8 Coal and ash handling facilities

7.4.8.1 Coal Handling System

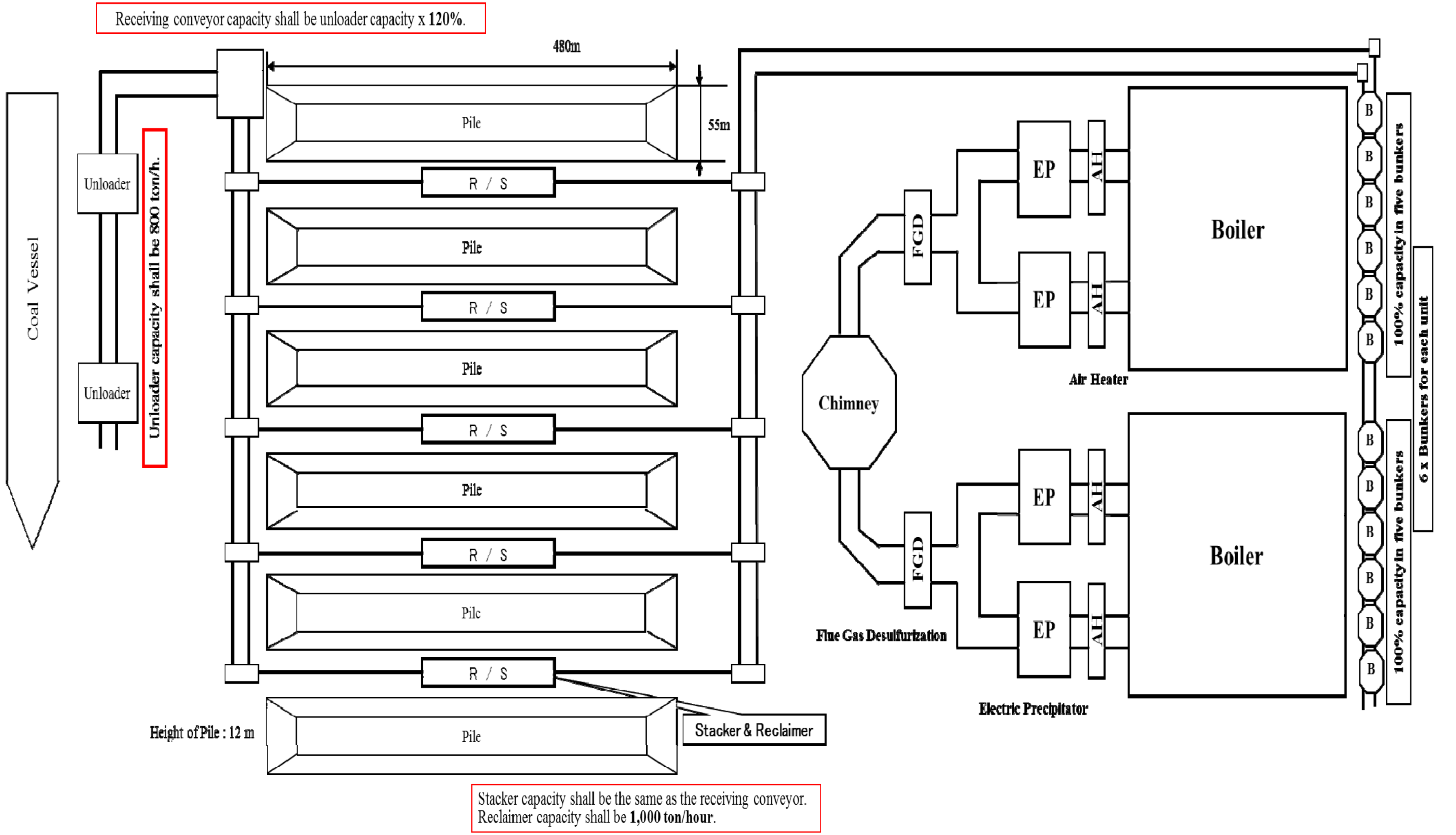
Fuel coal is accommodated at a berth located in the excavated port of the power plant.

Fuel coal is unloaded from a vessel by two unloaders installed on the berth. The unloaded coal is transferred to a relay station at the coal yard via a belt conveyer. Assuming 800 ton/hour as the capacity of each unloader, for 80,000 DWT (Panamax) class vessels, the unloading of the fuel coal from one vessel will be finished in approximately 96 hours. Coal in the coal yard is handled by five stackers/reclaimers. Figure 7.4-8 shows an indicative flow diagram of the coal handling system.

(1) Consumption of the Coal (Design Conditions)

The coal yard is assumed to be an open type. The storage nominal capacity of the coal yard is specified to meet coal consumption for approximately 60 days with continuous operation with a capacity factor of 100% of two units at the rated output. The number of 60 days for storing the quantity of the coal takes a margin of ten days into consideration, assuming that coal transport vessels may be prevented from coming alongside the quay for about 50 days a year due to the interference of cyclones every year.

- ➢ Study conditions
  - ✓ Gross power output (ECR) 2 x 600 MW
  - ✓ Gross power output ratio (B-MCR/ECR) 1.08 (assumed)
  - ✓ Gross thermal efficiency 41.29 % (HHV basis)
  - ✓ Coal calorific value (typical) 4,700 kcal/kg (HHV)
  - ・ Maximum Consumption of coal per hour (for 2 units, at B-MCR) = 600,000 kW x 2 x 1.08 x 860 kcal/kWh x (100 / 41.29) / 4,700 kcal/kg /1,000 = 574.3 ton/hour
  - ・ Maximum Consumption of coal per day = 574.3 ton/hour x 24 hours/day = 13,783.2 ton/day
  - ・ Consumption of coal per year = 600,000 kW x 860 kcal/kWh x (100 / 41.29) / 4,700 kcal/kg /1,000 x 365x 24 x 80% = Say 3,727 x 1,000 ton/year



(Source: JICA Study Team)

Figure 7.4-8 Indicative Flow Diagram of the Coal Handling System

(2) Nominal Capacity of the Unloader

It is necessary to consider the size of the coal transportation vessel to specify the capacity of the unloader. The capacity of the coal vessel is assumed to be 80,000 DWT class with a scheduled 49 entries into port per year.

- ✓ Vessel capacity : 80,000 DWT class
- ✓ Vessel coal loading rate : 0.95
- ・ Number of unloading = 3,727 x 1000/(80,000 ton x 0.95) = 49.03 = Say 49 times/year
- ♦ Number of coal vessel entries : 49 times/year

Assuming four days for each unloading of coal, the total days per year required for 49 unloadings of coal will be 196 days. This is a capacity utilization rate of about 55%. In consideration of efficient use of unloading coal equipment and the periods restricted entry into port by bad weather, this number can be said to be appropriate.

In consideration of the number of times of unloading fuel coal and the periodical inspection of the unloader, two unloaders are required.

(3) Unloader Type Selection

Table 7.4-15 shows a comparison between the grab type and continuous bucket type of unloaders.

The continuous bucket type has advantages over the grab type from various viewpoints such as dust prevention, operability and maintainability. However, it does not have a cost advantage.

For this project, considering that the coal vessels will be of the 80,000 DWT class, coal should be unloaded within four days per vessel including work preparation time. Therefore, the continuous bucket type unloader is better for this project because its unloading efficiency is greater than that of the grab type.

Table 7.4-15 Comparison between Grab Type and Continuous Bucket Type

	Grab Type	Continuous Bucket Type
Loading Efficiency	Basic	Better
Total Work Time for this Project	Approx. 110 hours	Approx. 96 hours
Dust Prevention	Base	Higher
Operability	Base	Easier
Maintainability	Base	Easier
Construction Cost	Base	Higher
Evaluation	Base	Better

(Source: JICA Study Team)

The coal handling system is planned to be operated continuously for 24 hours in 8-hour shifts.

Each shift takes 2 hours for work preparation and 6 hours for actual operation.

Study conditions

a) Usual conditions

- ✓ Unloading days : 4 day
- ✓ Number of unloaders : 2 units per vessel
- ✓ Unloader nominal capacity : 800 t/h (assumption)
- ✓ Entrance and departure of the vessel : 6 hours

b) Case 1 (Grab Type) conditions

- ✓ Loading efficiency : 0.6
- ✓ Work preparation time : 26 hours (2 hours x 13 shifts)
  - Total work time = (80,000 ton x 0.95) / (800 t/h x 2 x 0.6) + 32 hours = 111.2 hour/vessel

c) Case 2 (Continuous Bucket Type) conditions

- ✓ Loading efficiency : 0.7
- ✓ Work preparation time : 22 hours (2 hours x 11 shifts)
  - Total work time = (80,000 ton x 0.95) / (800 t/h x 2 x 0.7) + 28 hours = 95.9 hour/vessel
- ♦ Type of unloader : Continuous bucket type is better for the Project

(4) Nominal Capacity of the Receiving Conveyor

The capacity of the receiving conveyer must be specified to meet the total maximum capacity of the two unloaders. The number of the receiving conveyers to be installed is assumed to be two units (including one spare set). The maximum capacity of the unloader is said to be generally 120% of the nominal capacity. Therefore, the conveyor unit capacity shall be calculated based on the nominal capacity of the unloader.

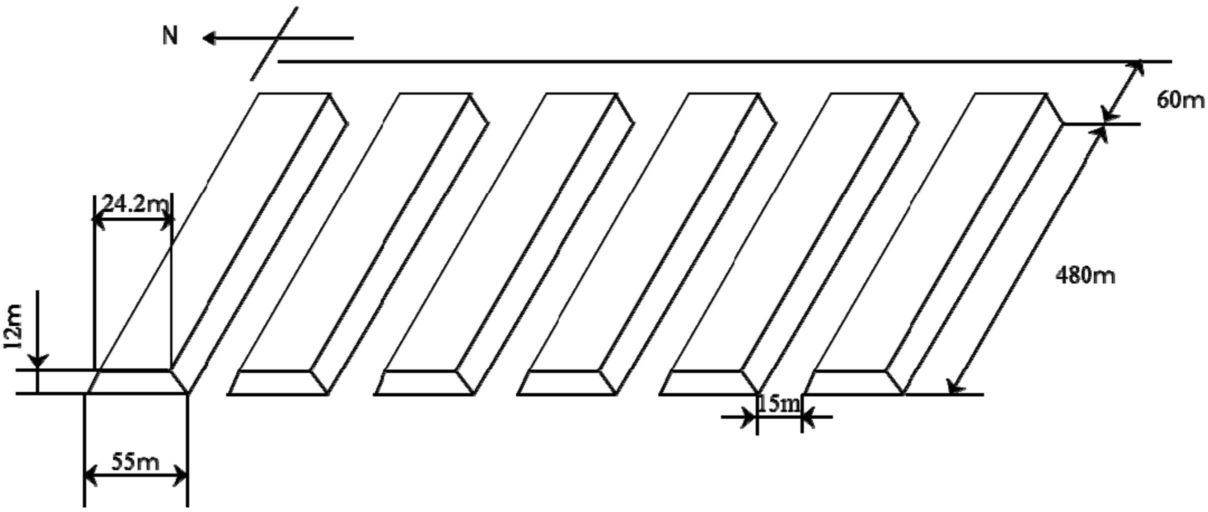
(5) Nominal Capacity of the Coal Yard

The coal yard is of open type. The storage nominal capacity of the coal yard is specified to meet the coal consumption for approximately 60 days of continuous operation with a capacity factor of 100% of two units at the rated output. The number of 60 days for storing the quantity of the coal takes a margin of ten days into consideration, assuming that coal transport vessels may be prevented from coming alongside the quay for about 50 days a year due to the interference of cyclones every year.

The necessary storage capacity is estimated at 830,000 ton as shown below:

- Quantity of coal stored = 13,783 ton/day x 1.0 x 60 day = 827,034 ton = Say 830,000 ton

It is assumed that the coal is stored with six piles as shown below:



(Source: JICA Study Team)

Figure 7.4-9 Pile Size

Sub-bituminous coal tends to combust spontaneously during storage. The following countermeasures should be taken to avoid such a phenomenon.

- Temperature monitoring of the insides of the pile
- Roller compaction by bulldozer
- Water sprinkling

The calculation of the coal yard size is assumed as below:

- ✓ Number of piles : 6, Height : 12 m, Bottom Width : 55 m, Repose angle : 38°
- ✓ The intervals and the perimeters of piles are 15 m
- ✓ Coal density = 0.8 ton/m^3
- ✓ Storage efficiency = 0.77

The nominal capacity of the coal stock yard size is as shown below:

- ✓ One pile capacity = 830,000 ton / 6 = 138,333 = Say 140,000 ton
- ✓ Pile capacity per meter = (29.4+55.0) x 10.0 / 2 = 422 m^3/m
- ✓ Pile length = 140,000 / 0.8 / 0.77 / 422 = 539 m = Say 540 m
- ✓ Space for coal handling = 60 m
- ✓ The directions of north and south = 480 m + 60 m + 15 m x 2 = 570 m
- ✓ The directions of east and west = 55 m x 6 + 15 m x 7 = 435 m
- ♦ Coal stock yard size = 570 m x 435 m = 247,950 m^2 < 25 ha

(6) Nominal Capacity of the Stackers/Reclaimers

a) Nominal Capacity of the Stackers

The nominal capacity of the stackers must be the same as the nominal capacity of the receiving conveyors.

b) Nominal Capacity of the Reclaimers

The coal handling system is planned to be operated continuously for 24 hours in 8-hour shifts. Each shift takes 2 hours for work preparation and 6 hours for actual operation. The nominal capacity of the reclaimer is estimated so that the required amount per day of coal can be supplied in 18 hours as shown below:

- Study conditions:
  - ✓ Actual operation time : 18 hours (6 hours x 3 shifts)
  - ✓ Work preparation time : 6 hours (2 hours x 3 shifts)
  - ✓ Loading efficiency : 0.8
  - ・ Nominal Capacity of the Reclaimer = 13,783 ton/day / 18 hours / 0.8 = 957 ton/hour < 1,000 ton/hour
- ♦ Reclaimer Nominal Capacity : 1,000 ton/hour

c) The number of the Stackers/Reclaimers

The number of stackers/reclaimers shall be 5sets in consideration with operability, and they will be installed between respective piles.

(7) Nominal Capacity of the Discharge Conveyor

The capacity of the discharge conveyor has to be designed so as to meet the capacity of the reclaimer with a 10% margin. Therefore, the nominal capacity of the discharge conveyor is estimated at 1,100 ton/hour as shown below. It is a definite requirement that the unit has to be continuously operated even if one discharge conveyor is out of order. For this purpose, the number of discharge conveyors must be two, including one spare.

Moreover, the type of the conveyer should be a ground type that can be easily inspected.

- ♦ Discharge Conveyor Nominal Capacity = 1,000 ton/hour x 1.1 = 1,100 ton/hour
- ♦ Discharge Conveyor Nominal Capacity : 1,100 ton/hour
- ♦ Number of Discharge Conveyors : 2 sets

(8) Conveyor Type Selection

Table 7.4-16 shows a comparison between the flat type and pipe type. The pipe type conveyor has advantages over the flat type conveyor from various viewpoints such as flexible layout and dust prevention. When the type of the conveyer is selected, reliability is an important factor. Therefore, the flat type conveyor is preferred for this project because its reliability is greater than the pipe type conveyor.

Moreover, after the plot plan is determined in the detailed design stage, the type of conveyor will be given further consideration.

Table 7.4-16 Comparison between Flat Type and Pipe Type

	Flat Type with Wind Guard	Pipe Type
Maximum Angle of Inclination	Approx. 15 degrees	Approx. 30 degrees
Curved Transport	No	Yes
Dust Prevention	Low	Base
Reliability	High	Base
Construction Cost	Slightly low	Base
Maintenance Cost	Low	Base
Experience	Many	Base
Evaluation	Better	Base

(Source: JICA Study Team)

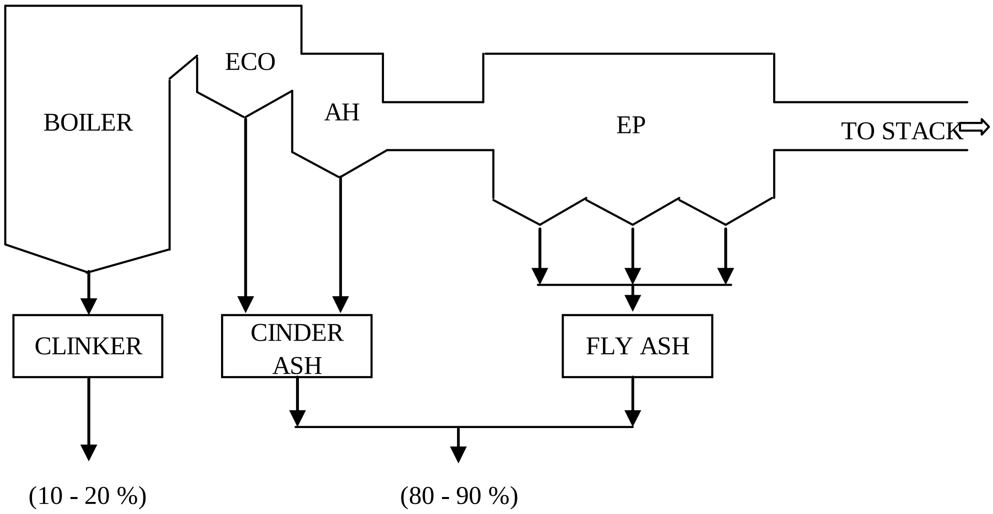
- ♦ Type of the Conveyor : Flat type with wind guard is better for the Project

7.4.8.2 Ash Handling System

Figure 7.4-10 shows an example of the distribution of ash in the various parts of the coal fired boiler.

In general, ash in coal is captured in various parts in the flue gas flow (outlined below) in the course of the combustion of coal in the boiler until the flue gas is discharged from the stack.

- ・The ash which is melted by the coal combustion falls to the bottom hopper of the boiler furnace and is captured. This is called clinker. About 10 - 20% of the amount of all ash is captured in this way.
- ・A part of the combustion ash which floats in the flue gas falls to the bottom hopper of the economizer and the air heater in the downstream of flue gas and is captured. This combustion ash is called cinder ash. 5% or less of the amount of all ash is captured here.
- ・The combustion ash which is captured by the electrostatic precipitator is caught in the bottom hopper of the electrostatic precipitator. It is called fly ash. In general, 80 - 90% of the amount of all ash is captured here.



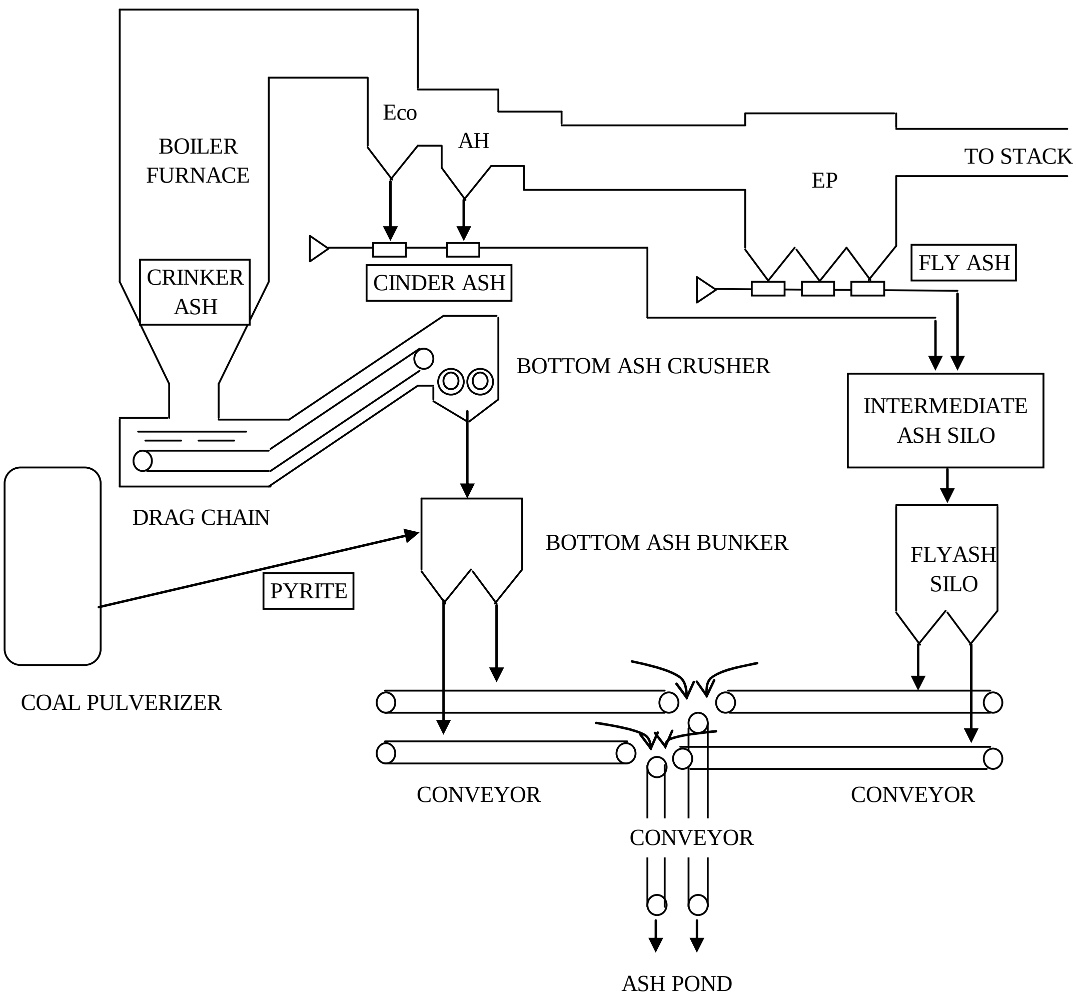
(Source: JICA Study Team)

Figure 7.4-10 Place of Generation and Ratio of Generation of Coal Ash

The collected coal ash is generally transported and processed through ash handling systems that may be roughly categorized into two systems as follows. Figure 7.4-11 shows an overview of the ash handling system.

・The first system handles clinker that falls to the bottom hopper of the boiler and the pyrite exhausted from the coal pulverizer.

・The second system handles the cinder ash and fly ash that falls to the bottom hopper of the economizer, air heater and electrostatics precipitator.



(Source: JICA Study Team)

Figure 7.4-11 Ash Handling System

(1) Bottom Ash Handling System

The bottom ash handling systems are classified into typical types, such as the water sealed drag chain system and air sealed drag chain system. The air sealed system is superior to the water sealed system, because waste water has no discharge. However, the air sealed system was only developed a few years ago and therefore there is limited experience with this system. The boiler sealed system is very important for the reliable operation of boilers. The most popular type, the water sealed drag chain system, is described for the purpose of this study.

The water sealed drag chain system handles clinker ash that falls to the bottom hopper of the boiler and the pyrite exhausted from the coal pulverizer. The clinker that falls to the bottom hopper of the boiler is collected using the water sealed conveyor and is dehydrated for transport to a bottom ash bunker for temporary storage. The pyrite flows into the bottom of the ash bunker. The clinker ash and pyrite are transported to the ash disposal pond by belt conveyer in order to keep the power station roads clean.

(2) Fly Ash Handling System

The fly ash handling systems are classified into the vacuum system, pneumatic system and vacuum - pneumatic system. The vacuum system is superior to the pneumatic system, because the ash does not disperse if the piping is damaged. However, the vacuum system can only be adopted for short distance transportation. Therefore, the vacuum - pneumatic system is often adopted in large scale power plants. For the purposes of this study, the most popular type, the vacuum – pneumatic system is described.

The vacuum – pneumatic system handles the cinder ash and fly ash that falls to the bottom hoppers of the economizer, air heater and electrostatic precipitator. The cinder ash and fly ash are transported to intermediate ash silos using a vacuum and transported from intermediate ash silos to the fly ash silos for temporary storage using compressed air. Finally, the fly ash is transported to the ash disposal pond by belt conveyer in order to keep the power station roads clean.

(3) Nominal Capacity of the Ash Pond

The nominal capacity of the ash disposal pond is calculated based on the total volume of the ash to be accumulated for the duration of 25 years operation with 80% capacity factor of two units.

- Consumption of coal per day (for 2 units, at 100% load) = 13,783 ton/day
- Annual consumption of coal = 13,783 ton/day x 365 day x 0.8 = 4,025 thousands ton/year
- ✓ Ash content of the coal is 20%
- Volume of coal ash per year = 4,025 thousand tons/year x 0.2 = 805,000 ton/year (A)
- ✓ Unburnt carbon is 0.125%
- Volume of coal ash per year = 4,025 thousand tons/year x 0.00125 = 5,031 ton/year (B)
- ✓ Annual ash volume : (A)+(B) = 805,000 ton/year + 5,031 ton/year = 810,000 ton/year
- ✓ 810,000 ton/year ÷ 1.2 ton/m^3 (compaction with bulldozer and roller) = 675,000 m^3/year

Therefore, the total volume of ash for 25 years operation is calculated as shown below:

- Ash total volume = 810,000 ton/year x 25 year = 20,250,000 ton
- 20,250,000 ton ÷ 1.2 ton/m^3 = 16,875,000 m^3

On the other hand, it is possible to discard the ash into the sloped portion of the embankment. The capacity of the sloped portion is 462,240 m^3 (= height 9m x width 24.1m x length 4,800m / 2).

Therefore, the required area of the ash pond without the sloped portion of the embankment is as follows:

- (16,875,000 - 462,240)m^3/ 9 m (tentative embankment height) = 182.3 ha

- ♦ Required area of ash pond: 183 ha.

(4) Utilization of Ash

Various studies have been conducted regarding effective utilization of coal ash produced in large quantities in the boiler, and the following uses have proven practical.

- Clinker
  - Road bed material
- Fly ash
  - Material for cement
  - Concrete aggregate
  - Road pavement
  - Fertilizer

As described above, there are various ways to use coal ash. However, coal ash cannot be utilized immediately after starting operation since at present there is no distribution system for coal ash in Bangladesh. CPGCBL could benefit by setting up an organization within CPGCBL to sell coal ash and finding ways to develop this market. This would make it possible to reduce the amount of waste ash in the ash pond, and if the cement plant is built in the surrounding area, it should stimulate the local economy.

(5) Utilization of Dredged soil

The JICA Study Team estimated the amount of dredging soil in the port plan area. The dredged range of soil will consist of silt soil and sandy soil. The quantity and classification of soil to be dredged are the key factors for the capacity of ash pond. The sandy soil is appropriate for the land development, and all sandy soils will be used by site development. The silt or clay soil will be useless but for embankment, the remaining soil will be poured into the ash discharge pond.

Based on the amount of dredged soil referred to Table 8.1-7, the additional required capacity of the ash pond is provided in section 8.1.4.

7.4.9 Water treatment system

(1) Water source

Service water is utilized as the source of demineralized water for boilers, cooling water for equipment, ash disposal and firefighting, etc.

There is no source of fresh surface water in the vicinity of the site, and underground water is not suitable to draw a sufficient amount of water given possible adverse effects, such as the drying up of wells in the vicinity of the site and subsidence of the ground.

Therefore, a desalination plant is required to produce service water.

(2) Desalination Plant

1) Comparison among MSF, MVC and RO

Desalination methods are roughly classified into three types such as Multi-Stage Flash distillation (hereinafter referred to as “MSF”), Mechanical Vapor Compression (hereinafter referred to as “MVC”) and Reverse Osmosis technology (hereinafter referred to as “RO”).

MSF applies the flash phenomenon induced when sea water decompresses under saturated pressure using steam heat. MVC applies a compressor as the heat source for vaporization. RO is a membrane separation process utilizing the principle of osmotic pressure. By pressurizing saline solution, pure water can be separated from the solutes through a membrane, as a reverse movement of normal osmosis (see Figure 7.4-11).

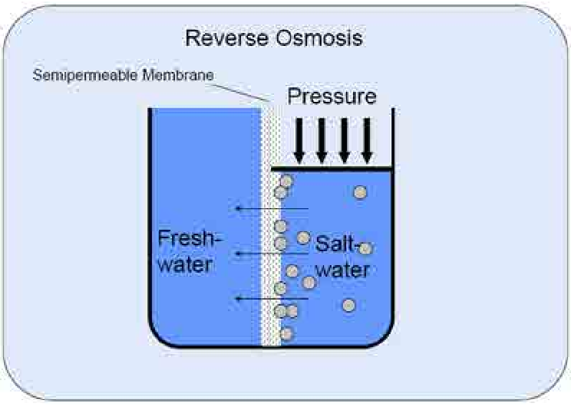


Figure 7.4-12 Principle of Reverse Osmosis

A comparison of each type of desalination method is provided in Table 7.4-15. Indicative technical data and comparison results are dependent on sea water quality so that a detailed selection of the type of desalination method should only be made after consideration of the actual water quality, especially Total Dissolved Solids (TDS), Turbidity (NTU) and Silt Density Index (SDI).

Suspended solids and colloidal materials in sea water are one of the biggest problems in reverse osmosis (RO) systems. Even though most systems have some pretreatment, including 5 micron prefilters, these fine particles are responsible for the fouling of reverse osmosis membranes.

In order to evaluate the degree of this fouling, the Silt Density Index (SDI or Fouling Index, FI) is measured. This method is standardized as ASTM D4189-07 Standard Test Method for Silt Density Index (SDI) of Water.

To measure the SDI, a 0.45 micron filter is exposed to the feedwater under pressure (2.07 bar) and flow rates are measured during the collection of 500 mL samples at the start of the test (T0) and after 15 minutes (T). Calculation of SDI is as follows.

$$SDI = (1-T0/T) \times 100/15$$

An SDI of less than 5 is considered acceptable for the reverse osmosis systems. This means that at values of SDI of less than 5, the membranes should foul at a very low rate. Even though the index works most of the time, there are exceptions when a lower SDI (less than 3) is desirable due to the nature of the suspended solids in that feedwater.
If sea water quality is acceptable and not very contaminated, applying the RO system is feasible as it is mature technology and has recently been viewed as economically efficient.

Table 7.4-17 Comparison between MSF, MVC and RO

	MSF	MVC	RO
Total dissolved substance (TDS) of produced water *1	10	5	10 (by two stages treatment)
Investment cost *1	Higher	Higher	Base
Energy Consumption *1	25 kWh/m^3 (incl. steam energy)	11 kWh/m^3	5 kWh/m^3
O&M cost *1 (excl. energy cost)	Cheaper	Cheaper	Base
Raw Water Consumption (per produced water m3) *1	6-8 m^3/m^3	3 m^3/m^3	2 m^3/m^3
Characteristics	- High reliability - Considerable experience for large capacity plants - Suitable for sea water desalination - Corrosion, scale problems	- Simple system - High reliability - Has become a possible process - Suitable for sea/river water desalination - Lower temperature operation than MSF	- Simple system - Least energy consumption - Has become a major process - Suitable for sea/river water desalination - Short life of membrane

		- Less corrosion, scale problems than MSF	(about 5 years) - Sensitive to sea water quality

(Note) *1: Depending on sea water quality.

2) Pre-treatment Facilities

Processes that rely on microporous membranes must be protected from fouling. Membrane fouling causes a loss of water production (flux), reduced permeate quality and increased trans-membrane pressure drop.

Membrane fouling is typically caused by precipitation of inorganic salts, particulates of metal oxides, colloidal silt, and the accumulation or growth of microbiological organisms on the membrane surface. These fouling problems can lead to serious damage and necessitate more frequent replacement of membranes.

Pre-treatment facilities, including chemical treatment, clarifier (if required) and filters, are required to remove suspended solids to avoid membrane fouling.

(3) Demineralization Plant

The demineralization plant is designed based on the latest cost effective ion exchange technique of counter current regeneration. The units consist of corrosion free pressure vessels internally connected in series. There is a column containing cation absorbing exchanger and another column is charged with an anion absorbing exchanger. Generally, in the final stage a mixed bed exchanger is equipped as back-up use against leaked ion.

Therefore the plant removes dissolved chemical impurities/salts from water to a specified degree. At certain regular intervals, the cation exchanger is regenerated with an acid and the anion exchanger resin is regenerated with an alkali solution.

(4) Potable Water Production Plant

Desalinated water will be used to produce potable water. To sterilize the water, hypochlorite dosing or ultraviolet (UV) disinfection will be applied.

(5) Scope of supply

1) Desalination Plant

Raw water intake strainer:	1 set/unit
Raw water supply pump:	1 set/unit
Raw water storage tank	1 set/unit
Raw water transfer pump:	1 set/unit
Initial Filtration device:	1 complete set
Intermediate Filtration device:	1 complete set
Reverse Osmosis (RO) device:	1 complete set
Chemical injection equipment:	1 complete set
Desalination water storage tank:	2 sets (100％ x 2)

2) Demineralization Plant

Raw water supply pump:	1 set/unit
Filter:	1 set/unit
Anion tower (if required):	1 set/unit
Cation tower (if required):	1 set/unit
Mixed bed type ion exchange tower:	1 set/unit
Intermediate pump:	1 set/unit
Waste water regenerating pump:	1 set/unit
Blower:	1 set/unit
Hydrochloric acid storage tank:	1 set
Caustic soda storage tank:	1 set
Various dilution tanks:	1 complete set
Demineralized storage tank:	2 sets (100% x 2)
Make-up pump:	2 sets (100% x 2)

3) Potable water production plant

Pump:	2 sets/unit
Carbon filter:	2 sets/unit
Disinfection system (Hypochlorite dosing or UV)	1 set/common (100% x 1)
Potable water storage tank:	1 set/common (100% x 1)

(6) Conceptual schematic diagram of water treatment system

Figure 7.4-12 shows the conceptual schematic diagram of the water treatment system. Figure 7.4-13 shows an Estimated Water Balance Diagram.

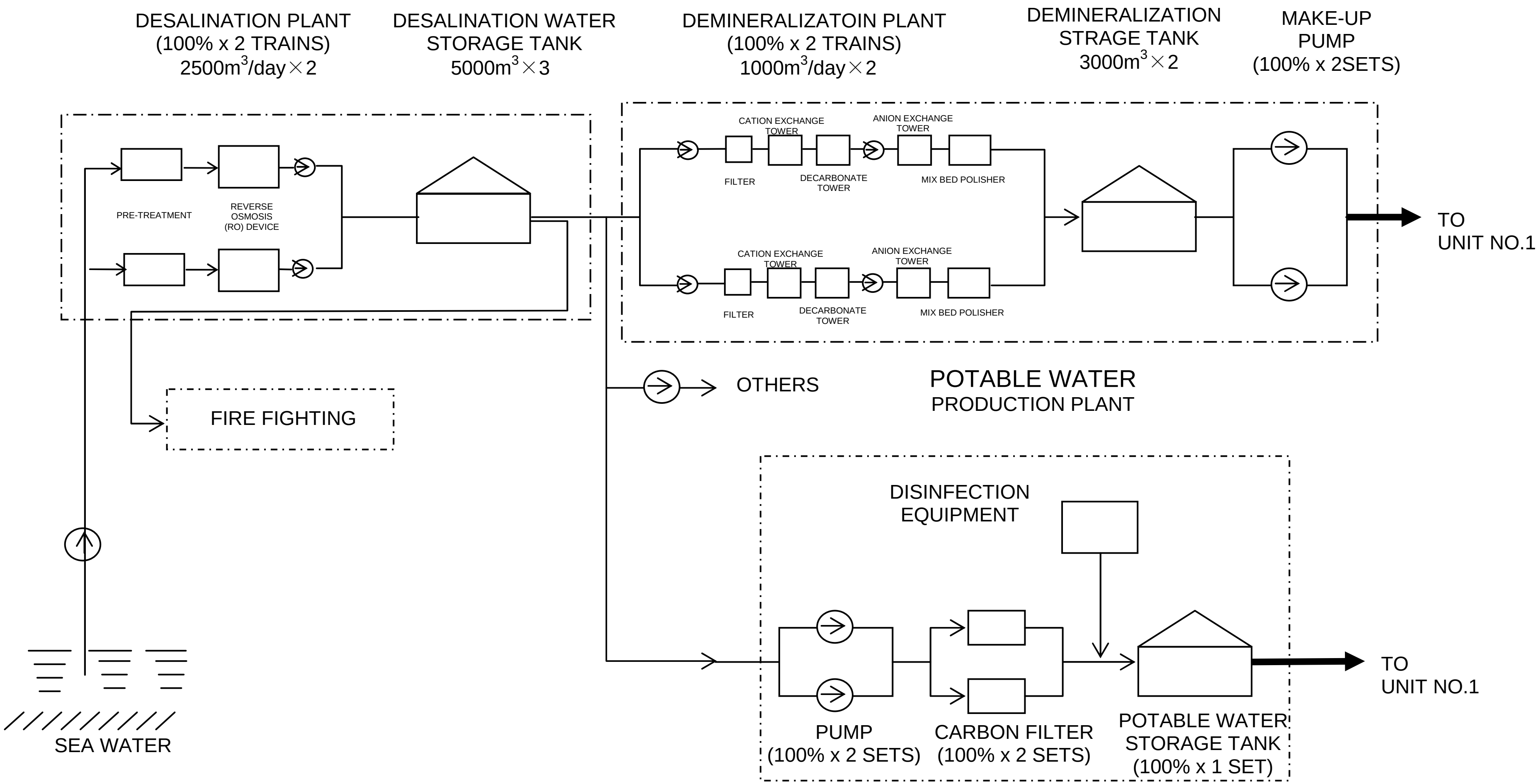


Figure 7.4-13 Conceptual Schematic Diagram of Water Treatment System

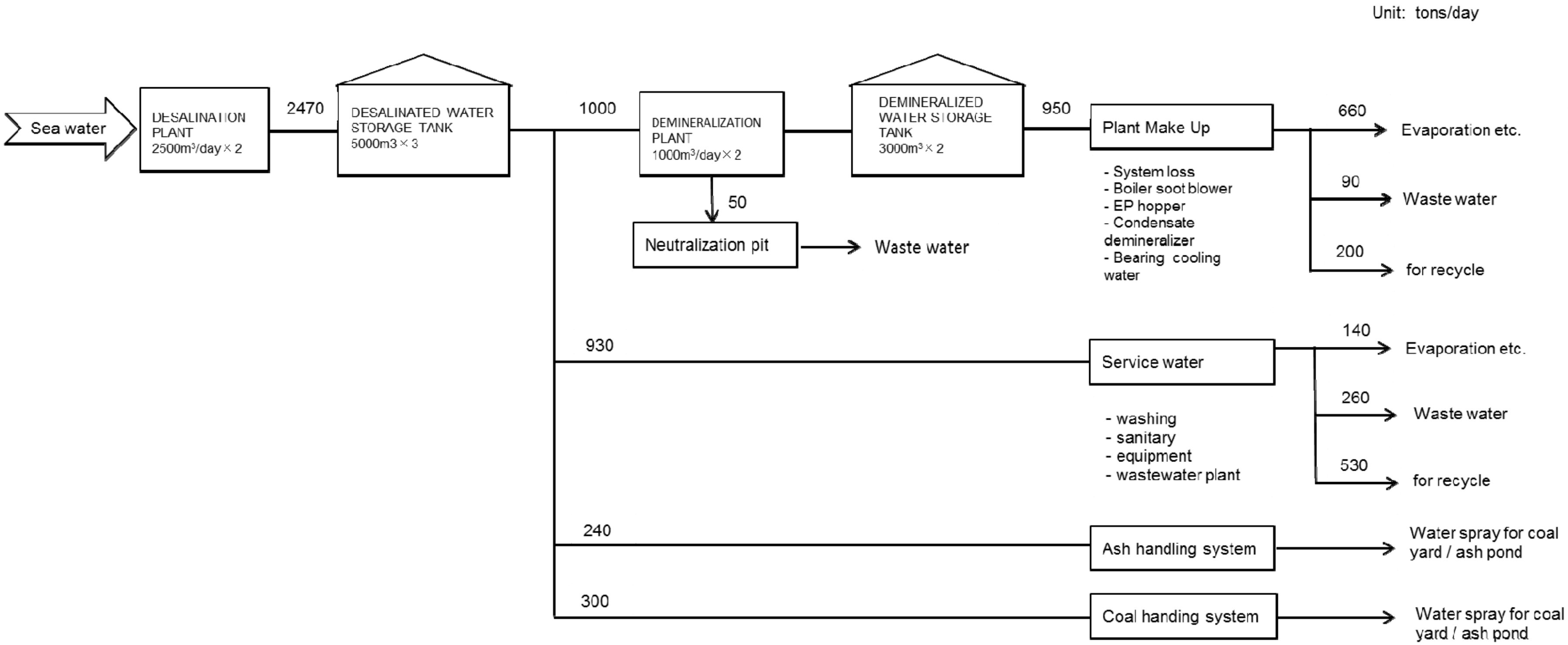


Figure 7.4-14 Estimated Water Balance Diagram

7.4.10 Wastewater treatment system

(1) Overview Specifications

1) General

The general treatment concepts of the various effluent streams are as follows:

i) The process wastewater shall be treated in the wastewater treatment plant, after which it shall be discharged into the cooling water discharge line with quality satisfying standards stipulated in Section 7.4.5 Environmental Requirements. The process wastewater includes waste streams from plant oily waste, drains, and other miscellaneous streams. Wastewater sample points shall be provided in the plant.

ii) Boiler blowdown shall be directed to the boiler blowdown tank with quenching by cooling water, after which it shall be directed into the boiler sump pit.

iii) Oil-contaminated effluent shall be treated in an oil/water separator. After which the effluent shall be routed into the wastewater storage pit.

iv) Wastewater from the water treatment plant shall be routed into the wastewater storage pit.

v) In no case shall the untreated effluent be discharged either directly or indirectly to any surface or ground water source.

vi) Sludge collected by the wastewater treatment plant shall be transferred to an appropriate disposal site.

vii) Sanitary wastewater from buildings in the plant shall be routed directly to an on-site sewage treatment plant.

viii) Roof drain, storm water and water tanks overflow shall be conveyed into a check pit and discharged into the cooling water discharge line after checking water quality (at least pH value and oil content).

ix) Coal yard rainwater shall be treated separately using the coagulation and filtration method.

x) Wastewater from the coal conveyer cleaning system shall be treated separately using the coagulation and sedimentation method. Concentrated coal slurry shall be returned to the coal yard.

xi) Ash pond wastewater shall be treated separately using the sedimentation and neutralization method.

2) Scope of supply:

Wastewater storage pit	1 set
pH regulator pit	2 sets
Coagulation pit	2 sets
Sedimentation pit	2 sets
Intermediate pit	1 set
Sludge storage pit	1 set
Neutralization pit	1 set
Filter	2 sets
Dehydration equipment	1 complete set
Supply pump	2 sets
Intermediate pump	2 sets
Sludge discharge pump	2 sets x 2
Dehydrator supply pump	2 sets

(2) Conceptual schematic diagram of the wastewater system

Figure 7.4-15 shows a conceptual schematic diagram of the wastewater system.

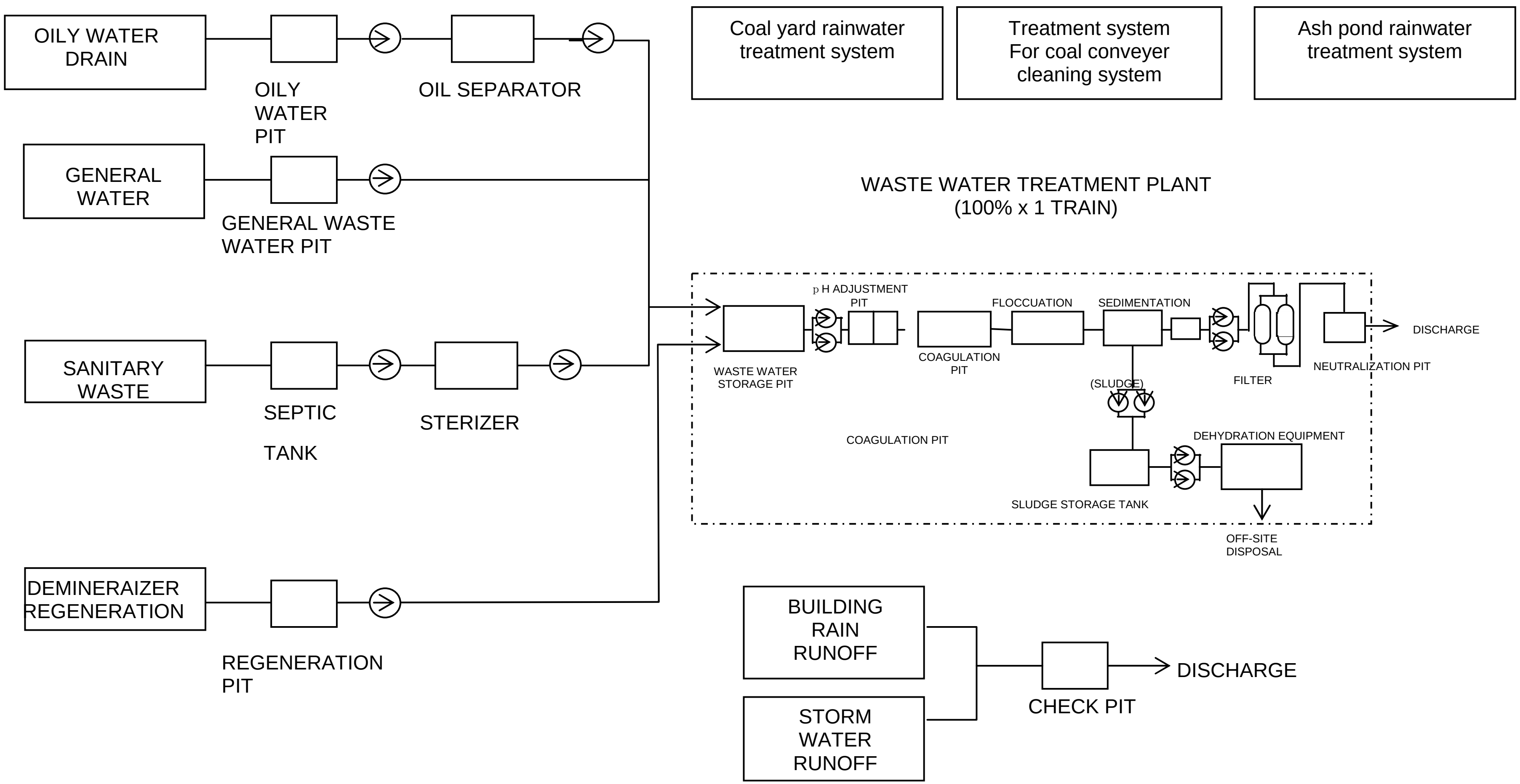


Figure 7.4-15 Conceptual Schematic Diagram of the Wastewater System

7.4.11 Fire fighting system

(1) General

A water spray system is recommended as it is quickly effective for the local cooling extinguishment of fires. And it is generally used for firefighting systems of thermal power plants in which there is the possibility of the spread of fire due to heat from the continuous fire of the plant.

The Fire Fighting System will be equipped with the following specialized fire alarm and hydrocarbon firefighting systems as a minimum requirement for one unit.

(2) Scope of supply

Fire extinguishers:	1 complete set
Handy firefighting implements:	1 complete set
Inside fire hydrants:	1 complete set
Foam fire extinguishing equipment	1 complete set
Inert gas (carbon dioxide) fire extinguishing equipment:	1 complete set
Halogenide (halon 1301) fire extinguishing equipment:	1 complete set
Powder fire extinguishing equipment:	1 complete set
Outside fire hydrants:	1 complete set
Electric fire extinguishing pumps:	1 complete set
Emergency alarm equipment:	1 complete set
Evacuation equipment and facilities:	1 complete set
Water for firefighting with water tank and reservoir:	1 complete set
Smoke control equipment:	1 complete set
Interconnected sprinkler system:	1 complete set
Emergency power lines:	1 complete set
Fire truck:	1 truck

(3) Standard

Firefighting activities for the main building are to be undertaken in accordance with the acting security norms, standards and regulations for power plants of Bangladesh, and facilities shall be designed on the basis of NFPA standards.

7.4.12 Electrical equipment

7.4.12.1 Conceptual Design of the Unit Electrical System

The configuration of the power plant consists of two boilers, two steam turbines and two generators. Each generator shall be connected to the Generator Step-Up Transformer (GSUT) by an Isolated Phase Bus duct (IPB) respectively. The voltage of the power output from the generator shall be stepped up to 400kV by GSUT. The output from the GSUT shall be transmitted to the Bangladesh network via the 400kV switchyard located next to the power plant area.

As a request from the BPDB, a generator main circuit breaker located at the GSUT low voltage side shall not be introduced. Therefore, each generator shall be synchronized with the Bangladesh network by a generator circuit breaker located at the GSUT high voltage side respectively.

In addition to the 400kV switchyard circuit breakers, the 400kV circuit breakers for the generator step up transformers and the station auxiliary transformers shall be provided at the high voltage side of each transformer, and these shall be controlled and monitored from the CCR by DCS.

The design criteria for configuration, size and rating of components of the unit auxiliary power distribution system are as follows:

(1) A single event (either a planned or forced outage of a piece of equipment) shall not cause the loss of the generating unit, but may lead to reduced output of the unit.

(2) For voltage levels 400V and above, except for the case of single-ended switchgear, it shall be possible for any switchgear power supply to transfer safety either automatically or manually as applicable from one source to the alternate source under normal operating conditions, without having to black-out the switchgear.

(3) Loss of the transformer (other than the generator step-up transformer and excitation transformer) shall not lead to an output of the generating unit.

The failure of a unit transformer may cause the loss of the generating unit until such time as the faulty unit transformer is isolated and the unit can be restarted from a healthy transformer.

(4) Loss of the switchgear bus bar, normally fed from the unit transformers shall lead to a power output reduction of generation less than 50% and shall not cause a loss of the generating unit.

Each unit shall be provided one three-winding Unit Auxiliary Transformers (UAT) and branched from the generator main circuit by IPB connection.

One three-winding Station Auxiliary Transformer (SAT) shall also be provided for each unit. This power shall be fed from the 400kV switchyard.
The UAT shall be connected to the two unit 6.6kV switchgears via a circuit breaker respectively. The SAT shall be connected to the two common 6.6kV switchgears via a circuit breaker respectively.
Both of the unit 6.6kV switchgear and the common 6.6kV switchgear shall be interconnected via a circuit breaker respectively.

During the unit operation, the power source to the unit auxiliary loads shall be fed from the generator output via a unit auxiliary transformer. During the unit shut down and the unit start up, the power source to the unit auxiliary loads shall be fed from the 400kV switchyard via the start up transformer.
Before de-synchronizing the generator, the power source to the unit auxiliary loads shall be transferred from the unit 6.6kV switchgear to the common 6.6kV switchgear, and after synchronizing the generator, the power source to the unit auxiliary loads shall be transferred from the common 6.6kV switchgear to the unit 6.6kV switchgear.
Figure 7.4-16 shows the key single line diagram for the electrical supply system.

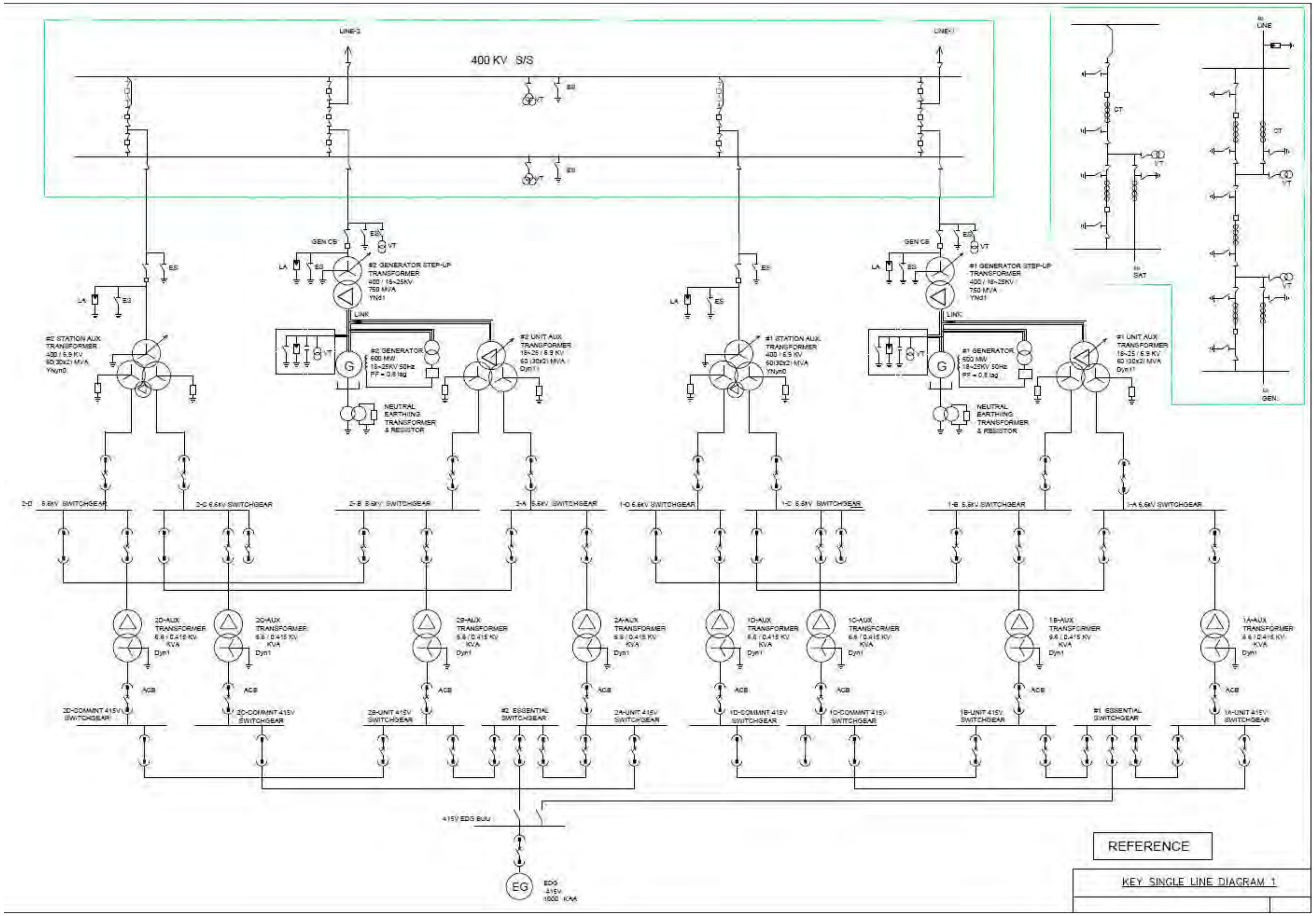


Figure 7.4-16 Key Single Line Diagram for Electrical Supply System

7.4.12.2 Generator

The overview requirements of the generator are shown below

Table 7.4-18 Overview Specification of the Generator

Item	Specification
Number of generators	2 (unit 1 and unit 2)
Type	Three phase field rotating synchronous
Number of poles	2
Number of phases	3
Rated output	600MW
Rated frequency	50Hz
Rated speed	3,000rpm
Rated terminal voltage	Manufacture's standard (18 – 25kV)
Power factor	0.80 (lagging), 0.95 (leading)
Short circuit ratio	Not less than 0.5
Cooling method	Water or H_2 gas direct cooling for stator coil H_2 gas direct cooling for rotor coil
Type of excitation system	Static or brushless excitation system

7.4.12.3 Transformer

(1) Generator step-up transformer (GSUT)

The GSUT shall be oil immersed type and shall be fitted with On Load Tap Changer (OLTC) on the high voltage winding, having a range sufficient to allow for the voltage variation at transmission voltage (400kV) and the transformer regulation.

The GSUT shall be provided with Oil Natural Air Forced (ONAF) cooling.

The GSUT shall be rated to match the generator output.

(2) Unit Auxiliary Transformer (UAT) and Station Auxiliary Transformer (SAT)

The UAT shall step down the voltage from the generator terminal voltage to 6.6kV, to provide power supply to the unit auxiliaries.

The SUT shall step down the voltage from the 400kV to 6.6kV, to provide power supply to the plant auxiliaries during the unit start-up and shut down.

Both the UAT and the SAT shall be oil immersed and shall be fitted with On Load Tap Changer (OLTC) on the high voltage winding with automatic voltage regulator, having a range sufficient to allow for the voltage variation at generator terminal voltage/transmission voltage (400kV) and the transformer regulation.

Both the UAT and the SAT shall be provided with Oil Natural Air Forced/ Oil Natural Air Natural (ONAF/ONAN) cooling.

Sizing of the UAT and the SAT shall be based on the total unit load.

(3) Comparison of Single Phase Transformer and Three Phase Transformer

BPDB requested the JICA Team to study the introduction of a single phase transformer and two half capacity transformers for this project. It is certain that the single phase transformer has merit in the case of transportation and replacement of one phase transformer by accident. In regards to transportation, the two half capacity transformers also have advantage.

However, single phase transformers are expensive because of the necessity of having a spare transformer, control equipment for each transformer and a large space for installation. Two half capacity transformers are also more expensive and difficult to operate.

Although it depends on the Contractor's recommendation, if there are no problems with transportation of the three-phase transformers, one three-phase transformer is preferable.

Table 7.4-19 Comparison of Types of Transformers

Type	Three Phase	Single Phase	Three Phase
Number	One	Four :Three + One spare	Two half capacity
Transportation	Base	Easier	Easier
Cost	Base	Higher	Highest
Space	Base	Larger	Largest
Construction	Base	Longer	Longer
Management	Base	Same (as base)	Difficult
Reliability	Base	Same	

7.4.12.4 Generator Circuit Switching Devices

The generator circuit breaker and the disconnecting switches with earthing switches shall be provided at the high voltage side of the GSUT for the generator synchronization with the Bangladesh network.

7.4.12.5 Unit Electric Supply

The unit electric supply shall be configured from unit auxiliary transformer and station auxiliary transformer. The unit load for plant operation shall be powered from the unit transformer and the common load for plant operation, such as water handling, waste water handling; coal handling, etc., shall be powered from the station auxiliary transformer.

Moreover, as an electric power source for emergencies, one set of diesel engine driven generators shall be provided for the purpose of safety shut down of the unit.

(1) 6.6kV Unit and Common Metal Clad Switchgears

Two sets of 6.6kV unit metal clad switchgears and two sets of common 6.6kV metal clad switchgears shall be provided for power supply to the unit auxiliary loads and the common auxiliary loads.

Each unit switchgear shall be powered from the unit auxiliary transformer secondary winding respectively and each common switchgear powered from the station auxiliary transformer secondary winding respectively.

The unit switchgear and the common switchgear shall be interconnected via bus-tie circuit breaker respectively for the purpose of a back-up power supply vice versa.

(2) 415V Unit and Common Switchgears

Several 415V unit and common switchgears shall be provided for power supply to the unit auxiliary loads and the common auxiliary loads.

Each switch gear shall be powered from 6.6kV switchgear via 6.6kV/415V low voltage transformer respectively. The unit switchgear and the common switchgear shall also be interconnected via bus-tie circuit breaker respectively for the purpose of a back-up power supply vice versa.

7.4.12.6 400kV Switchyard

400kV switchyard shall be provided next to the power plant area for delivery of the generating power to the Bangladesh network. This switchyard will be interconnected with the Bangladesh network by two circuits of new 400kV transmission lines.

(1) Design Concept

In order to maintain the reliability of the switchyard, the 400kV bus bar system shall preferably be double bus with 1+1/2 circuit breaker configuration of outdoor type.

The switchyard shall be designed to be able to connect six circuits, consisting of two circuits for transmission lines, two circuits for unit 1 and Unit 2, and two circuits for station auxiliary transformers of each unit. The circuit breaker shall be the type of gas insulation breaker (GCB) and the disconnecting switch shall be the type of air insulation switch (AIS).

This switchyard is owned by PGCB and the control and monitoring of this switchyard equipment shall be done from NLDC by remote control.

(2) Quantity of main equipment

The quantity of the main equipment is as follows:

Circuit Breakers (3-phase)	10 sets
Disconnecting Switches (3-phase)	26 sets
Earthing Switches (3-phase)	28sets
Current Transformers (3-phase)	16 sets
Voltage Transformers (3-phase)	8 sets
Lightning Arresters (3-phase)	2 sets

In addition to the above, other equipment including the control equipment is required. The switchyard equipment shall be controlled and monitored from NLDC by remote control through the Substation Control System (SCS) located in the switchyard.

Equipment and its location

Control building	At the switchyard
Bay Control Unit (BCU)	In the control building at the switchyard or switchyard
Station Control System (SCS)	In the control building at the switchyard
SCADA	In the control building at the switchyard
Protection relay	In the control building at the switchyard
AC and DC auxiliary power system including battery	In the control building at the switchyard (power source will be fed from the power plant)

7.4.13 Instrumentation and control system

The power plant shall be designed to be operated from the Central Control Room (CCR). The Distributed Control System (DCS) shall be employed for this purpose.

7.4.13.1 System Configuration of the instrumentation and control system

The design of all the instrumentation and control system shall be provided the maximum security for plant personnel and equipment, while safety and efficiently operating the plant under all conditions with the highest possible standards.

The configuration of the system for control and monitoring of the fully automated operation of the plant will be the DCS from the perspective of technology and cost.

The DCS equipment will undertake the control and monitoring of the whole power plant, including the common equipment.

- The computing and electric power section shall be duplex and the input and output of the DCS will be single
- Power supply to the DCS system shall be duplex with both AC and DC of butted method
- Operation during normal times will be via computer through the use of a mouse while confirming the LCD screen

7.4.13.2 Power Plant Control and Monitoring System

The operating and monitoring system of the power plant are configured by DCS, information management system, maintenance and repair system, network system and related equipment.

The DCS is comprised of the LCD operation system, plant interlock system, boiler control system, burner management system, turbine control system, plant auxiliaries interlock and sequence control system, and data acquisition system, etc.

Each independent system shall be integrated with DCS.

7.4.13.3 DCS Function of the Power Plant

The DCS shall have the following functions:

(1) Plant interlock system
(2) Boiler control system
(3) Burner management system
(4) Turbine control system
(5) Plant auxiliaries interlock and sequence control system
(6) Data acquisition historical storage and retrieval system

7.5 Operational Requirements

7.5.1 General

The main components and their auxiliaries shall be designed to ensure that trouble free starts and operations are achieved throughout the design life of the plant. Adequate redundancies for auxiliary facilities and equipment shall be made available to achieve high availability. The main components and their auxiliaries shall be designed to be able to start and rise up to full load by the initiation of a single push button. The entire plant shall be suitable for continuous power load operation.

7.5.2 Plant duty

(1) Cold start

Cold start is defined as:

- Start after 56 continuous shutdown hours, boiler unfired and not drained
- For shutdown periods of less than 72 hours, the boiler may not be drained. If the shutdown period exceeds 72 hours, the boiler shall be drained

(2) Warm start

Warm start is defined as:

- Start after more than 8 hours, but less than 56 continuous shutdown hours, boiler unfired and not drained

(3) Hot start

Hot start is defined as:

* Start after not more than 8 continuous shutdown hours

(4) Black start

Not applicable

7.5.3 Control and operation philosophy

(1) Plant automation

The degree of automation is such that the start-up/shutdown sequential control and the protection of the plant shall be fully automated to enable overall supervision of the plant by operators at CCR (Central Control Room).

However, the start-up/shutdown control sequence shall include break points to allow the operator to intervene and provide normal assistance as needed.

The start-up/loading procedures, including draining and venting of the plant, shall be selectable and controlled automatically, contingent upon the status of the plant such as very hot, hot, warm or cold.

(2) Plant operation

The CCR shall be accommodated in the steam turbine building of the plant and be equipped with the state of the art DCS (Distributed Control System) with data logging system so that generated power can be automatically controlled to meet demand. The operator console, which consists of LCD (Liquid Crystal Display) for monitoring of operating conditions and keyboard panels with mouse for operation of the plant, will be installed as the operator console in the CCR.

The LCD operation will be employed to make human-machine interface easier and to facilitate monitoring and operation and higher operating reliability.

The CPU shall be of duplicate configuration using the standby redundant system to ensure the reliability of the control system.

(3) Under and over frequency operation

Generators shall be so designed that they can withstand continuous operation under and over frequency from 48.5Hz to 51.5Hz under load conditions. They shall also be capable of load operation under the frequency range of 46.5Hz to 48.5Hz with operation time limitation. Control devices required to limit the load operation time shall be provided in consideration of the requirement from the Bangladesh network system.

(4) Power control

The plant power load will be demanded by the SCADA system from the NCC (National Control Center) to the plant. The plant shall be automatically operated after setting the plant power load demand into the DCS through the operator console by the operator of the plant, so that the plant power load demand will be satisfied.

7.6 Comparison Summary for Each Design Option

Table 7.6-1 summarizes a comparison for each design option evaluated in this chapter. The reasons why those options are selected for evaluation are follows.

(1) Steam Cycle

Steam cycle for thermal power plant is classified broadly into three types. Therefore the JICA Study Team selected typical steam conditions (temperature, pressure) for his evaluation.

(2) Flue Gas Desulfurization (FGD)

These options are typical system commercially available for FGD of thermal power plants.

(3) Steam Turbine Shaft Configuration

In view point of shaft configuration steam turbine is classified broadly into two types.

(4) Desalination Plant

There are several systems to be commercially used for a desalination plant. MSF and RO are top two major systems and MVC has become possible for selection.

Table 7.6-1 Comparison Summary for Each Design Option

Steam Cycle						
	Subcritical (16.6MPag, 538/538°C)		Supercritical (24.1MPag, 538/566°C)		Ultra Supercritical (USC) (24.5MPag, 600/600°C)	
Record of application	Many	◎	Moderate	◎	Increasing rapidly	○
Reliability	High	◎	High	◎	High	◎
Tehrmal efficency	39.15%	△	40.32%	○	41.29%	◎
CO2 emission	Base	△	110,500 ton/yr less	○	198,300 ton/yr less	◎
Econmic Evaluation	Base	△	n.a.	○	98 to 158 mil.USD more economical	◎
Total Evaluation	△		○		◎	
Flue Gas Desulfurization (FGD)						
	Limestone/Gypsum FGD		Seawater FGD			
FGD efficiency	90~99%	◎	90~95%	○		
Absorbent	Limestone Required to install limestone unloading / handling facilities	△	Seawater	◎		
Byproduct (Waste)	Gypsum Required to dispose or to establish recycle chain.	△	Sulfate ion discharged to the sea	○		
Waste water treatment	Wastewater treatment plant is required.	○	Only oxidation in seawater aeration pond	◎		
Plant space	Larger	○	Smaller	◎		
Service water consumption	Much	△	Little	◎		
Availability	Very high	◎	Higher (no limestone/gypsum handling)	◎		
Levelized cost	Base	○	Cheaper	◎		
Record of application	Since 1970s, world share 83%	◎	Since 1990s, world share 3%	△		
Total Evaluation	○		◎			
Steam Turbine Shaft Configuration						
	Tandem Compound (TC)		Cross compound (CC)			
Shaft length	Longer	○	Base	◎		
Reliability	Similar	◎	Base	◎		
Turbine efficiency	Same	◎	Base	◎		
Installation space	Smaller	◎	Base	○		
Operability	Simpler	◎	Base	○		

Maintainability	Easier	◎	Base	○		
Construction cost	Less	◎	Base	○		
Running cost	Same	◎	Base	◎		
Total Evaluation	◎		○			
Desalination Plant						
	Multi Stage Flash (MSF)		Mechanical Vapor Compression (MVC)		Reverse Osmosis (RO)	
Total dissolved substance (TDS)	10	○	5	◎	10 (by two stages treatment)	○
Investment cost	Higher	○	Higher	○	Base	◎
Energy Consumption	25 kWh/m3 (incl. steam energy)	△	11 kWh/m3	○	5 kWh/m3	◎
O&M cost (excl. energy cost)	Cheaper	◎	Cheaper	◎	Base	○
Raw Water Consumption (per produced water m3) *1	6-8 m3/m3	△	3 m3/m3	○	2 m3/m3	◎
Record of application	Considerable experience for large capacity plants	◎	Has become a possible process	○	Has become a major process	◎
Reliability	High reliability Corrosion, scale problems	◎	Simple system Lower temperature operation than MSF	◎	Simple system	◎
Operability		◎	Simple system	◎	Simple system	◎
Total Evaluation	○		△		◎	

Legend: ◎Excellent, ○Good, △Poor

Chapter 8

Study on Civil and Construction Work

Chapter 8 Study on Civil and Construction Work

8.1 Study of Power Plant Ground Level

8.1.1 Design tidal level

The design tide level was set as shown in paragraph 5.7 Tidal.

H.W.L. = +2.20m M.S.L.

L.W.L. = -2.20m M.S.L.

M.S.L. = EL ±0.0m

As a general rule, the water level that is most dangerous for the safety of objects is used as the design water level. This level shall be determined from the tide observation records over a one year or longer period of time. The Water Development Board (WDB) records the water levels at different locations of rivers and channels. In the Kutubdia channel, there is one station (SW-176) to record the water level of the channel, at a distance of 18km from the project site. The records are measured in meters from the Public Works Department (PWD) Datum.

For reference, the following table shows the water level data for 22 years (from 1990 to 2011).

District	Cox's Bazar
Channel	Kutubdia Channel
Station Name	Lemsilhali (SW-176)

Table 8.1-1 22 Years of Water Level Data (for reference)

Year	WL(m.MSL)	
	max	min
1990	2.93	-1.80
1991	3.26	-2.25
1992	2.96	-1.96
1993	2.76	-2.26
1994	2.64	-2.01
1995	3.39	-2.01
1996	3.44	-1.96
1997	3.74	-1.96
1998	2.94	-2.01
1999	2.99	-1.91
2000	3.04	-1.76
2001	2.94	-1.76
2002	3.04	-1.81
2003	3.04	-1.81
2004	2.99	-1.81
2005	2.99	-1.81
2006	2.94	-3.61
2007	3.04	-1.81
2008	1.79	-0.94
2009	1.81	-0.83
2010	1.76	-0.83
2011	2.01	-0.69
Ave.	**2.8**	**-1.8**

Source : WDB (Water Development Board)

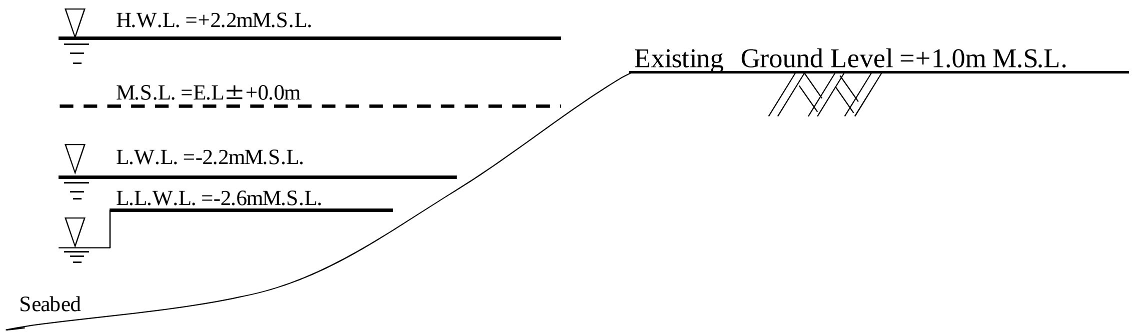


Figure 8.1-1 Related Figure of EL and MSL

8.1.2 Design storm surge height

In relation to storm surges, there are two types of data, one is the list of cyclone storm surges in Chapter 5.1 Major Historic Cyclone Data, and the other is based on the BANGLADESH NATIONAL BUILDING CODE 2006.
The results of design condition based on these two data sources are as follows.

(1) Historic Cyclone Data and Statistical Analysis
The Bay of Bengal is an area favourable for the generation of tropical cyclones.
A description of historical storm surges is shown in paragraph 5.1. Information on the landfall dates and maximum wind speeds of cyclones are shown in Table 8.1-3, and Figure8.1-2 shows the tracks of major cyclones crossed Bangladesh. The source of this cyclone data is the Bangladesh Meteorological Department (BMD).

1) Historic Cyclone
Two major cyclones have hit near the Matarbari site in the past.
In November 1970, the Bhola cyclone struck the low-lying islands of Ganges delta (Bhola district). The exact death toll will be never known, but reports estimate that approximately 500,000 people lost their lives. As the storm made landfall, it caused a 10.6m high storm surge at the Ganges delta. At the meteorological station in Chittagong, 95km to the east of where the storm made landfall, the storm tide peaked at about 4m above the average sea level, 1.2m of which was the storm surge height. Given the difference between the landfall area and a location about 100km from the landfall area, it is understandable that the impact was relatively small. Furthermore, the Bhola cyclone track went off the Coastal Region Code based on BANGLADESH NATIONAL BUILDING CODE (refer to Figure8.1-5).
However, in April 1991, the 1991 Bangladesh cyclone struck the coast north of Chittagong

port with winds of around 225km/h. At another places, the maximum wind speed was reported as follows; Kutubdia 180 km/h, Cox's Bazar 185 km/h. It is estimated that about 138,000 people lost their lives. As the storm made landfall, it caused a 7.6m high storm surge at the Chittagong district. More importantly, the track of 1991 Bangladesh cyclone hit the Coastal Region Code area at the Matarbari site. The JICA Study Team used this incident in estimating the highest storm surge on record.

2) Statistical Analysis

The JICA Study Team performed statistical analysis to clarify the relationship between storm surges and elevation of the extreme water levels corresponding to the 25-year and 50-year return period.

On the basis of this data, a frequency distribution chart is shown in Figure 8.1-3, and statistical analysis results in Table8.1-2 and Figure 8.1-4.

Table 8.1-2 Storm Surge Height (statistical analysis result)

Storm Surge Height	Average	25-year Return Period	50-year Return Period
Base on maximum data	4.2 m	8.0 m	9.0 m
Base on minimum data	3.3 m	6.2 m	7.0 m

Table 8.1-3 List of Major Cyclones

Date	Landfall Area	Maximum Wind Speed (km/h)	Surge Height (m)	
			Min	Max
1960.10.11	Chittagong	160	6	
1960.10.31	Chittagong	193	6.6	
1961.05.09	Chittagong	160	5	
1961.05.30	Chittagong	160	2	4.55
1963.05.28	Chittagong-Cox's Bazar	200	6	
1965.05.11	Chittagong-Barisal Coast	160	3.7	
1965.11.05	Chittagong	160	6.1	7.6
1965.12.15	Cox's Bazar	210	2.4	3.6
1966.09.23	Noakhali Coast	139	6	6.7
1970.10.23	West Bengal Coast	163	4.7	
1970.11.12	Chittagong	224	3-10	10
1971.05.08	Chittagong	81	2.4	4.2
1971.09.29	Sundarban Coast	97-113	0.6	
1974.11.28	Chittagong-Cox's Bazar	163	3	5.1
1981.12.10	Khulna Coast	120	2.1	4.6
1983.11.09	Chittagong-Cox's Bazar	136	1.5	
1985.05.24	Chittagong	154	4.6	
1988.11.29	Khulna Coast	160	4.4	
1991.04.29	Chittagong	225	6	7.6
1991.05.31	Noakhali Coast	83	2.5	
1994.05.02	Cox's Bazar-Teknaf Coast	200-25	3.6	4.9
1966.10.26	Sundarban Coast	70	1.5	2
1997.05.19	Sitakundu	232	4.6	
1997.09.27	Sitakundu	150	3	4.6
1998.05.20	Chittagong	173	0.9	
2000.10.28	Sundarban Coast	50-60	0.6	1.2
2002.11.12	Sundarban Coast	65-85	1.5	2.1
2003.05.20	Myanmar Coast	65-85	0.9	1.5
2004.05.19	Cox's Bazar-Akyab Coast	65-90	0.6	1.2
2007.11.15	Khulna -Barisal Coast	223	4.6	6.1
2008.10.26	Khulna -Barisal Coast	-	1.5	2.1
2009.05.25	Khulna	92	2.1	2.4

Source : BMD

: This is the largest cyclonic storm, and highest record, that has ever come close to the Matarbari site.

: This is the highest on record to ever hit Bangladesh

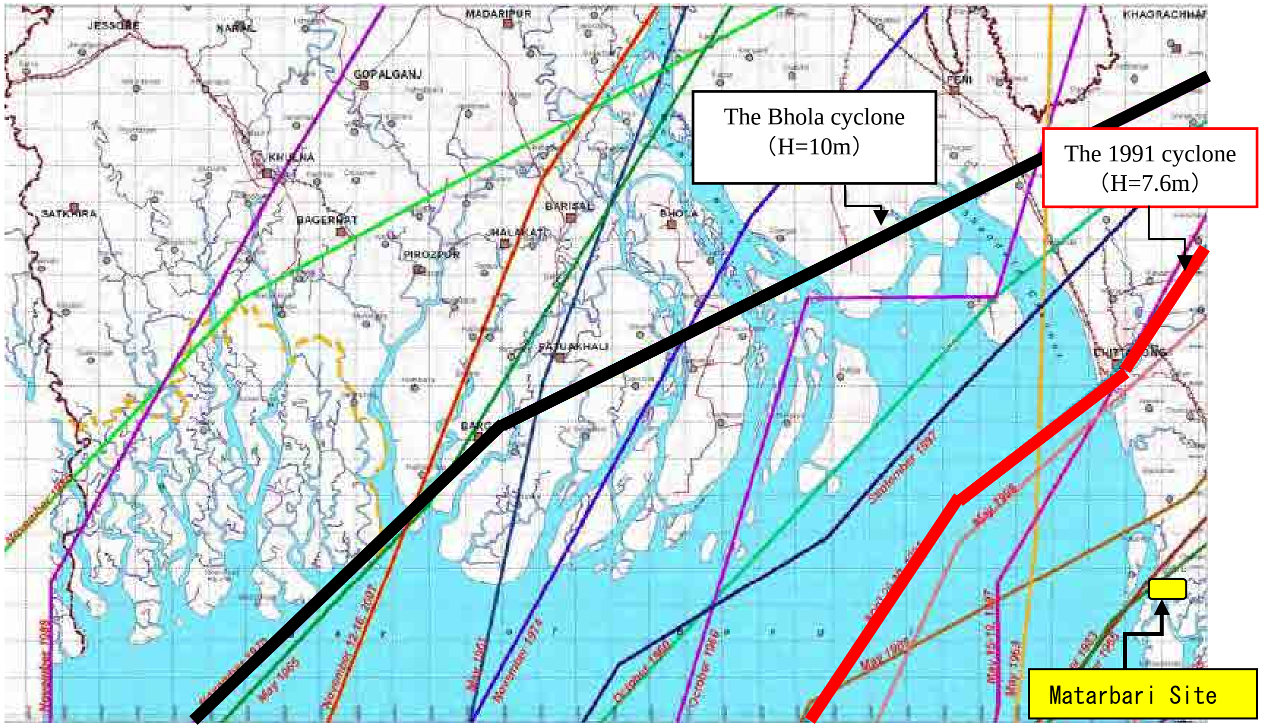


Figure 8.1-2 Tracks of Major Cyclones Across the Bangladesh Coast

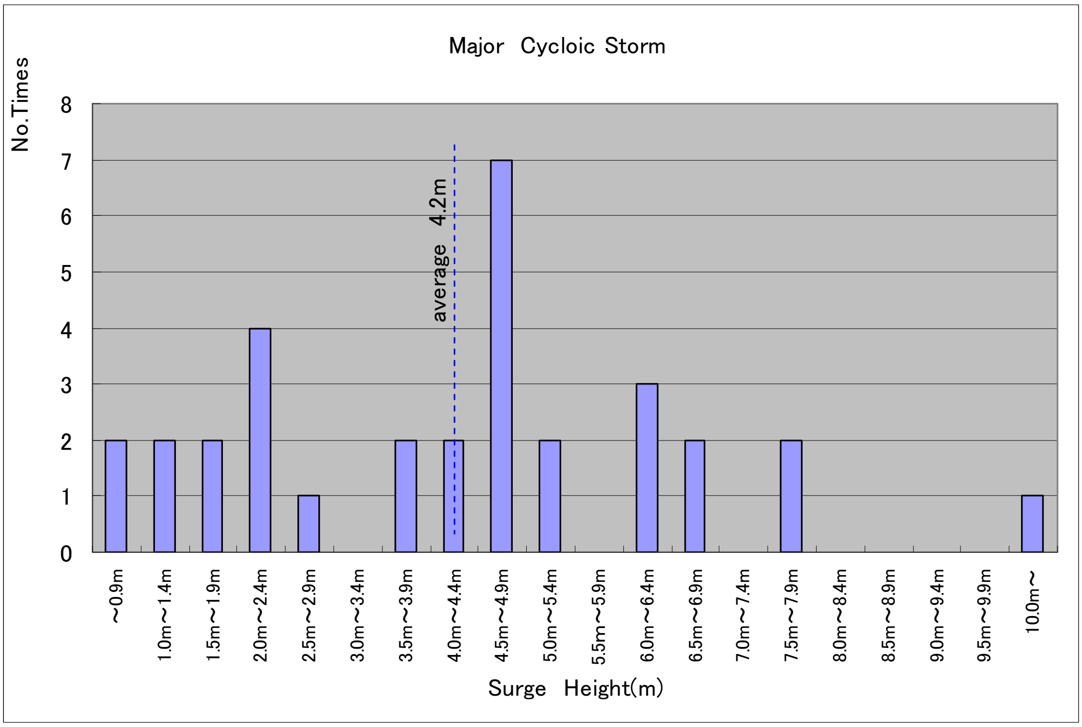


Figure 8.1-3 (1) Frequency Distribution Chart (adopt max. data)

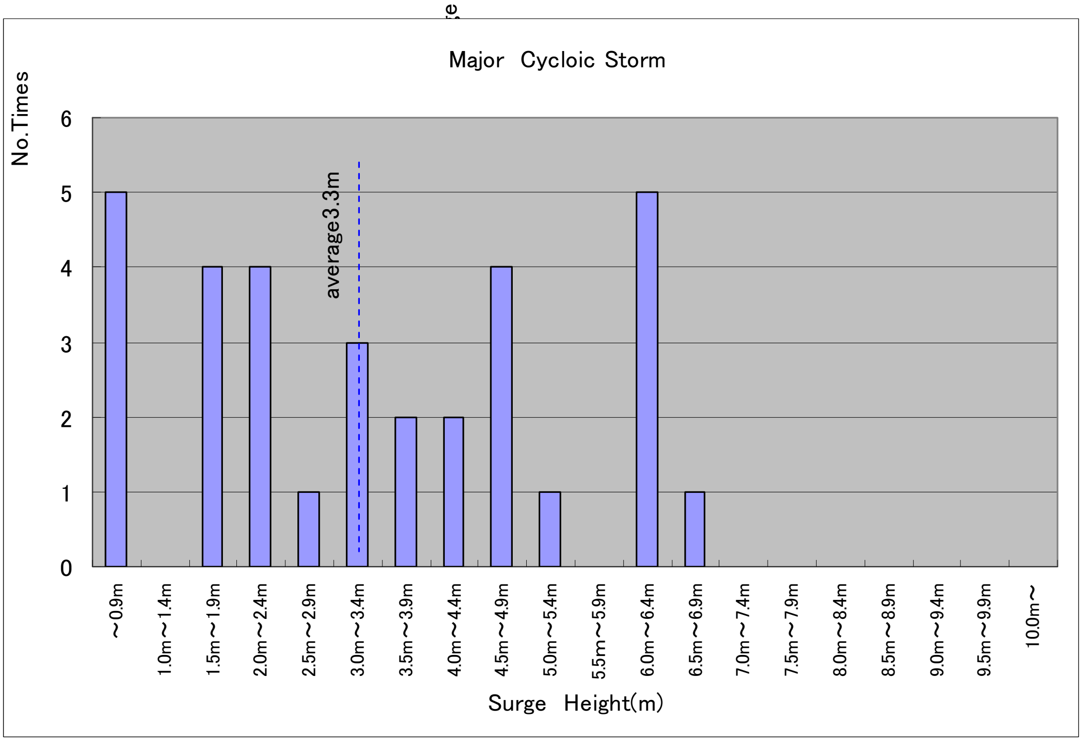


Figure8.1-3(2) Frequency Distribution Chart (adopt min. data)

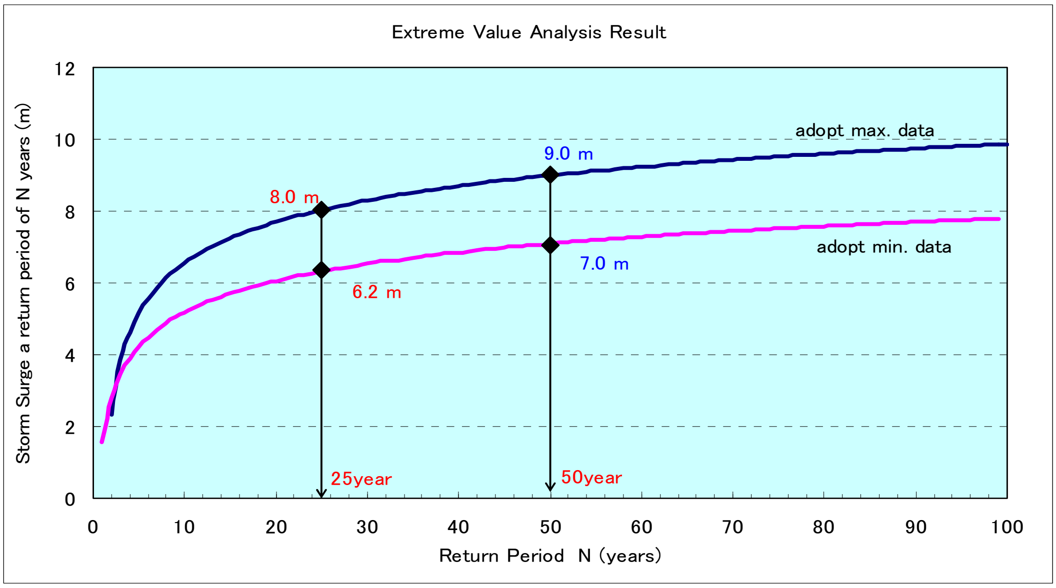


Figure 8.1-4 Statistical Analysis Result

(2) BANGLADESH NATIONAL BUILDING CODE

Under the BANGLADESH NATIONAL BUILDING CODE, for determination of flood and surge loads on structures, consideration shall be given to hydrostatic effects. The storm surge height associated with cyclones is that corresponding to a 50-year or 100-year return period as may be applicable, based on site specific analysis.

The design surge height corresponding to a return period of T-years at the sea coast is given in Table 8.1-4, and the coastal region is shown in Figure 8.1-5.

Table 8.1-4 Design Surge Heights at the Sea Coast

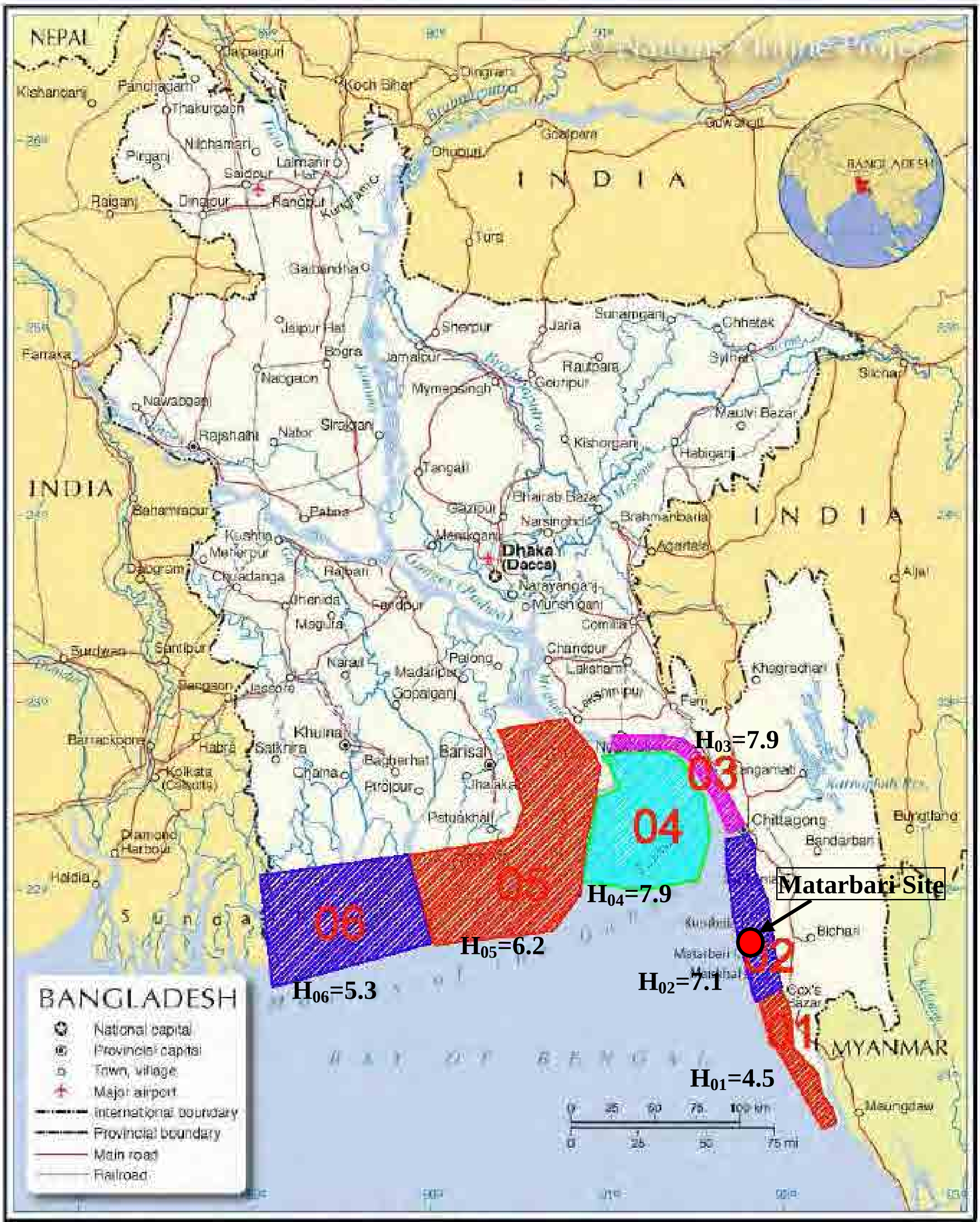
Coastal Region	Surge Height at the Sea Coast, h_T (m)	
	T=50-year(1)	T=100-year(2)
Teknaf to Cox's Bazar	4.5	5.8
Chakaria to Anwara, and Maheshkhali-Kutubdia Islands	7.1	8.6
Chittagong to Noakhali	7.9	9.6
Sandwip, Hatiya and all islands in this region	7.9	9.6
Bhola to Barguna	6.2	7.7
Sarankhola to Shyamnagar	5.3	6.4

* Values prepared from information obtained from Annex-D3, MCSP.

Note : (1) These values may be used in the absence of site specific data for structures other than essential facilities listed in Table 6.1.1.

(2) These values may be used in the absence of site specific data for essential facilities listed in Table 6.1.1

Source: BANGLADESH NATIONAL BUILDING CODE 2006



COASTAL REGION CODE

H: Storm Surge Height (50-year)

01- Teknaf to Cox's Bazar
02- Chokoria to Anowara and Moheshkhali-Kutubdia islands
03- Chittagong to Noakhali
04- Sandwip, Hatiya and all islands in the region
05- Bhola to Borguna
06- Sarankhola to Shyamnagar

Figure 8.1-5 Surge Heights Zoning Map

(3) Storm Surge Height

The storm surge height is set as shown in Table 8.1-5 below, tabulating for ready comparison.

Table 8.1-5 Design Storm Surge Height

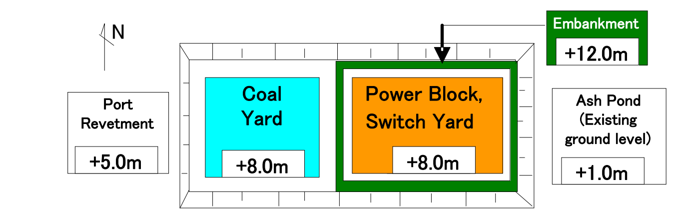
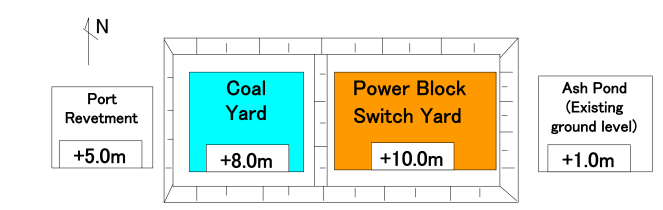
Range	25-year Return Period	50-year Return Period	Actual Result in period of near50 years	Remarks
Maximum	8.0 m	9.0 m	-	Statistical analysis results (Conservative Condition)
↕	-		7.6 m	Previous highest Record* (April 1991,Chittagong Patenga)
	-	7.1m	-	Standard of Bangladesh national code
Minimum	6.2m	7.0 m	-	Statistical analysis results (Critical Condition)

* the worst cyclone in 50 years observed November 1970 in Chittagong, Sarankhola-Bhola Noakhali is not adopted, since it is geographically so far from Matarbari site that it didn't strike, refer to Figure8.1-2.

8.1.3 Anti-inundation measures

The JICA Study Team took two types of measures for cyclonic storm surges into consideration. The two types of anti-inundation measures are shown in Table 8.1-6. As the result of a comparison, the JICA Study Team suggests that the fill-up ground method has advantages in stability.

Table 8.1-6 Comparison of Anti-inundation Measure

<table>
<tr><th colspan="2">Plan</th><th>The Original Plan</th><th>Alternative Plan</th></tr>
<tr><td colspan="2" rowspan="2">Planning</td><td>
</td><td>
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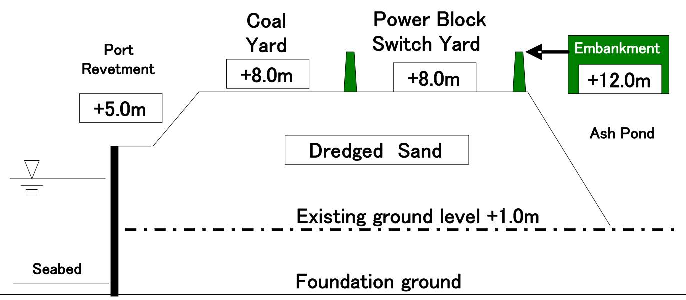
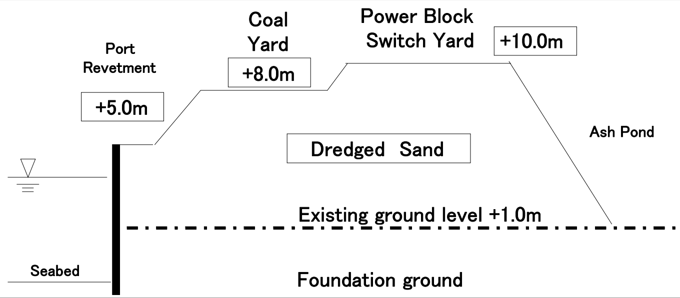
<tr><td>
</td><td>
</td></tr>
<tr><td rowspan="5">Basis of Elevation</td><td>Revetment</td><td>E.L.=+5.0mM.S.L.</td><td>E.L.=+5.0mM.S.L.</td></tr>
<tr><td>Coal Yard</td><td>25-year return period of statistical analysis result
E.L.= +8.0m M.S.L.</td><td>25-year return period of statistical analysis result
E.L.= +8.0m M.S.L</td></tr>
<tr><td>Power Block</td><td>H.W.L + 50-year return period of statistical analysis result
E.L.=+2.2mM.S.L +9.0mM.S.L =+11.2mM.S.L → +12.0mM.S.L.</td><td>H.W.L + 50-year return period of Previous highest Record
+2.2mM.S.L +7.6mM.S.L =+9.8mM.S.L → +10.0mM.S.L.</td></tr>
<tr><td>Switch Yard</td><td>H.W.L + 50-year return period of statistical analysis result
E.L.=+2.2mM.S.L +9.0mM.S.L =+11.2mM.S.L → +12.0mM.S.L.</td><td>H.W.L + 50-year return period of Previous highest Record
+2.2mM.S.L +7.6mM.S.L =+9.3mM.S.L → +10.0mM.S.L.</td></tr>
<tr><td>Ash pond</td><td>Existing ground level</td><td>Existing ground level</td></tr>
<tr><td colspan="2">Evaluation</td><td>When a cyclone arrives, the water level outside is high, and power block side is low. Therefore, water may gush up from the ground. This is an unstable structure.</td><td>This is quite effective to prevent inundation damage from cyclones in order to develop the site elevation to be higher than water level.
The dredged sand is used for site development. The fill-up ground method is a reliable method.</td></tr>
</table>

8.1.4 Amount of dredged soil

The JICA Study Team calculated the amount of dredging soil required for raising the site. The dredged area of the port formation is shown in 8.2 Port and Harbor facilities. Moreover, since the dredged range of soil will consist of cohesive soil and sandy soil, which is appropriate for the ground foundation, the amount of dredged soil can be calculated from this range. This result is shown in Table 8.1-7.

Amount of dredged sandy soil ≒ 8,670,000 m^3

All this soil will be used by the site development (refer to 8.1.5).

Amount of dredged clay soil ≒ 8,971,000 m^3

Although a part of the dredged silty soils will be used for the embankment of the ash discharge pond, the remaining clay soils will be filled into the ash discharge pond.

By taking a rough estimate as follows:

- Amount of embankment volume ＝ 1,310,000 m^3
- Remaining amount = 8,971,000－1,310,000 ＝ 7,661,000 m^3
- The additional height of embankment ＝ 7,661,000／2,000,000 m^2 ＝ 3.8 m

Table 8.1-7 Amount of Dredged Soil

(unit: m^3)

Soil Characteristics	Dredged Sea Area	Excavated Land Area	Total
Clay (surface layer)	271,000	5,350,000	5,621,000
Sand	4,660,000	4,010,000	8,670,000
Clay (deep layer)	0	3,350,000	3,350,000
Subtotal	4,931,000	12,710,000	17,641,000

Elevation= M.S.L , Chart Datum(C.D.)= -2.6m M.S.L
Excavated Land Are: base on boring №.BH-02
Channel Are: base on boring №.BH-03
Dredging Bottom Level is including approximation 0.5m of overbreak(Bottom level=-18.0m MSL)

8.1.5 Power plant ground level

The ground level for the power plant shall be higher than the water level in consideration of the storm surge height in order to avoid any flood damage.
In order to raise the power plant, the JICA Study Team assumes the use of excavated sandy soil to build the ground foundation.
This chapter examines the site development based on the balance between dredged sandy soil and filling soil.

-Divided Zone
It is assumed that the power plant will be classified into two areas according to the importance of equipment, as explained below.

-Lot A
The importance of equipment is comparatively low and the equipment will not be the direct cause of any power generation stops, e.g., Coal Stock Yard.
In Lot A, the storm surge height will be from the plant operation for 50-year return period. The design water level is set to perform an addition of M.S.L plus storm surge level.

・E.L. ＝ M.S.L. ＋ Surge Height
＝ +0.0m M.S.L.＋ 7.6m
＝ +7.6m M.S.L. ≒ +8.0m M.S.L.

-Lot B
The importance of equipment is high and the equipment may be the direct cause of a power generation stop, e.g., Power Block and Switch Yard. The storm surge height adopts the 50-year return period. The design water level is set to perform an addition of H.W.L. plus storm surge level.

・E.L. ＝ H.W.L. ＋ Surge Height
＝ +2.2m M.S.L.＋7.6m
＝ +9.8m M.S.L. ≒ +10.0m M.S.L.

The power plant plan has been made based on the above results, and is shown in Figure 8.1-6.

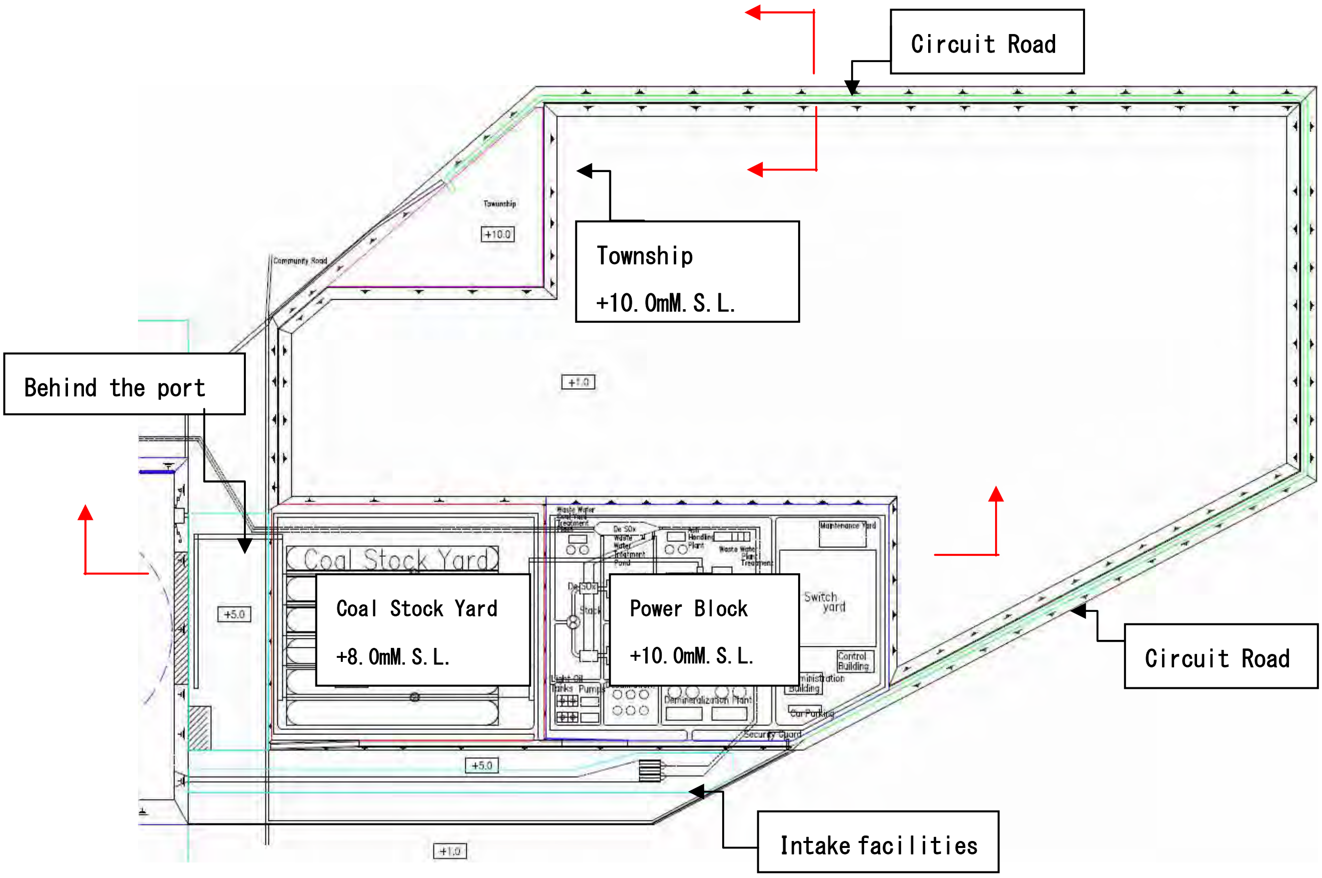


Figure 8.1-6 The Site Development of the Power Plant Plan

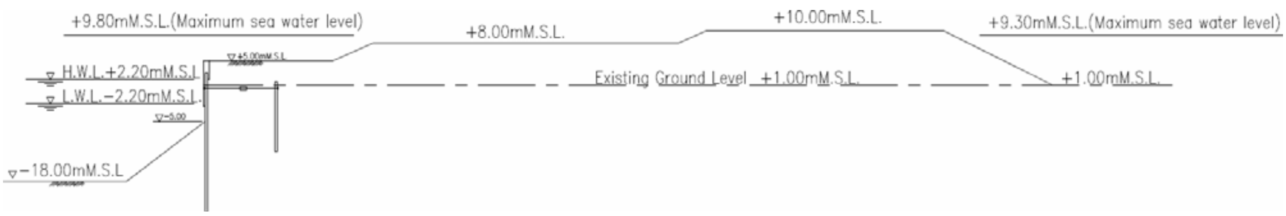


Figure 8.1-7 Cross Section of Site Power Plant

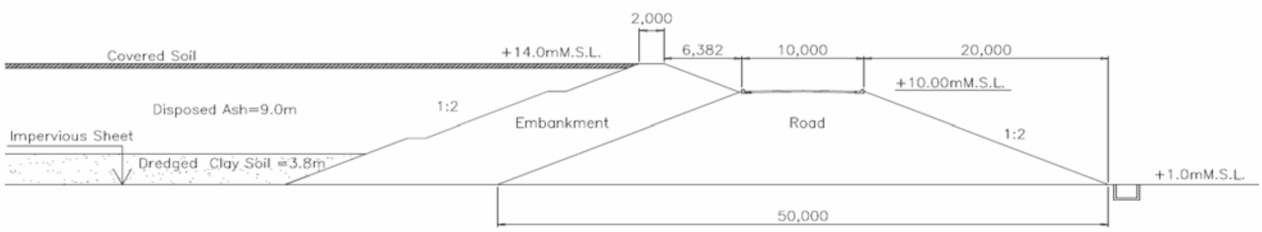


Figure 8.1-8 Cross Section of Circuit Road

-The balance between dredged sandy soil and filling soil:

Amount of Dredged Sand	Amount of Filling Sand	
＝8,670,000 m^3	2,390,000 m^3	Coal Stock Yard
	3,760,000 m^3	Power block, Switch Yard
	1,130,000 m^3	Township
	780,000 m^3	Circuit Road
	95,000 m^3	Access Road
	515,000 m^3	Behind the Port and Circumference of Intake facility

8.2 Port and Harbor Planning

8.2.1 Vessel specification and port facilities

The vessel specification and port facilities are based on TECHNICAL STANDARDS AND COMMENTARIES FOR PORT AND HARBOR FACILITIES IN JAPAN .

8.2.2 Dimensions of target vessel

The dimensions of the target vessels based on Study on Ship Dimensions by Statistical Analysis (National Institute for Land and Infrastructure Management Ministry of Land, Infrastructure and Transport, Japan) have been assumed as indicated in Table 8.2-1.

Table 8.2-1 Dimensions of Target Vessels

Type	Class (DWT)	Length L (m)	Breadth B (m)	Draft Df (m)
Coal carrier	80,000	243	37.4	14.4

8.2.3 Dimensions of navigation channel and mooring basin

The dimensions of the navigation channel and mooring basin are as indicated in Table 8.2-2. Figure8.2-1 shows a plot plane of port type. The depth of the navigation channel is shown by datum level of M.S.L. That is to say, -15.8m M.S.L-2.2m M.S.L= -18.0m M.S.L.
-2.2m M.S.L shows Lowest Low Level.

Table 8.2-2 Dimensions of Channel and Mooring Basin

Type	Channel			Mooring Basin		Berth
	Width (m)	Length (m)	Depth (m)	Width (m)	Depth (m)	Length (m)
Coal carrier	250 (1 L)	1200 (5 L)	15.8 (1.1Df)	500 (2 L)	15.8 (1.1 Df)	600(*)

* : Coal vessel 80,000DWT×1 (length300m)、oil vessel 5,000DWT×1 (length150m),include a separation distance of 50m

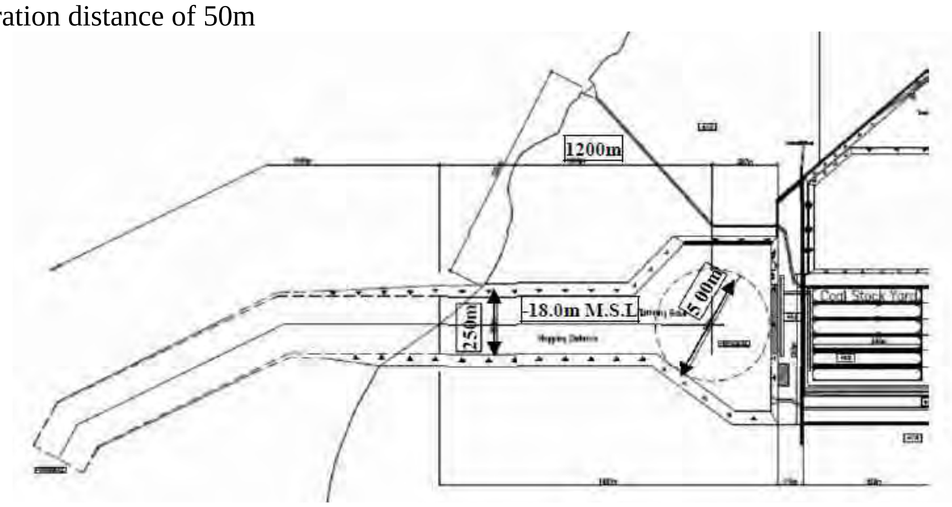


Figure 8.2-1 Plot Plan (Excavated Port)

8.2.4 Comparison of layout

(1) Layout Plan

A comparative analysis of the port formation was performed in relation to the ocean waves, geographical features, and water depth.

On the basis of the wave conditions set in Clause 4.1.2, the layout of the port and harbor facilities for receiving coal vessels has been studied.

The layout design of the port and harbor facilities has been carried out according to the following policy:

In the water area to be used for arrivals and departures of coal vessels and coal handling, a mooring basin will be provided at a water depth of -15.0m or deeper.

A straight line navigation channel with a width of 250m will be provided over an extension of 1200m from the center of the mooring basin.

In consideration that the direction of waves approaching these project sites are limited to S ～ SW, a breakwater will be arranged to shield the navigation route and anchorage from the waves in these directions. In this case, a dispersion equivalent to roughly half the direction should be taken in consideration of the direction.

The layout plan of the port and harbor facilities studied based on the above policy is indicated in the following Figures and Table.

- Plan A: Conventional Port Type

The port and harbor are located on the sea. A breakwater is needed to shield them from ocean waves. Figure8.2-2 is shown Plan A Conventional Port Type.

- Plan B: Excavated Port Type

The port and harbor are located in the land. In this case, shipping conditions are secure.
Figure8.2-3 is shown Plan B Excavated Port Type.

(2) Selection of Port Type

The comparison analysis results are shown in Table 8.2-3.

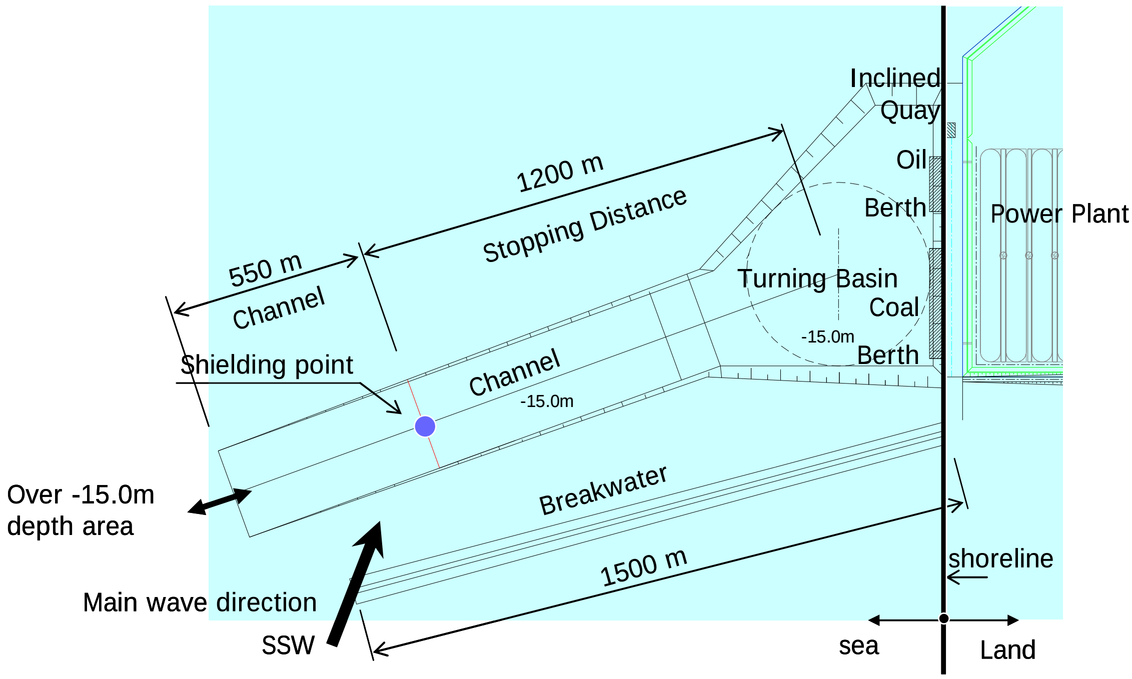


Figure 8.2-2 Plan A: Conventional Port Type

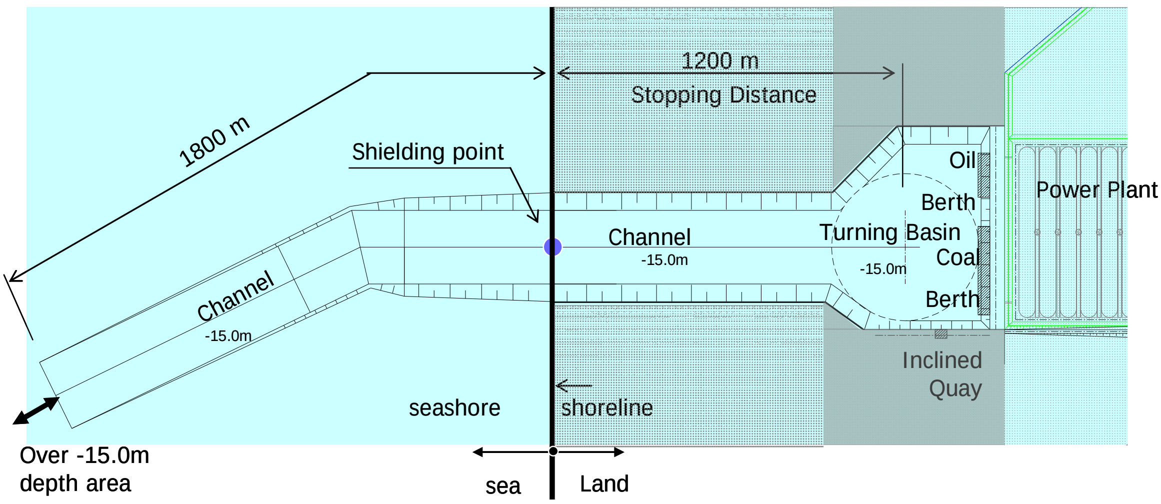
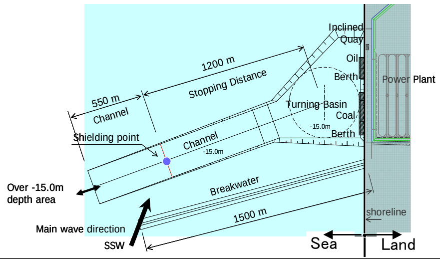
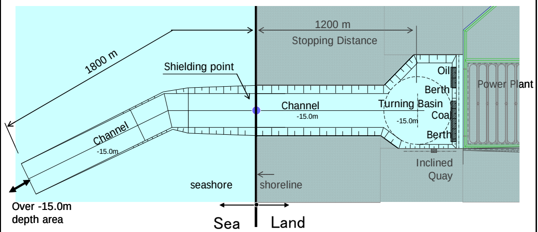


Figure 8.2-3 Plan B: Excavated Port Type

Table 8.2-3 Comparison of Port Types

Plan		Conventional Port Type		Excavated Port Type	
Plan					
Comparision of relative costs	Initial cost		**Relative cost ratio**		**Relative cost ratio**
				Purchasing Land Cost	→ 0. 004
				Discharge Tunnel (Difference Cost)	→ 0. 03
		Breakwater Work	→ 0. 43		
		Dredging Work for Channel,Turning Basin,Port	→ 0. 43	Dredging Work for Channel,Turning Basin,Port	→ 0. 53
		Berth Work for Coal Berth,Oil Berth, Revetment, Inclined Quay	→ 0. 13	Berth Work for Coal Berth,Oil Berth, Revetment, Inclined Quay	→ 0. 13
			Subtotal **0. 99**		Subtotal **0. 69**
	Maintenance cost	Maintenance Dredging Work for Channel,Turning Basin,Port	→ **0. 59**	Maintenance Dredging Work for Channel, Turning Basin,Port	→ **0. 29**
	Total cost	**High costs**	Total **1. 6**	**Low costs**	Total **1. 0**
Merits and demerits		× Conventional Port Type is relatively expensive . The breakwater cost is high.		○ There are cost benefits. The dredging work in the excavated land area is not directly affected by ocean waves. Although there is an more dredged soil than the Conventional Port Type, the unit cost can be cut	
		× The breakwater obstructs tidal flows. Necessity of continual maintenance dredging for channel and		△ Periodical dredging is needed but the amount is less than the Conventional Port Type.	
		△ There will be small quantities of surplus soil.		× There will be large quantities of surplus soil.	

○:merit、×:demerit

Maintenance Cost is about 25years working expenditure.

8.2.5 Maintenance dredging

(1) The result of computer simulation about sediment transport

The JICA Study Team carried out a simulation about sediment transport.

It is considered that sediment transport of the seashore is caused by near shore currents, tidal currents and the inflow discharge of rivers. Suspended sediment accrues in areas where the velocity distribution is low, and where the velocity distribution is high, tides erode the sediment. For more information about simulation model and input conditions, refer to Chapter 4.5.2. The necessity of maintenance dredging is based on the computer simulation of sediment transport results. The result of sediment transport is shown in Figure 8.2-4 and Figure8.2-5.

It will be surmised from the results that the excavated channel will be needed a maintenance dredging works.

(2) The round estimate of amount soil

On basis of the result about sediment transport simulation, the amount of dredging soil can be estimated at 360,000m3 a year. The result of calculation is shown below;

-Input condition of tidal movement：10 (ten) tidal (approximately 5 days)
-Input condition of tidal current： Flood tide 1.45m/sec、Ebbing tide 1.20m/sec
-The sedimentation area ： 250m×600m (based on simulation result)
-The thickness of sedimentation ： 30cm (based on simulation result)

Taking 5 days as a year, multiply the amount of soils by 73 (=365/5), and the amount of soil is on the decreases ,since the velocity of tidal current is 0.3m/sec ～0.5m/sec at all time, then the rate of decrease is one-third. (0.5/1.45≒3). The Energy of oscillation is proportional to the square of the velocity.

$$V = (250\times600)\times0.30\times365/5\times(1/3)^2 \quad =365{,}000 \text{ m3}$$

However, there are points to be aware of when considering a maintenance dredging plan.

The amount of dredging soil is calculated for the reason mentioned above, based on a sediment transport simulation, tidal current, suspended soils. Details such as the conditions have yet to be determined. After publication of this report, if such data is interchanged based on well-grounded information (for example on-site studies of the ocean in order to determine these conditions), the outcome will likely be different. In the event that the amount of soil increases, it is conceivable that countermeasures will be taken to reduce the deposit of soil by submerged mound and other methods at offshore structures in a much more environmentally friendly manner.

(3) The soil classification

The JICA Study Team carried out a sediment sample collection at the Matarbari sea area.
There are 4 collection points nearest to channel is shown in Figure8.2-6 and the grain size of seabed is shown in Table8.2-4. According to the survey results, the particles range in size of almost more than 75 micrometers, which is classified as sand.

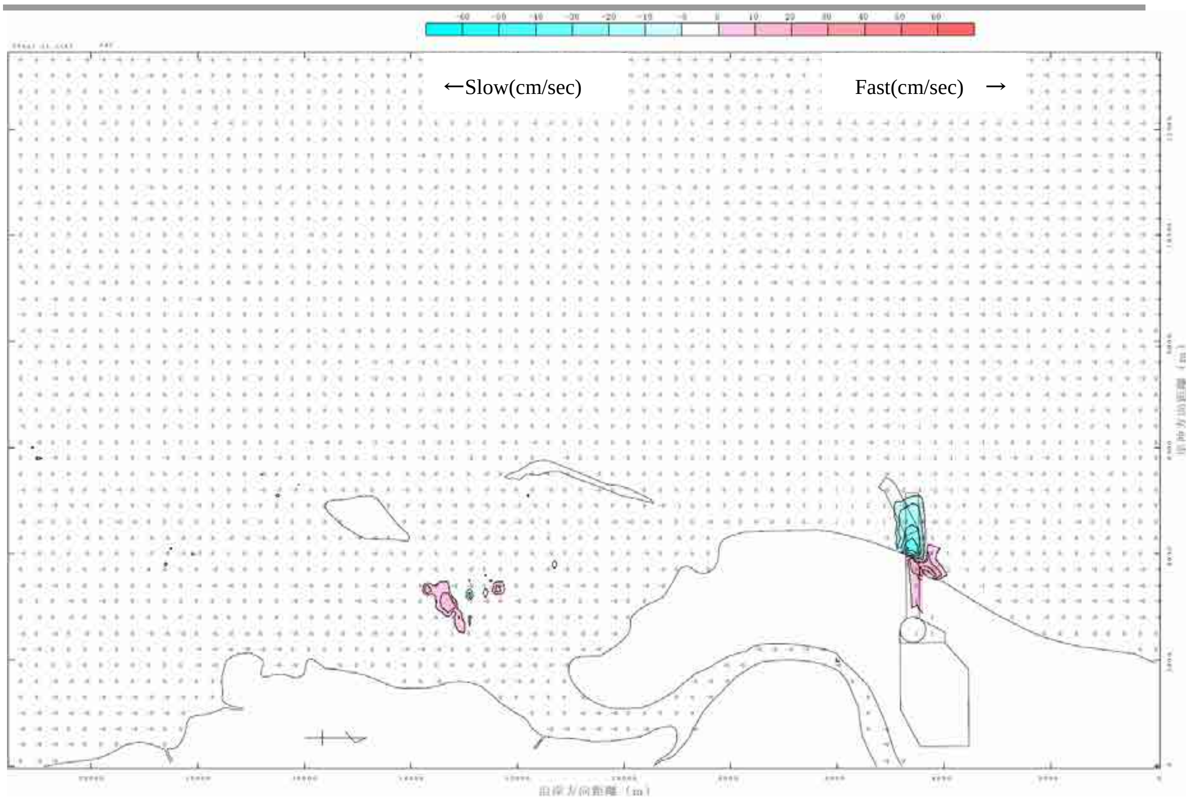


Figure 8.2-4 Transition of Velocity Distribution

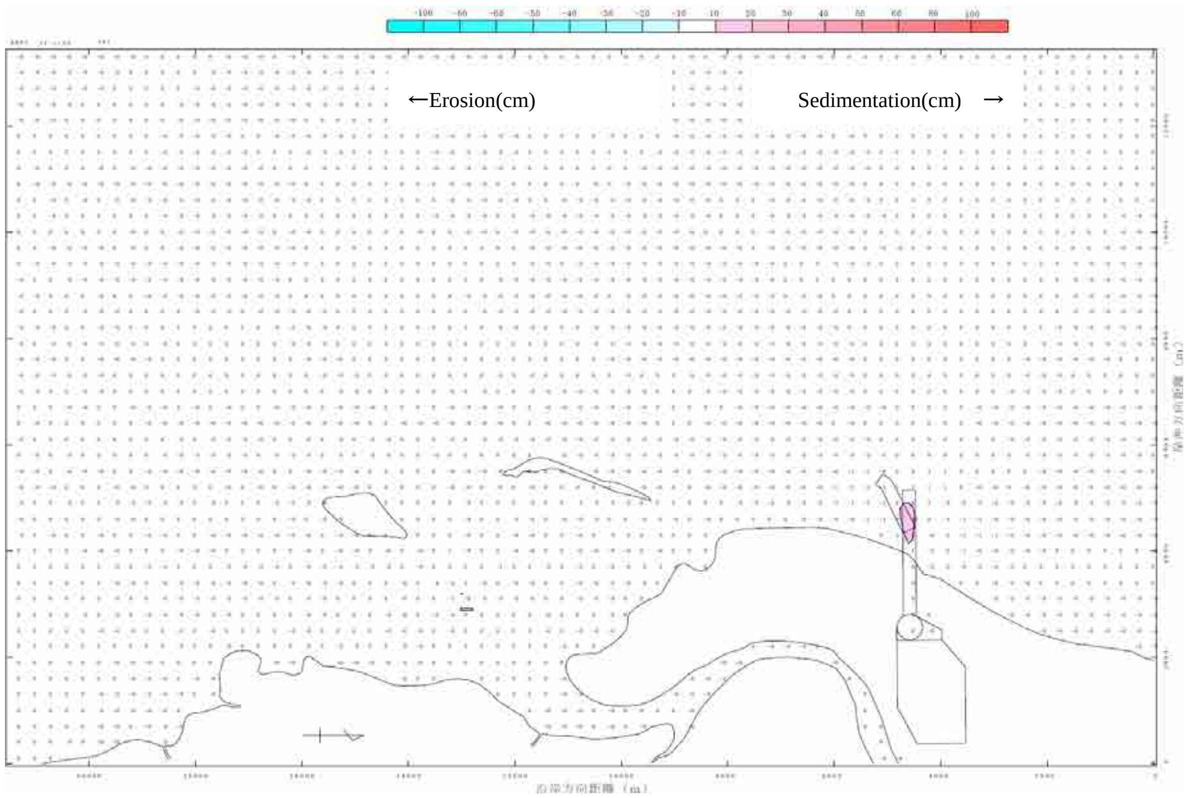


Figure 8.2-5 Transition of Coastal Topography

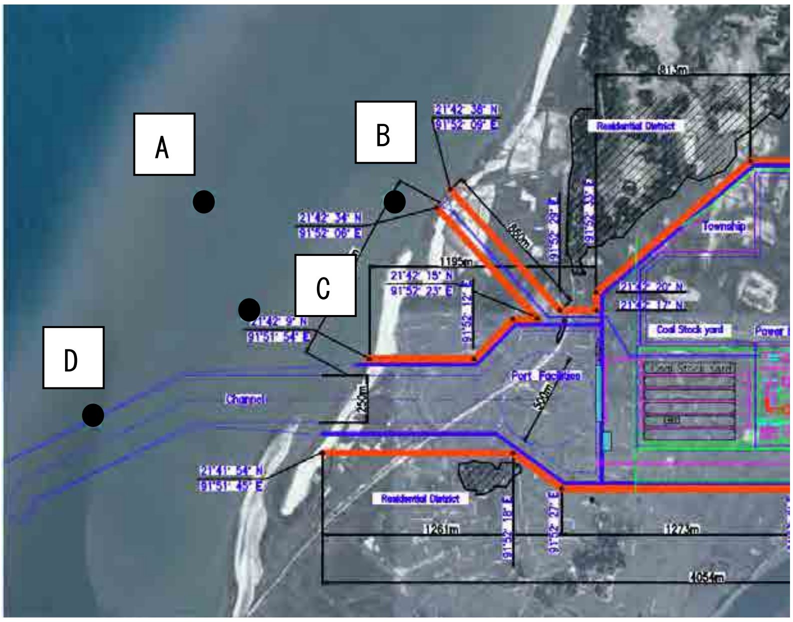


Figure 8.2-6 Sediment Sample Point

Table 8.2-4 Seabed Materials

(percentage)

Area	Sand (0.075mm～)	Silt (0.075mm～0.005mm)	Clay (～0.005mm)
A	100	0	
B	98	2	
C	98	2	
D	2	82	

8.2.6 Outline of design

(1) Wave Analysis of Calmness

Please refer to the part describing the results of harbor calmness analysis Plan A-2 (Excavated Type) in Chapter 4.3

This section will be analyzed in the Draft Final Report for the second time on the basis of the site investigation results.

(2) Computer Simulation of Sediment Transportation

Please refer to the part describing the computer simulation results of sediment transportation Plan A-2 (Excavated Type) in Chapter 4.3.2.

(3) Conceptual Design for Port Facilities

1) General View

The general view of port facilities are shown in Figure 8.2-7.

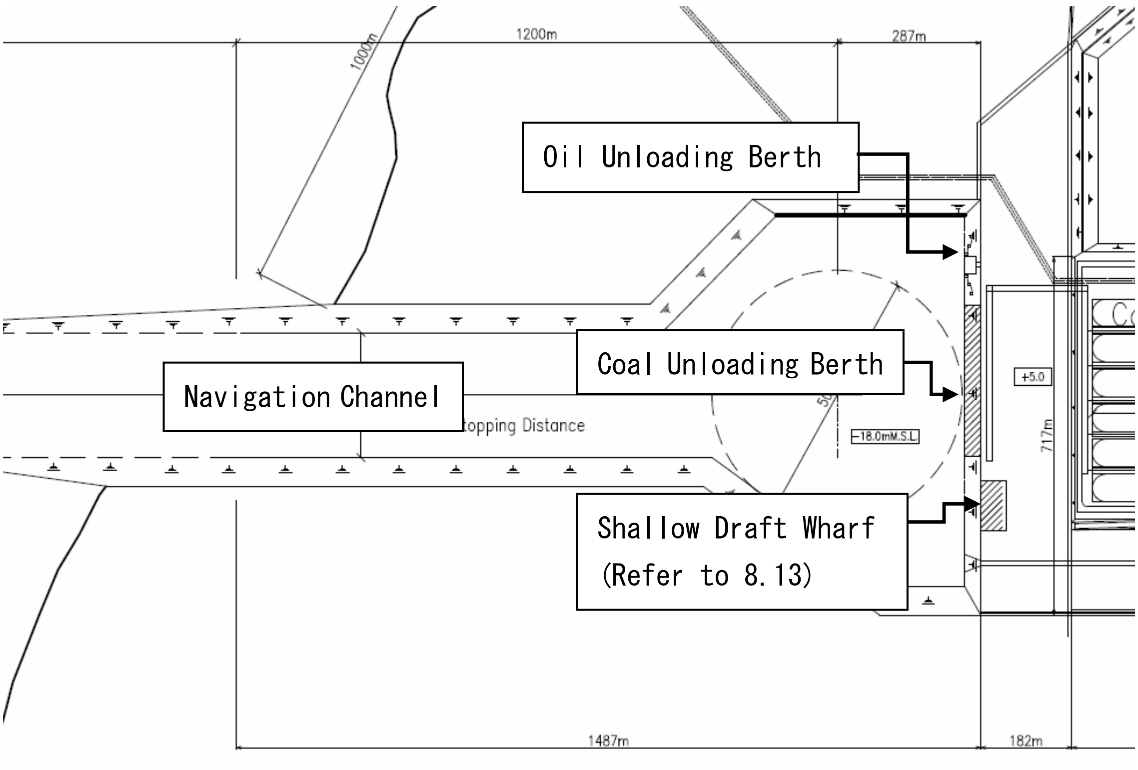


Figure 8.2-7 General View of Port Facilities

The following facilities will be fully earthquake proof based on the BANGLADESH NATIONAL BULDING CODE.

2) Navigation Channel

The type of navigation channel is the open-type which is the most inexpensive.

The cheapest and most often used contours are shown in Figure 8.2-8.

The slope protection should be a stone revetment.

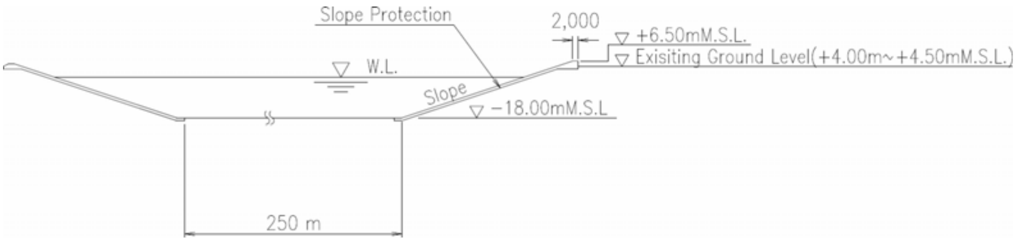


Figure 8.2-8 Channel (Standard Section)

3) Coal Unloading Berth and Oil Unloading Berth

The berth for unloading coal and oil are constructed for the inside of an excavated port.

The width and length are shown in Table8.2-2

The structure of the berth foundation shall be steel pipe piles and to resist the berthing force, it is assumed that there will be open-type wharves. For the crown height of berth, the following conditions must be met. Even for a 80,000DWT coal cargo berthing at the time of L.W.L., the setting position of the fender is satisfactory. For the inspection and maintenance of the undersurfaces of concrete slabs and steel pipe piles, etc., the height (not less than 2m) will be sufficient at the time of H.W.L. The crown height of berth is set at EL + 5.00m M.S.L.

Figure 8.2-9 shows an example of coal berth design.

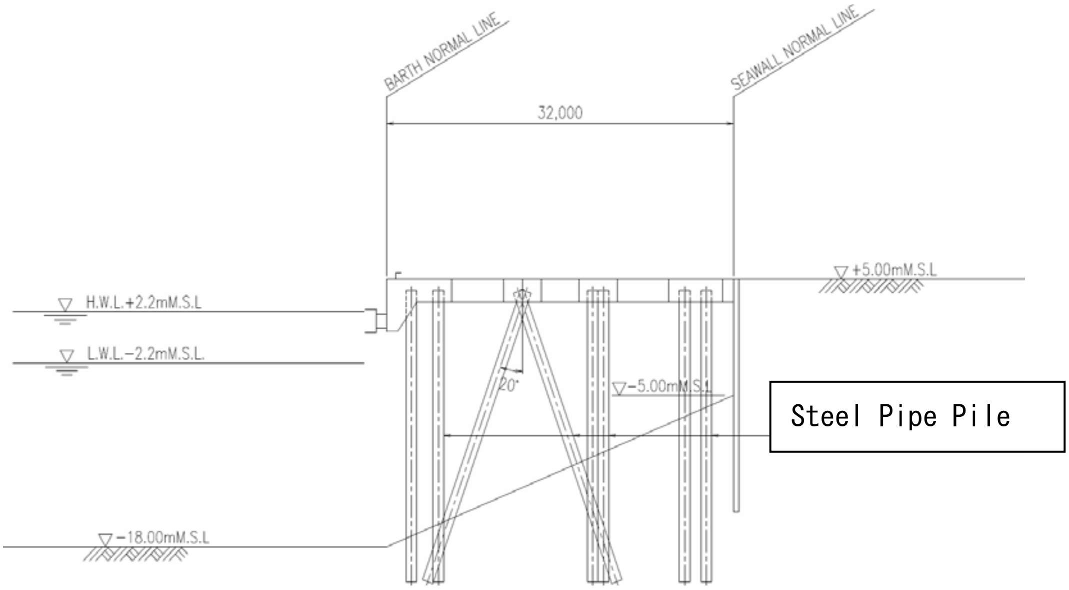


Figure 8.2-9 Coal Berth (Standard Section)

4) Sheet Pile Quay Wall

In a deep-water harbor, the structure of the quay wall is considered to be a gravity–type or a sheet pile quay wall.

The front of the quay wall will be shaped as a bottom slope, and taking the passive soil pressure into consideration. The sheet pile quay wall has a huge cost advantage over a gravity-type wall. Figure 8.2-10 shows an example of a sheet pile quay wall design.

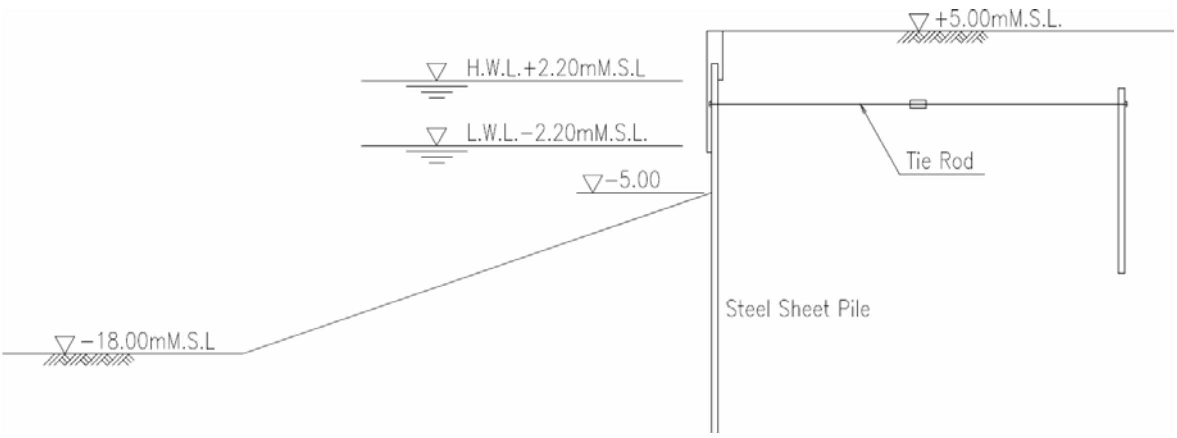


Figure 8.2-10 Sheet Pile Quay Wall (Standard Section)

8.2.7 Study of dredging work

(1) Quantity of Dredging

The quantity and classification of soil to be dredged are the key factors for the construction methodology. Based on the soil investigation results, the quantity for dredging is summarized as shown in Table 8.1.7. According to the summary, it is considered that the main soil to be dredged in the channel area is sand, and clay soil in the land area.

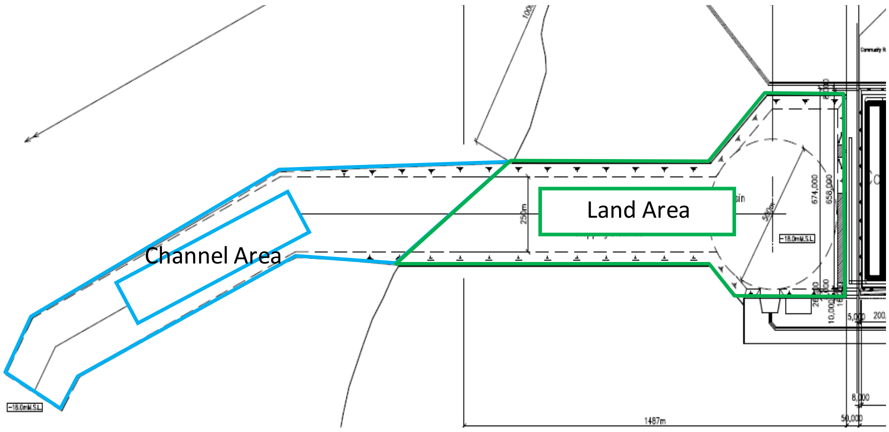


Figure 8.2-11 Dredging Area

(2) Basic Concept of Dredging Methodology

In order to discuss the construction methodology of dredging, the factors below shall be considered.

1) Sea Conditions

The project site faces the open sea and rough sea conditions during the dredging work are expected. The type of dredging equipment will depend on the sea conditions.

2) Weather Conditions

There are two monsoon seasons each year in this area. Cyclones in the monsoon season bring high tides and waves, and it is possible that sea water may cover the whole area of the project site.

3) Soil Conditions

As discussed above, there is a thick layer of sand in the channel area and two thick layers of clay in the land area.

4) Utilization of Dredged Materials

Utilization of dredged materials shall be maximized in order to reduce using other materials. Considering the above, the dredging method is selected (as shown below) for each area.

Table 8.2-5 Dredging Method

Area	Layer	Dredging Method
Channel Area	Clay-1	A. Grab Dredger + Split Barge + Cutter Suction Dredger + Discharge Pipe Line
	Sand	
Land Area	Clay-1	B. Excavator + Dump Truck
	Sand	C. Cutter Suction Dredger + Discharge Pipe Line
	Clay-2	

A brief explanation of each method is described in Table 8.2-6 and Figure8.2-12, Figure8.2-13.

Table 8.2-6 Brief Explanation of Dredging Methods

Dredging Method	Brief Explanation
A. Grab Dredger + Split Barge + Cutter Suction Dredger + Discharge Pipe Line	1) A Combination of grab dredger and split barge shall be adopted for dredging work at the channel area. 2) The dredged material shall be discharged at a pocket area near the shoreline, which is prepared prior to dredging work for the channel area. 3) The discharged material is again dredged by a cutter suction dredger and pumped out to a discharge area on the land through the discharge pipe line.
B. Excavator + Dump Truck	In order for a cutter suction dredger to work, a certain depth of water shall be secured. For this reason, Clay-1 layer at land area shall be excavated by combination of excavator and dump truck.
C. Cutter Suction Dredger + Discharge Pipe Line	1) After Clay-1 layer is excavated by Dredging Method B for the land area, the cutter suction dredger shall enter into the land area for further dredging work. '2) The following dredging work shall be exectued layer by layer in order to segregate sand material and clay material. 3) The discharge area for each material shall be allocated seperately.

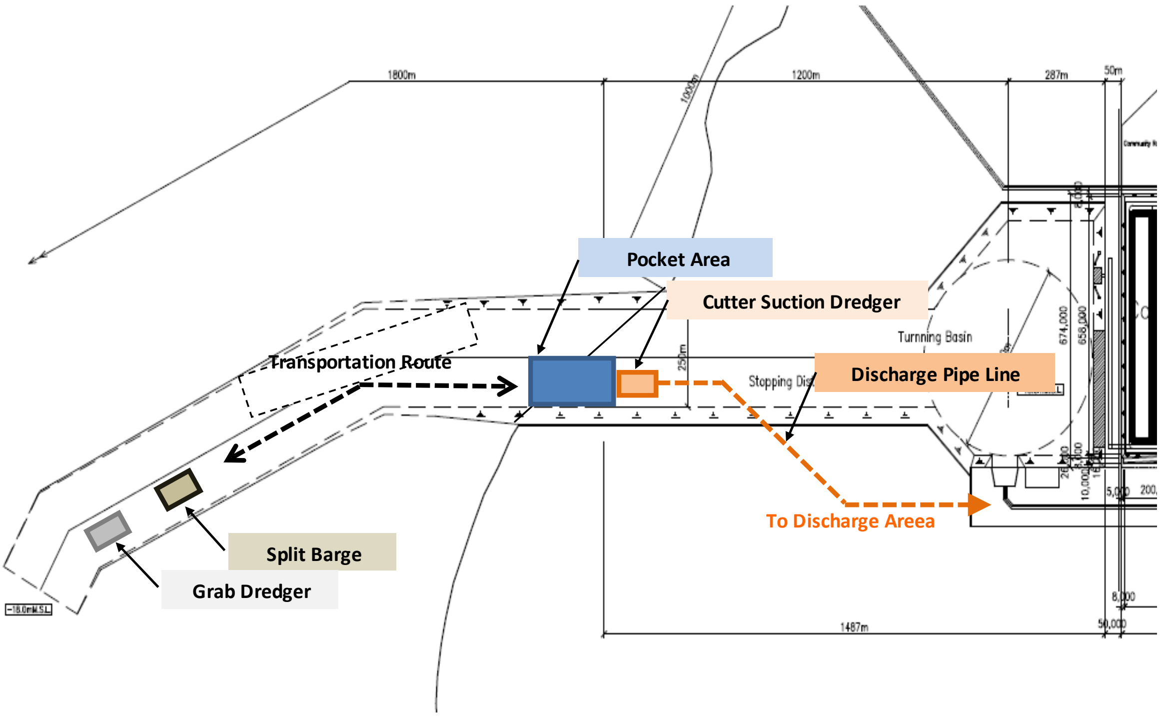


Figure 8.2-12 Dredging Method A for Channel Area

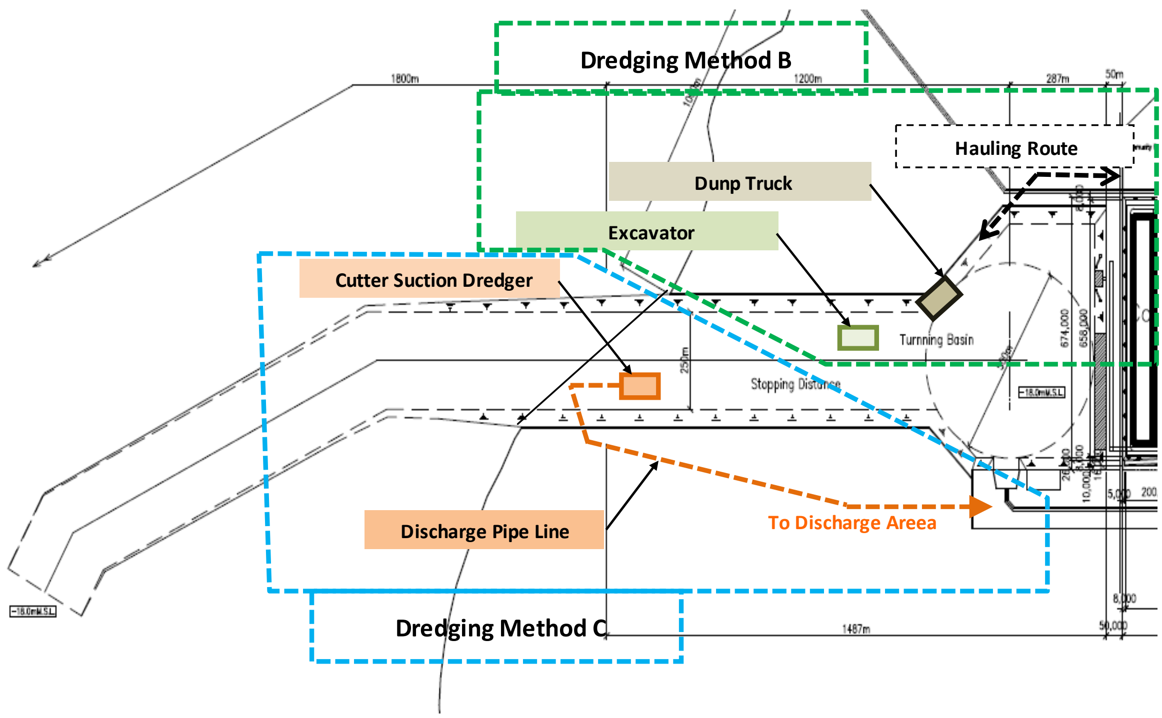


Figure 8.2-13 Dredging Method B and C for Land Area

(3) Productivity of Dredging

1) Rate of Operation

According to a report issued by the Kyoto University, there are two monsoon seasons each year in this area. The first monsoon season is called "Pre-monsoon" in May and the second is the "Post-monsoon" between October and December. For construction planning, these seasons shall be considered as non-working periods. Therefore, the rate of operation ("Ro") is set out below.

Ro = (12-4) / 12 = 0.67

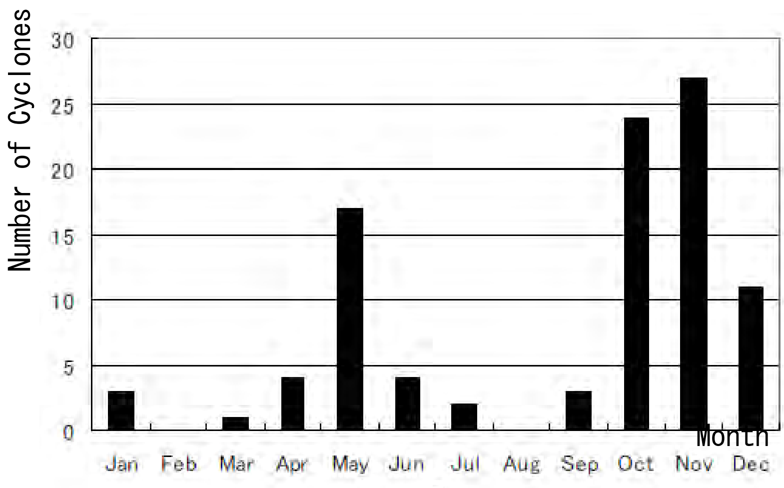


Figure 8.2-14 Number of Cyclones in Bengal Bay between 1977-2007

2) Dredging Method A

Selection of Dredger Capacity

Water Depth	<	20	m	Grab Dredger
Thickness of Dredging	>	4	m	23 m3 Class
Dredging Quantity	>	90,000	m3	

Productivity of Dredging

Q = q x E1 x E2 x E3 x T
= 527.9 x 0.85 x 0.80 x ((1.00 - 0.02 x (18 - 15)) x 18
= 6,074 m3/day

Working Period

N = 4,931,000 / 6,074 / 0.67 / 25 = 28.3 months / 1 grab dredger fleet
= 8.1 months / 6 grab dredger fleet

Secondary Dredging by Cutter Suction Dredger (2 unit x D 8000 PS Class)

Q = q x E1 x E2 x E3 x E4 x E5 x E6 x T
= 2 x 956 x 1.0 x 1.0 x 1.0 x 1.0 x 0.9 x 1.0 x 18
= 30,974 m3/day > 4 x 23m3 Class Grab Dredger

Dredging Method A		
Grab Dredger	4 x 23m3 Class	8 months
Cutter Suction Dredger	2 x D 8,000 Class	8 months

3) Dredging Method B

Selection of Excavator and Dump Truck Capacity

Excavator	3.0	m3	Class
Dump Truck	40.0	ton	Class

Productivity of Clay-1 Layer Dredging

Q = q x T
= 288.0 x 8
= 2,304 m3/day

Working Period

N = 5,350,000 / 2,304 / 0.67 / 25 / 15 = 9.2 months / 15 x 3.0m3 Class Excavator

Dredging Method B		
Excavator	15 x 3.0m3 Class	9.2 months

4) Dredging Method C

<u>Selection of Cutter Suction Dredger Capacity</u>

Discharge Distance	<	3	km	Cutter Suction Dredger
N Value of Sand Layer	<	40		D 8,000 PS Class x 2 unit
N Value of Clay-2 Layer	<	15		

<u>Productivity of Sand Layer Dredging</u>

Q = q x E1 x E2 x E3 x E4 x E5 x E6 x T
= 576 x 1.0 x 1.0 x 1.0 x 1.0 x 0.9 x 1.0 x 18
= 9,331 m3/day

<u>Productivity of Clay-2 Layer Dredging</u>

Q = q x E1 x E2 x E3 x E4 x E5 x E6 x T
= 950 x 1.0 x 1.0 x 1.0 x 1.0 x 0.9 x 1.0 x 18
= 15,390 m3/day

<u>Working Period for Sand Layer Dredging</u>

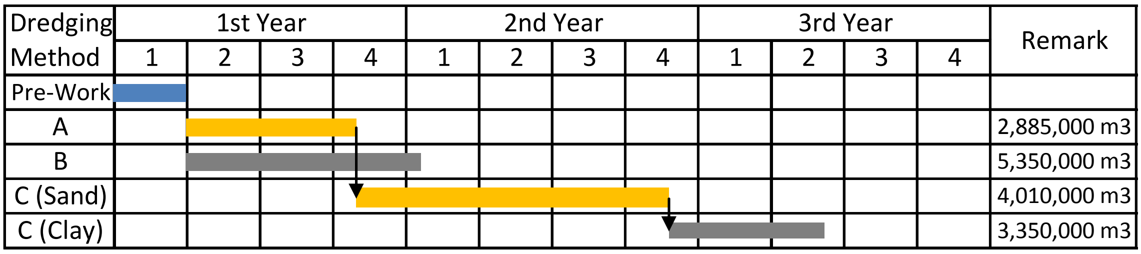
N = 4,010,000 / 9,331 / 0.67 / 25 /2 = 12.8 months / 2 cutter suction dredger

<u>Working Period for Clay-2 Layer Dredging</u>

N = 3,350,000 / 15,390 / 0.67 / 25 / 2 = 6.5 months / 2 cutter suction dredger

Dredging Method C		
Cutter Suction Dredger	2 x D 8,000 Class	12.8 + 6.5 = 19.3 months

5) Schedule



Note: In the period of Pre-work, pocket area and cutter suction dredger area shall be formed.
Legend : Sand Clay

Figure 8.2-15 Schedule of Dredging Works

8.2.8 Construction procedure for the dredging and land development work

In this section, the procedures of the dredging and land development works were examined. Then, in order to shorten the construction period, a Critical Path Process from the Award of Contract to Piling Work was proposed based on the certain Preconditions.

(1) Preconditions

Regarding the examination, the following Preconditions were set for Dredging Work in the port and channel, Soil Improvement Work in the power block area, and Land Filling Work in the power block areas as the main construction work;

- The dredged soil is to be classified into sand and silt/clay in the course of a dredging work.
- The dredged sand is to be used as the land filling material.
- The dredged sand is to be deposited at a temporary storage yard near the power block area.
- The filling material can be obtained from the early stage of the dredging work.
- The earth work is carried out with a sufficient amount of construction machinery.

(2) Critical Path Process of the Dredging Work and Land Development

For shortening the construction period, a construction procedure, or Critical Path Process, of the dredging and land development works from Award of Contract to Piling Work is proposed as follows;

a. Award of Contract and Commencement of Work
b. Detailed design
c. Preparation work
    - Land Survey
    - Mobilization and Placement of Dredger
    - Construction of a Temporary Jetty and a Temporary Yard
    - Installation of construction machineries
d. Sand Mat Work
    - Power Block Area (640 m X 640 m) and 1.5 m thickness
e. Soil Improvement Work (PVD driving)
    - The drain materials should be installed in the ground from the sand mat surface.
    - 9.5 m length and number of 104,000
f. Land Development (Filling Work)
    - Power Block Area is to be filled up 11.5 meters above M.S.L.
    - Dredged sand is used as a part of the filling material

- Dredged sand, which is dewatered in the temporary storage yard, is transported to the land development area by dump tracks.
- The power ground should be filled up gradually in a manner for confirming the strength of the existing ground.

g. Advancement of Consolidation and Settlement Measurement

- Keep the situation as it is for the advancement of the consolidation for approximately six months.

h. Completion of Soil Improvement and Land Development

- The slope protection work should be planned not to become a part of Critical Path during and after the Consolidation.

i. Commencement of Piling Work

(3) Remarks

The abovementioned Critical Path Process was proposed based on the Preconditions in the section (1) and the application of PVD placing to find the shortest way from Dredging Work to Piling Work. Therefore, provided the Preconditions are changed in accordance with the detailed study in the future, the procedure and Critical Path need to be re-examined.

8.3 Cooling Water Facilities

8.3.1 Intake water volume

The intake water volume for 2x 600MW of the power plant is estimated as follows:

- Intake water temperature: 30℃
- Warm water discharge temperature: 7℃ increase
- Calculation (circulation water volume per unit)

$$
\begin{aligned}
Q &= 150(m3/MW/h) \times Output (MW / unit) \\
&= 150(m3/MW/h) \times 600(MW / unit) \\
&= 90,000(m3/h/unit) = 90,000(m3/h/unit) \div 3,600(sec/h) \\
&= 25(m3/sec/unit)
\end{aligned}
$$

Moreover, although the discharged water temperature will become 37℃, this is not considered a problem since the temperature is not higher than 40℃ as stipulated in the warm circulation water discharge standards of Bangladesh

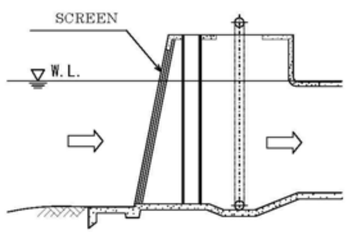
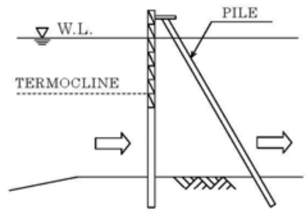
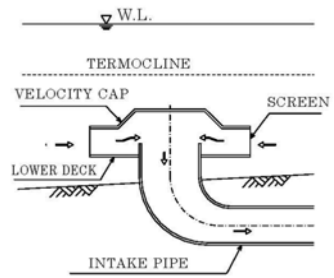
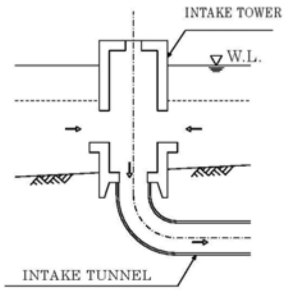
8.3.2 Selection of water intake and discharge system

The intake system shall be selected taking into account the following items:

- Effects of warm waste water from discharge outlet
- Effects of flowing wood, PVC, plastics and other foreign matters
- Location of this intake mouth is adopted inside of the harbor
- Location of the intake mouth in the southern side of the plant harbor is adopted

In consideration of the above items, the curtain wall type intake system shall be adopted.
The intake velocity at the intake mouth shall be about V = 0.2m/sec (at LWL) so as not to disturb the passage of small ships and boats in the sea.

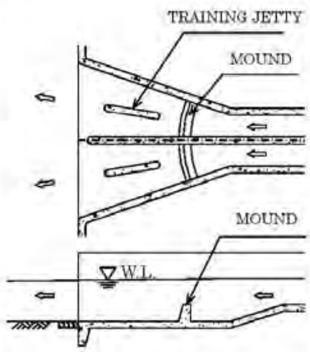
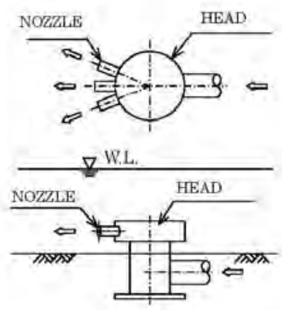
Table 8.3-1 Comparison of Different Intake System Characteristics

TYPE		TYPE OF SURFACE INTAKE SYSTEM	TYPE OF DEEP LAYER INTAKE SYSTEM		
		ONSHORE		OFFSHORE	
		ONSHORE DIRECT TYPE	CURTAIN WALL TYPE	PIPELINE TYPE	TUNNEL TYPE
PLOFILE					
DESCRIPTION		It is a comparatively simple form. It is the form that it faces shore that the depth of water is comparatively shallow. Generally, it is a structure thing made of the concrete which uses shore, and has equipment such as screen and pump.	It is a selective withdrawal form for the depths water in front of shore. A stake such as H steel and a steel pipe was driven into the central part of the sea in front of shore, and a curtain panel was set up.	It is a selective withdrawal form for the offsore depths water. A pipe way is laid in the bottom of the sea, and it is the structure that lead does intake directly from raising, velocity cap and the lower deck from the horizontal direction in intake point.	It is a selective withdrawal form for the offsore depths water. An undersea tunnel and offshore intake tower are built, and it is the structure that intake is done from the opening set up in intake tower from the horizontal direction.
CHARACTERISTICS	FLOW RATE	Smaller, better effect.	For any size adaptable.	For any size adaptable.	Bigger, better effect.
	WATER. DEPTH	Limited due to suitability to shallow area	Deeper, better effect.	For any depth adaptable.	Deeper, better effect.
	INTAKE VELOCITY	About 0.2～0.5m/s	About 0.2m/s	About 0.2m/s	About 0.2m/s
	WAVE	It faces it against the small wave.	It faces it against the small wave.	Enough stability can be attained against high wave	Enough stability can be attained against high wave
	SURFACE WATER	The inflow of the surface water isn't avoided.	The inflow of the surface water can be avoided.	The inflow of the surface water can be avoided.	The inflow of the surface water can be avoided.
	FLOATING TRASH	The trash which stagnated in front of on shore flows in easily.	The trash which stagnated in front of on shore flows in easily.	Because the top is spacious, trash doesn't stagnate easily.	Because the top is spacious, trash doesn't stagnate easily.
	COST	3	4(Cheapest)	1(Most expencive)	2

8.3.3 Discharge system

The open channel type of surface discharge system along the shoreline shall be adopted.
And the heated effluent diffusion analysis of the discharged water shall be conducted to confirm the sea water temperature conditions.

Table 8.3-2 Comparison of Different Discharge System Characteristics

TYPE		TYPE OF SURFACE DISCHARGE SYSTEM	TYPE OF SUBMERGED DISCHARGE SYSTEM
		ONSHORE	OFFSHORE
		OPEN CHANNEL TYPE	MULTI-NOZZLE TYPE
PROFILE			
DESCRIPTION		It is the form that it faces shore that the depth of water is comparatively shallow. However due to limited entrainment expected from backside of outlet, the dispersion efficiency is considered comparatively poor.	Dispersion efficiency is excellent. Regardless of water depth, varieties of diameter of nozzle, number of nozzle & its directions & angles provide for flexibility of design. Less restriction for area or water depth & smaller scale of foundation work is required.
CHARACTERISTICS	FLOW RATE	For any size adaptable.	For any size adaptable.
	WATER DEPTH	Limited due to suitability to shallow area	Deeper, better effect
	FLOW VELOCITY	Limited in outfall velocity due to restricted water depth	Reasonable velocity can be attained with-Out jeopardizing loss head
	WAVE	It faces it against the small wave.	Enough stability can be attained against high wave
	INITIAL DISPERSION	The dilution effect by initial mixture is seldom expectable.	The dilution effect by initial mixture is expectable.
	COST	Low	High

8.4 Screen Pump Pit

The screen pump pit shall be made of reinforced concrete to ensure convenience of maintenance, reduction of costs and other requirements.

Six sets of circulating water pumps (50% capacity/unit × 3 set/unit × 2 units) will be installed.

Stop logs shall be provided in front of and behind the screen room in dry conditions during the maintenance of the screen, and a gantry crane will be installed for maintenance of the circulating water pump, screen and other equipment.

The screen pump pit structure must be designed to maintain normal operations during emergency height sea levels (+ 10.0m M.S.L).

The average velocity of the inside of the pump pit (near the pump) V = 0.3m/sec is adopted.

In the case that the average velocity of the inside of the pump pit far from 8 (eight) × (bell mouth's diameter distance) is over V = 0.5m/sec, model experiments of streamline analysis shall be conducted to confirm the pump capability.

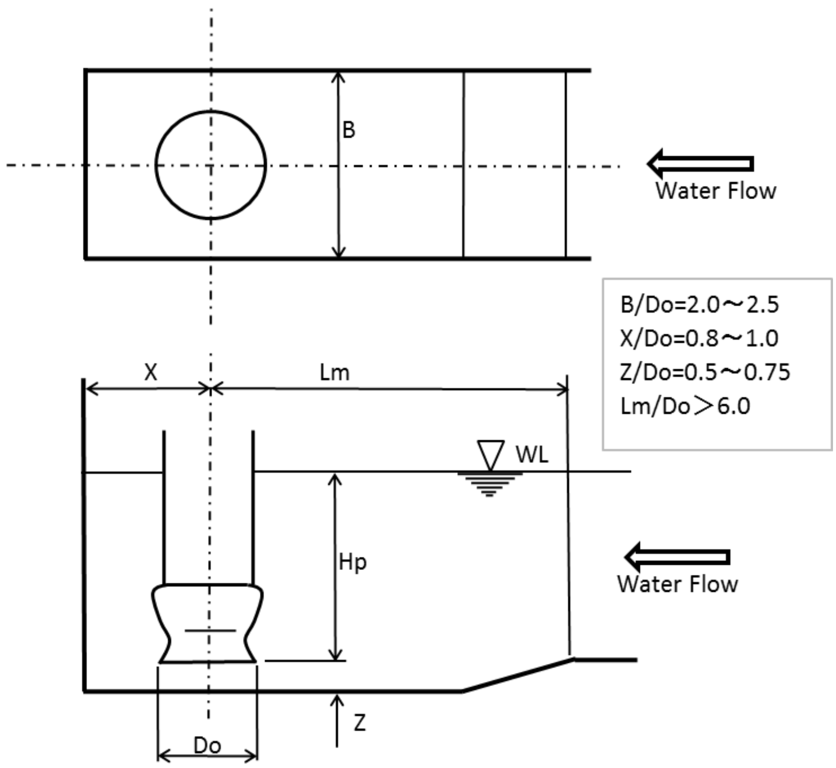


Figure 8.4-1 Standard Form and Dimensions for Pump Pit

An outline of the pump pit is shown below.

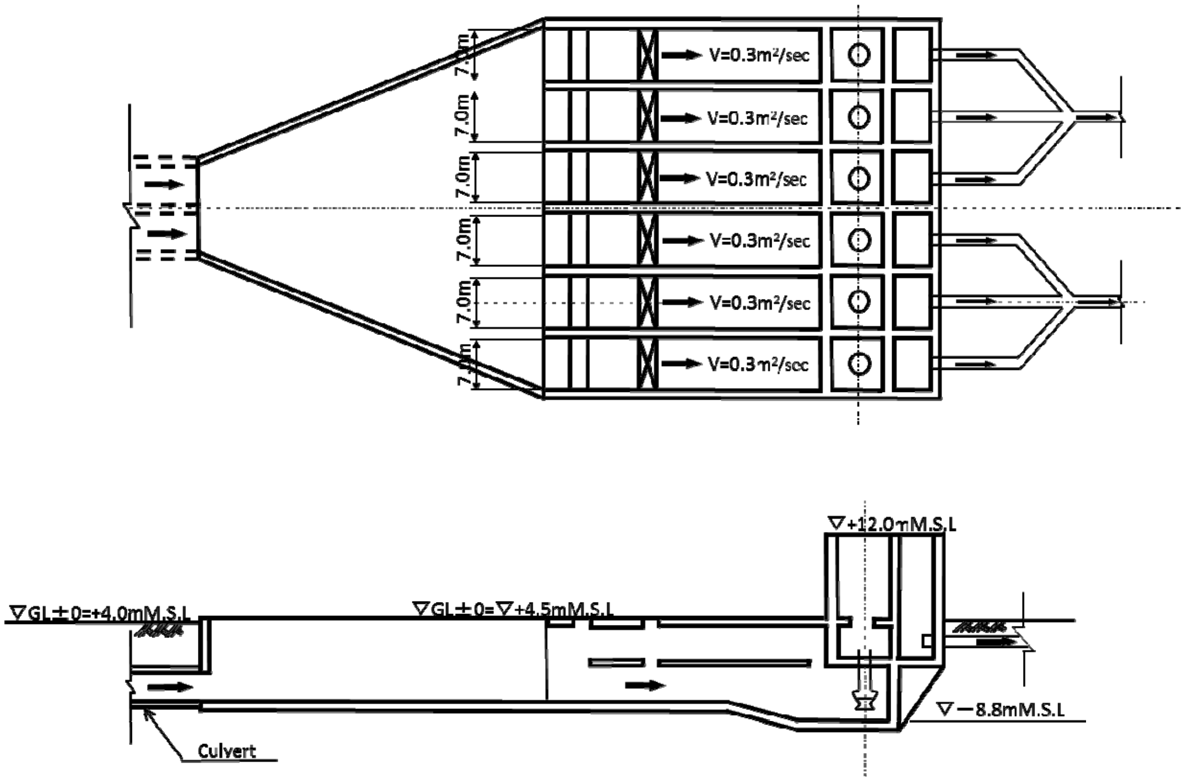


Figure 8.4-2 Outline (Plan and Section) for Pump Pit

8.5 Circulating Water Pipe

The circulating water pipe shall consist of steel pipes and be a direct buried system with a depth of 1.5m or more.

Back filing shall be carried out around this pipe with sand of a good quality. In addition, the upper ground surface load must be considered for calculation of the wall thickness of the pipe.

The design upper ground surface load is as follows:

Heavy Equipment Transportation area	10 ton / m^2
Road Area	T-25
Other Area	1ton / m^2

Flow velocity of the CW pipe is as follows:

Steel Pipe Size (mm)	Flow Amount (m3/s)	Average Flow Velocity (m/s)
3600	25 m^3/s/unit	2.5m/s

Moreover, a cross section of a standard underground piping is as shown below:

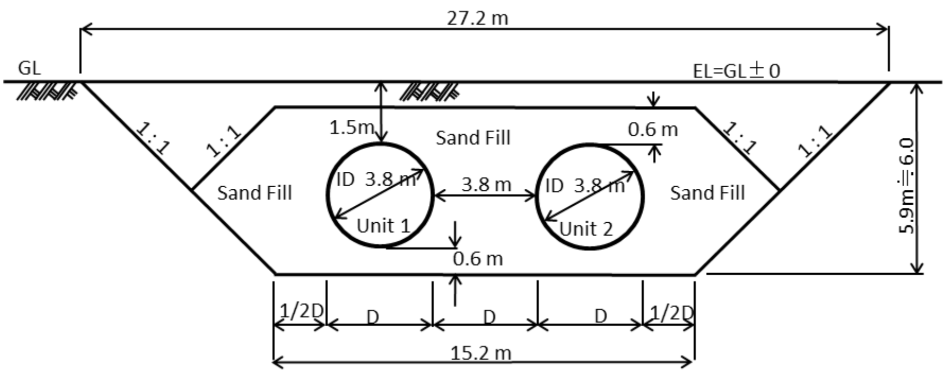


Figure 8.5-1 Section of a Standard Underground Piping

8.6 Discharge Tunnel

A discharge tunnel is a common facility for Units 1 & 2 and is made for a box culvert type of reinforced concrete.

The crown height of the culvert is -10 cm from LWL to prevent water hammering.

The box culvert will take a square format to minimize the water head loss, and the culvert laying gradient will be roughly 1/1200 toward the downstream side.

The flow velocity of the discharge tunnel is as follows:

Size (m)	Flow Amount (m3/s)	Average Flow Velocity (m/s)
3.5m(H)*3.5m(B)*2 units	50 m^3/s(2 units)	2.0m/s

In addition, a cross section of a standard underground discharge tunnel is as shown below:

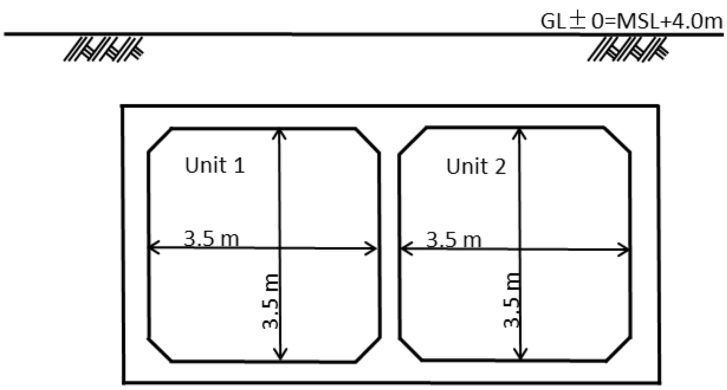


Figure 8.6-1 Section of a Standard Underground Discharge Tunnel

8.7 Outlet

The discharge outlet is a surface layer discharge system through a discharge tunnel.

The outlet is made of reinforced concrete.

The discharge flow velocity of the outlet shall be 0.3～1.0m/sec (at LWL) at the end of the discharge outlet in order to not disturb the passage of small ships and boats in the sea. For the purpose of preventing any scouring of the discharge outlet and protecting its slope, gabions will be laid over a section of approx. 20m in front of the outlet.

The location of the discharge outlet is along the sea shoreline at the northern side of the navigation channel, and a distance of 1 km from the navigation channel will be adopted.

A plan and section of an outline of an outlet is as shown below:

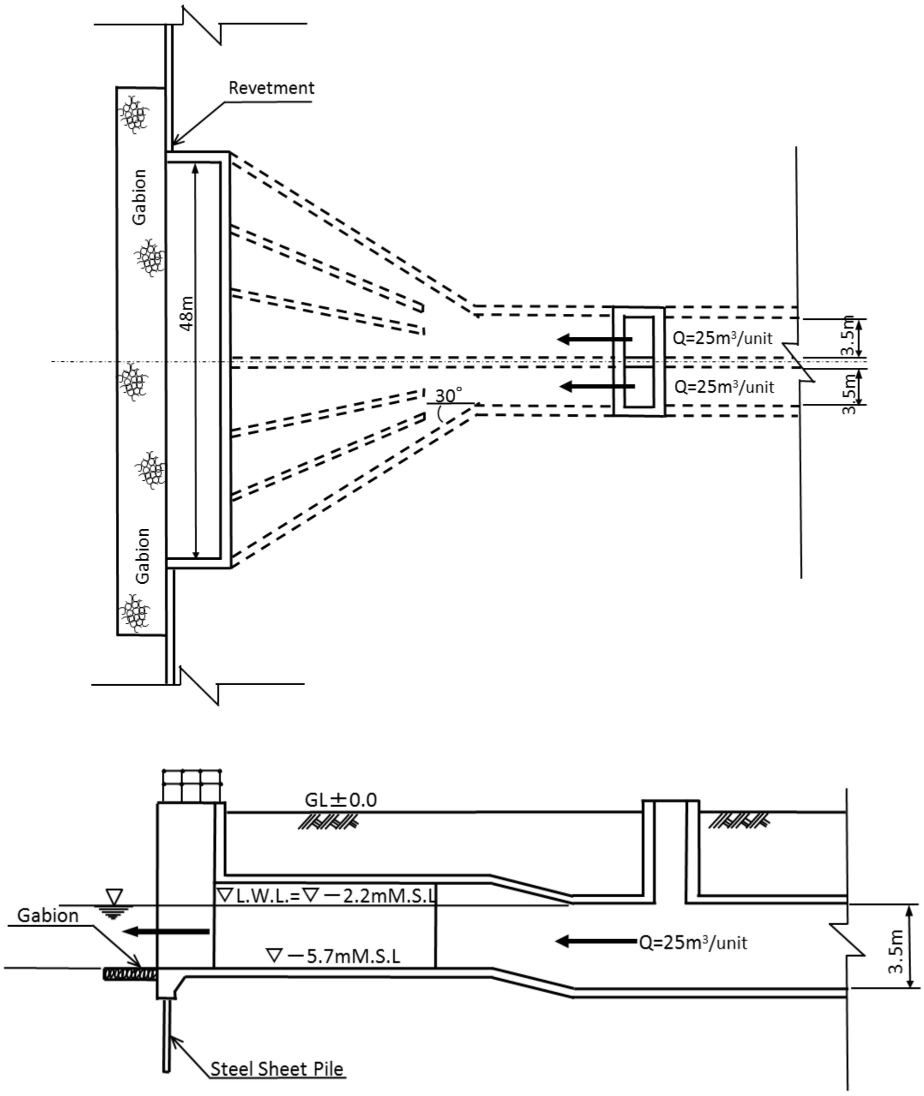


Figure 8.7-1 Outline (Plan and Section) for Outlet

8.8 Building

A description of each building planned for construction in this project is as follows.

Table 8.8-1 Description of Each Building

Building Name	Foundation Type	Superstructure Type
Power House	Pile Foundation	Structural Steel
Central Control Building	Pile Foundation	Reinforced Concrete
Administration Building	Pile Foundation	Reinforced Concrete
Passage Way	Pile Foundation	Structural Steel
Workshop	Pile Foundation	Structural Steel
Warehouse	Pile Foundation	Structural Steel
Fuel Oil Pump House	Pile Foundation	Structural Steel
Water Treatment Plant Control Building	Pile Foundation	Reinforced Concrete
Waste Water and Dehydrator Building	Pile Foundation	Reinforced Concrete
ESP & Ash Control Building	Pile Foundation	Reinforced Concrete
CW Intake Electrical, Chlorination and Desalination Building	Pile Foundation	Reinforced Concrete
Coal Unloading Control Building	On the Berth	Structural Steel
Coal Handling Building	Pile Foundation	Reinforced Concrete
FGD Electrical and Control Building	Pile Foundation	Reinforced Concrete
Oxidation Air Blower House	Pile Foundation	Reinforced Concrete
H2 Gas Generation House	Pile Foundation	Reinforced Concrete
Filtered Water Pump and Air Compressor House	Pile Foundation	Reinforced Concrete
Leachate Water Treatment Control Building	Pile Foundation	Reinforced Concrete
Switchyard Control Building	Pile Foundation	Reinforced Concrete
Fire Station	Pile Foundation	Reinforced Concrete
Canteen	Direct Foundation	Reinforced Concrete
Guard House	Direct Foundation	Reinforced Concrete
Vehicle Service Center and Garage	Direct Foundation	Structural Steel
Vehicle Garage for Coal Storage Yard	Direct Foundation	Structural Steel
Vehicle Garage for Ash Disposal Area	Direct Foundation	Structural Steel

8.9 Stacks

Stacks are a common facility for Units 1 & 2.

(1) Foundation

The foundation is of a mat foundation (shape octagonal) type supported with pile.

(2) Concrete windshield

The windshield is made of reinforced concrete. It protects the inner flues form wind-force, seismic-force and other forces.

- Height: GL + 275m
- Form works: Slip form

(3) Inner flues

The castable lining type is selected for this project from the viewpoint of the availability and cost of the material.

- Cylinder: Two cylinders (an extension of the cylinder of Unit 2 is expected in the future)
- Material: SS400

(4) Platform and ladder

Ten platforms are set up inside the windshield for maintenance of the stack.
A ladder is also set up inside the windshield for access to the platforms.

(5) Ventilation system

Natural ventilation is provided for maintaining the inside temperature during maintenance in good conditions.

(6) Aeronautical light

An aeronautical light system and aircraft warning will be provided based on the regulation.

(7) Lightning

Lightning protection will be set up on the top of the stack.

8.10 Service Roads

Roads will be provided for vehicular access around all plants, administration building, etc. Roads are classified in three classes. Road widths, radius of corners, curves and pavements are designed to be entirely suitable for the sizes of vehicles which are likely to be used during the life of the power plant, including articulated vehicles and transporters used for the removal and replacement of major items of plant and equipment as follows.

Table 8.10-1 Road Width and Radius

Class	No. of Lanes	Width between Kerbs* (m)	Minimum radius (m)
A-10	2	10**	7.5
B-8	2	8	7.5
C-6	1	6	7.0

*Width includes travel lanes, shoulders and parking lanes.

**The width of class A-10 road is 13m, including both sides of sidewalks with minimum widths of 1.5m.

The cross slope of the road will be 2% and the maximum grade of road will be 5%.
Sidewalks will be surfaced with asphalt wearing course and concrete block lying on a crushed-stone base.

8.11 Rainfall Drainage Facilities

The rainfall drainage system within the premises of the power plant will consist of concrete drain pipe, reinforced concrete manhole, side ditches, catch basin, check pits and so forth.

Check pits are planned in the storm water drainage system to discharge drainage in the plant area smoothly.

Check pits will have the capacity sufficient to store an amount of inflow drainage of approximately one minute.

Rainfall drainage facilities are required to maintain normal operations during emergency height sea level (El + 10.0m).

At the drain outlet of rainwater, two sets of gates are required.

The purpose of the outside gate (valve) is to prevent any seawater from entering the power plant during the emergency height sea level, and the purpose of an inside gate (valve) is to prevent any dirty rainwater entering the power plant.

8.12 Ash Pond

The ash disposal pond is located at east of the power plant site. An area of 200 ha is required. For sufficiently preserving the environment around the power plant area, the ash disposal area shall be a control type construction.

The general standards for the construction of ash disposal area, to be considered in designing the ash disposal area, are as follows:

Major Requirement for the Construction of Ash Disposal Area
・Fence for preventing entry of personnel into the area around the reclamation site ・Notice board and other warnings indicating the ash disposal area ・Countermeasures for preventing landslide or ground slides ・Countermeasures for preventing settlement of equipment installed in the ash disposal area ・Retaining wall, embankment and other equipment for preventing spillover of ash ・Impermeable retaining wall sufficient for preventing leaching of water contained in ash, rainwater, from the reclamation site ・Conduit and other water collecting equipment sufficient for efficiently collecting retained water ・Leakage treatment equipment sufficient for treating collected retention water, etc., to a standard quality level ・Conduit and other equipment sufficient for preventing inflow of surface water into the reclamation site ・Ash conditioning or watering system for the ash at the disposal area ・Mobile equipment (Bulldozer/Wheel Dozer, Water Tank Truck & Excavator) for the management of the ash disposal area

Therefore, the ash disposal area studied herein has been designed based on the following basic concept:

- The construction of this ash disposal area shall be according to the Standards for Construction of Ash Disposal Area.
- The reclamation work shall be carried out by horizontal spreading and roller compaction.
- After completion of reclamation, the disposal area shall be covered by soil and trees, etc., and be planted.

-Construction of Ash Pond

The ash pond shall be a controlled type taking into account the environmental aspects of the surrounding area so that any ash, rain water, and wastewater, etc., will not be leaked directly into the outside area.

The ash pond shall be coffered with soil banking, and ash will be disposed into the pond.

Since the soil embankment is permeable, the coefficient of permeability ($K = 10^{-6}$), complying with the standard values for ash ponds, should be obtained by using an impermeable layer.

For attaining this coefficient of permeability, a high density polyethylene ("HDPE") sheet shall be laid inside the soil banked area.

The general section shall be covered by soil with a thickness of roughly 50 cm to protect the section from being damaged by heavy-duty machinery during reclamation and prevent deterioration of the polyethylene (HDPE) sheet material due to ultraviolet rays, etc., with the elapse of time.

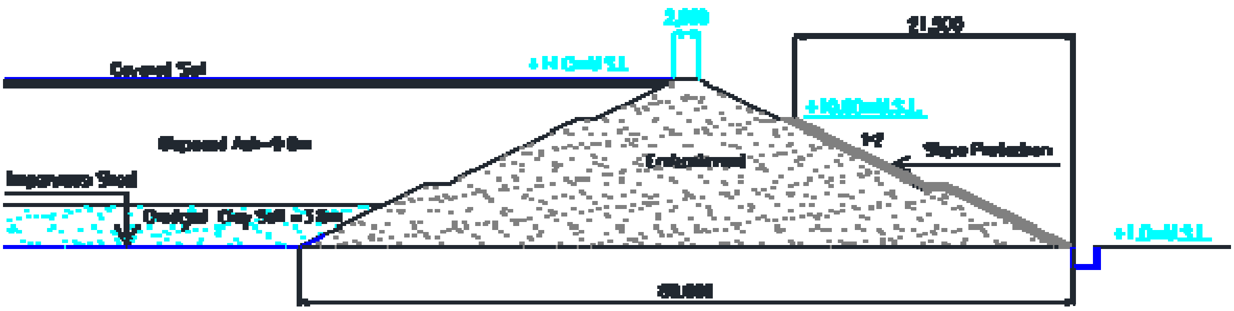


Figure 8.12-1 Typical Cross Section

8.13 Transportation of Heavy Equipment and Materials

Thousands of tons of equipment and materials shall be transported during the construction of the power plant. From this equipment and materials, the heaviest item shall be the step-up transformer or generator weighing as much as approximately 500 tons. The transportation method for moving the heavy equipment to the construction site is specified so that barges shall be used for delivery of the equipment from freighters to the power plant site.

A special unloading place shall be considered for the unloading of heavy equipment from 4,000 ton class barges to the construction site. The unloading place shall be a shallow draft wharf where barges can moor to unload the cargo to be handled later through the ramp way.

The seabed in front of the shallow draft wharf is designed at a depth of -5m taking into account the dimensions of a barge-handling tug boat. The shallow draft wharf is around 8000m^2 (100m×80m) with a load bearing capacity of 10 ton/m^2 for the unit dolly transportation. This unloading facility is designed as a permanent facility because of the necessity for future expansion and maintenance work.

Figure 8.13-1 shows an example of a shallow draft wharf design.

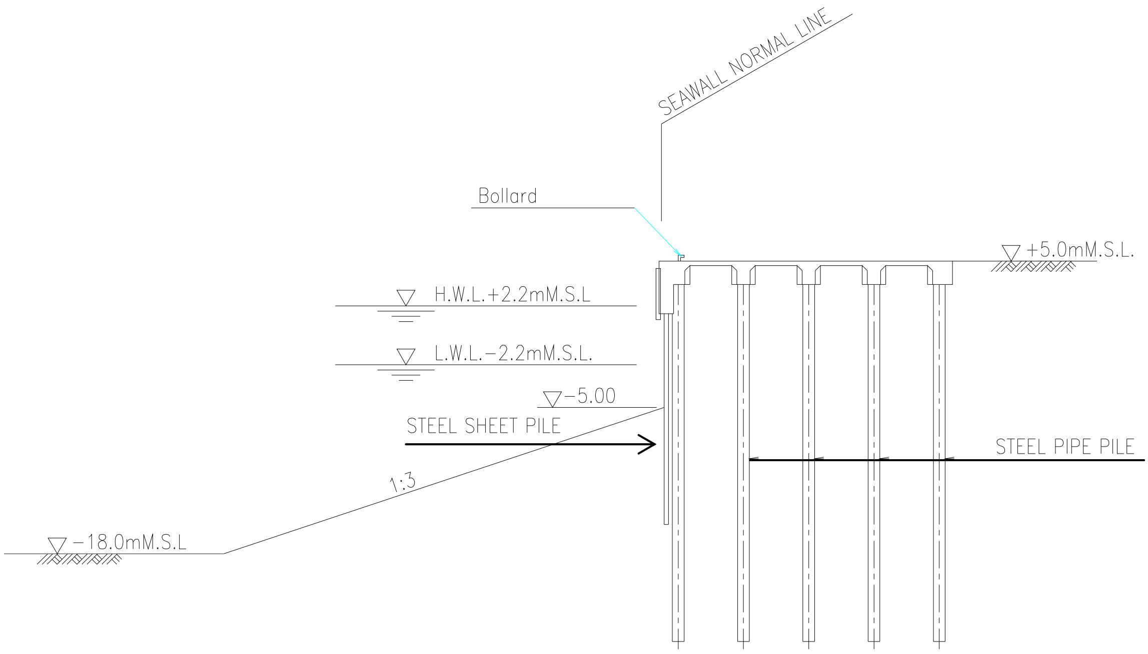


Figure 8.13-1 Shall Draft Wharf (Standard Section)

8.14 Soil Improvement

The existing ground foundation is very soft as shown in Chapter 5.2.4 Geology.
If the ground is filled in, consolidation settlement and circular slip may occur in the existing ground. Such a state is shown in Figure 8.10-1.

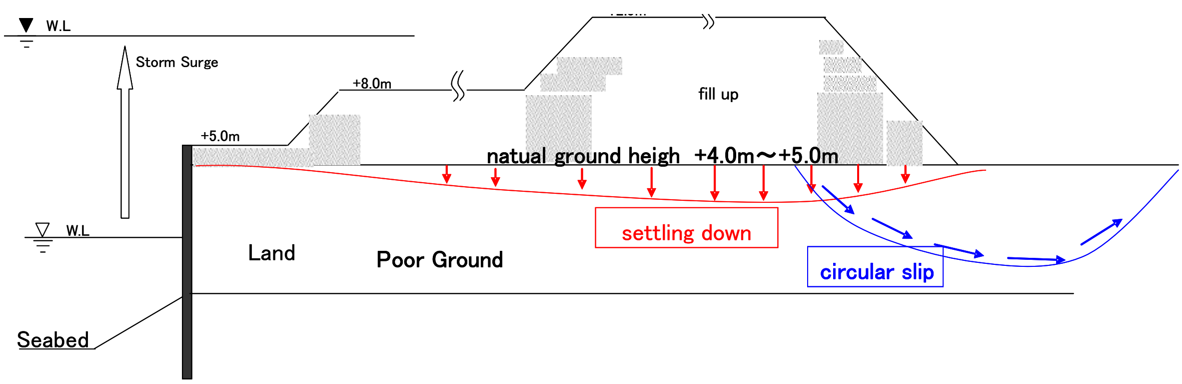


Figure 8.14-1 Consolidation Settlement and Circular Slip

Generally, as examples of soil improvement, the JICA Study Team suggests the following improvement method.

-Vertical Drain Method
For the vertical drain method, plastic-board drains are inserted into the foundation ground.
This method is mainly used for the settlement and consolidation of clay ground, e.g., reclamation sites with sand surcharges stacked on the ground to press out ground water.
The purpose of preloading and vertical drains is to increase the shear strength of the soil, to reduce the soil compressibility and to reduce the permeability of the soil prior to construction and placement of the final construction load, and prevent large and/or differential settlements and potential damage to the structures.
Although the Sand Compaction Pile Method or Deep Mixing Method of Soil Stabilization could be adopted in this case, in general the Vertical Drain Method has a cost advantage over these methods.

Chapter 9

Power System Analysis and Transmission Line/Substation Plan

Chapter 9 Power System Analysis and Transmission Line/Substation Plan

This chapter describes the results of the transmission system study for the power evacuation line of the new Matarbari power station. The power station is supposed to be connected to the new Anowara substation which is located 80 km north of this power station and 10 km south of Chittagong city.

9.1 Power System Analysis

9.1.1 Conductor selection

The optimum configuration of the transmission line depends on the assumed loading levels under normal, peak and off-peak conditions, construction and power loss costs. This study evaluates several types of conductors, including the conventional ones and new technologies, to evacuate the power from the new Matarbari power station which has a 1,200 MW generation output.

(1) Cost Estimation of Each 400kV Transmission Line

The cost of the 400kV transmission line between Bibiyana-Kaliakoir, which is under construction, is provided by PGCB as follows:

Table 9.1-1 Cost of 400kV Bibiyana – Kaliakoir Transmission Line

Transmission line		400kV Bibiyana – Kaliakoir
Conductor		ACSR Finch (564 mm^2)
No of conductor		2
Current carrying capacity	[MVA]	1374
Route length	[km]	170
Total cost (170 km)*	[US$]	65,925,000
Unit cost of conductor	[US$/km]	8,100
Conductor cost	[US$/km]	97,200
Tower cost	[US$/km]	290,594
Transmission line cost	[US$/km]	387,794

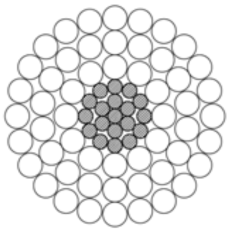
*) Local currency is converted to US$ with 80 BDT/US$.

The following table shows a list of the conductors evaluated in the study:

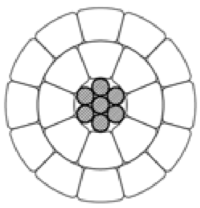
Table 9.1-2 List of Conductors

Conductors	Unit costs (US$/km)	Nominal Weight (kg/km)	Remarks
1. ACSR Finch 564 mm^2	8,100	2,045	Conventional type, Used in the transmission line under construction
2. ACSR Martin 685 mm^2	9,800	2,584	Conventional type, larger than ACSR Finch
3. Low Loss ACSR/AS 756 mm^2	14,470	2,582	New technology, Weight is equivalent with ACSR Martin
4. Low Loss TACSR/AS 490 mm^2	9,270	1,609	New technology, Thermal resistant
5. TACSR Condor 403 mm^2	5,902	1,522	Conventional type, Thermal resistant

ACSR and TACSR respectively stand for Aluminum Conductor Steel Reinforced and Thermal Resistant aluminum alloy ACSR,. The continuous allowable temperatures are 80 °C for ACSR and 150 °C for TACSR. Since a higher temperature is allowed for TACSR, it has a much higher capacity than that of ACSR. The resistance of the line increases according to the temperature increase, and the higher temperature operations cause higher losses. The low loss type of conductor uses new technology and it uses a trapezoid shaped aluminum wire to have a large aluminum sectional area as shown in the following figure.



Conventional ACSR/TACSR



Low Loss ACSR/TACSR

Figure 9.1-1 Configuration of Conventional and Low Loss Type ACSRs

Since only one 400kV transmission line cost is available in Bangladesh, the costs of the transmission lines are roughly estimated in consideration of the weight of the conductors as follows:

Table 9.1-3 Cost Estimation of Each Transmission Line

Transmission lines	No of conductor	Cost for double circuits transmission lines (US$/km)
1. ACSR Finch 564 mm^2	4	572,172
2. ACSR Martin 685 mm^2	4	688,527
3. Low Loss ACSR/AS 756 mm^2	4	800,607
4. Low Loss TACSR/AS 490 mm^2	4	524,698
5. TACSR Condor 403 mm^2	4	443,866

As shown in the table, each transmission line has more than the transmission line capacity of 2,700 MVA, which means the lines have adequate capacity to evacuate the power generated at the new Matarbari coal-fired power station having a 1200MW capacity. Approximately 30 % - 50 % of its maximum current carrying capacity could be the most economical range of the operations in a general practice when the conductor is a conventional ACSR.

(2) Loss Factor

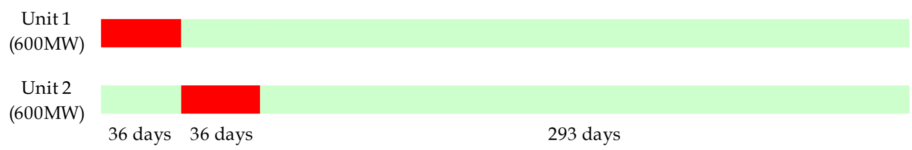
The conductor selection should consider the cost of losses in its calculation. The loss factor is used to calculate the annual kWh losses and the cost of transmission line losses defined in the following equations:

Annual kWh loss [kWh/year] = Loss factor × kW loss [kW] × 8760 [hours]

Annual cost of transmission line loss [US$/year] = Annual kWh loss [kWh/year] × Fuel cost [US$/kWh]

This study assumes that the planned outage of the new power plant is 10 % (36 days) per year as a regular maintenance period and the plant is under full operation (100% output) during the other period since it could be the base generation in Bangladesh. The loss factor is given as follows:

Loss factor = (average of current for a period)^2 / (peak current for a period)^2



Loss factor = (((72 × I^2) + (293 × (2I)^2) / 365) / (2I)^2 = 0.8520….

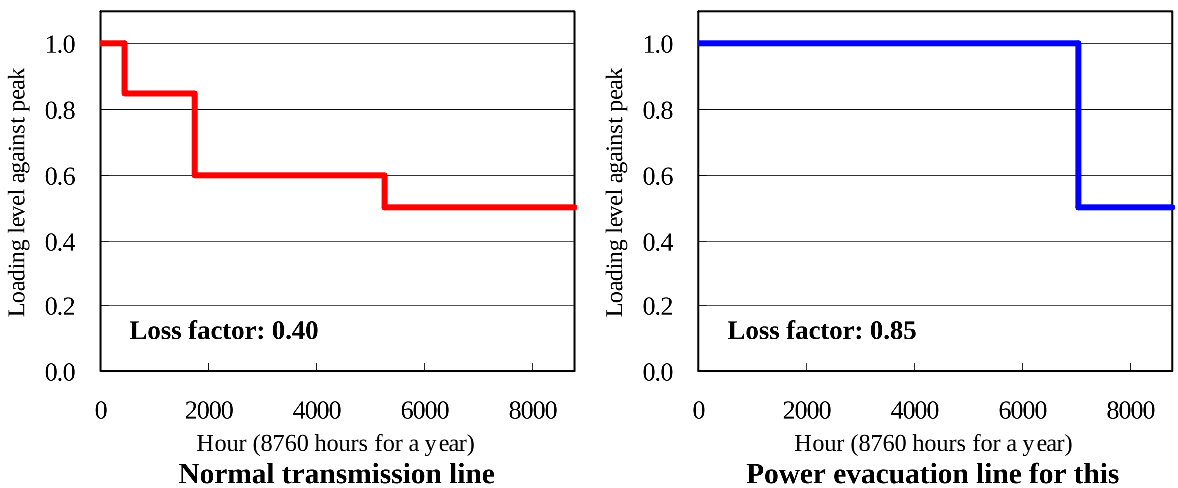


Figure 9.1-2 Loading Level of Transmission Lines

Table 9.1-4 Assumptions for Loss Factor Calculation

Loading level against peak	Typical transmission line (hours)	Power evacuation line for this project (hours)
1.00	438 (5%)	7008 (80%)
0.85	1314 (15%)	0 (0%)
0.60	3504 (40%)	0 (0%)
0.50	3504 (40%)	1752 (20%)
Total	8760	8760
Loss factor	0.40	0.85

The figures and table above show the typical loading level against the peak load and loss factors for the normal transmission line and the power evacuation line for this project, respectively.
The loss factor of 0.85 for the transmission line for this project is very high compared to the typical transmission line. The loss factor near the loads is approximately 0.3 – 0.4 in general due to a gap between peak and off-peak demands. This high loss factor may induce the higher capacity transmission line because it has lower impedance and then gives lower losses. As a result, the life time cost of the transmission line including the transmission line losses can be reduced by the higher capacity transmission lines.

(3) Current carrying capacity of each transmission line

The current carrying capacities of each transmission line are calculated using the CIGRE method under the following conditions in this study:

Table 9.1-5 Calculation Conditions for Current Carrying Capacity

Ambient temperature	35 °C
Wind speed	0.5 m/sec
Wind angle	45°
Global solar radiation	0.089 W/cm^2
Absorptivity of conductor surface	0.9
Emissivity of conductor surface	0.9
Height above sea level	0 m

The table below shows the current carrying capacity of each transmission line:

Table 9.1-6 Current Carrying Capacity for each Transmission Line

Transmission lines	No of conductor	Cost for double circuits transmission lines (US$/km)	Continuous allowable temperature (°C)	Current carrying capacities (MVA)
1. ACSR Finch 564 mm^2	4	572,172	80	2,748
2. ACSR Martin 685 mm^2	4	688,527	80	3,006
3. Low Loss ACSR/AS 756 mm^2	4	800,607	80	3,135
4. Low Loss TACSR/AS 490 mm^2	4	524,698	150	4,063
5. TACSR Condor 403 mm^2	4	443,866	150	3,687

As shown in the table above, each transmission line has more than the transmission line capacity of 2,700 MVA, which means the lines have adequate capacity to evacuate the power generated at the new Matarbari coal fired power station with a 1200MW capacity. Approximately 30 % - 50 % of its maximum current carrying capacity could be the most economical range of the operation in a general practice when the conductor is a conventional ACSR.

(4) Conductor selection at the 600 MW power flow per circuit

The optimum conductor is selected considering the construction, operations and maintenance, and the loss costs under the following conditions:

Table 9.1-7 Calculation Conditions for Annual Cost of Transmission Lines

Power factor	95 %
Life time of transmission line	40 years
Discount rate for the life time	12 %
O&M cost	2 %
Loss factor	0.85 (0.4 for reference)
Fuel cost (= Loss cost)	0.06 US$/kWh

This project assumes the development of the 1,200 MW (2 units × 600 MW) coal-fired power plant in Matarbari. The double-circuits transmission line is necessary to evacuate power considering the N-1 contingency criteria. This means that each circuit has 600 MW under normal operating conditions. The table below shows the characteristics of each transmission line at a 600 MW power flow per circuit.

Table 9.1-8 Characteristics of Transmission Lines at 600 MW Power Flow per Circuit

Conductor		Aluminum sectional area	Current carrying capacity	DC resistance at 20 °C	Power flow at 600 MW		
					Conductor temp.	AC resistance	kW loss
Name	Bundle	[mm^2]	[MVA]	[ohm/km]	[°C]	[ohm/km]	[kW/km]
ACSR Finch 564mm^2	4	564	2,748	0.05144	51	0.0145	35.91
ACSR Martin 685mm^2	4	685	3,006	0.04238	52	0.0120	29.58
LL-ACSR 756mm^2	4	756	3,135	0.03760	51	0.0106	26.25
LL-TACSR 490 mm^2	4	490	4,063	0.05910	51	0.0166	41.26
TASCR Condor 403mm^2	4	403	3,678	0.07330	52	0.0207	51.17

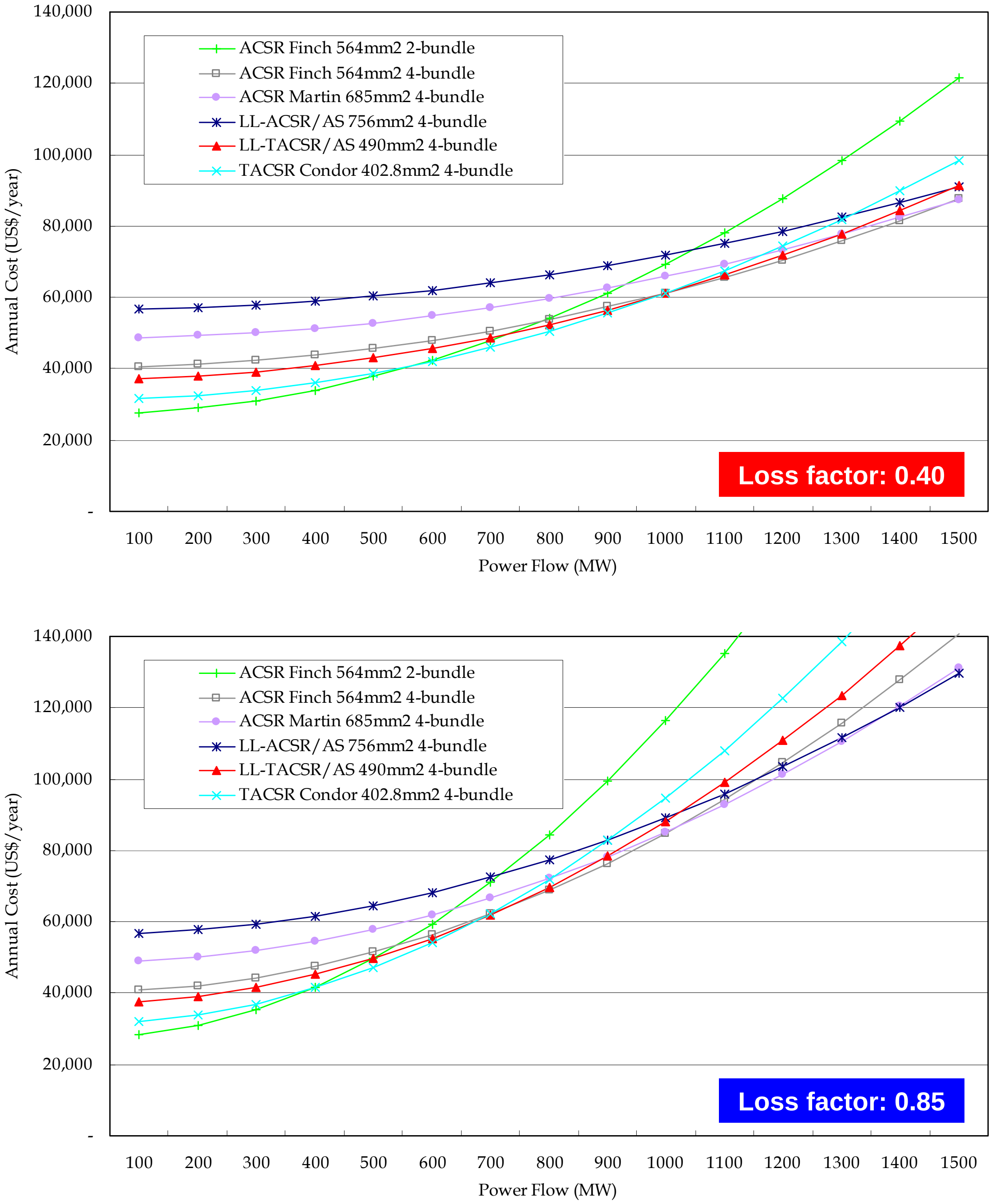


Figure 9.1-3 Annual Costs of Transmission Lines

Table 9.1-9 Annual Costs of Each Transmission Line at Loss Factor 0.85 (line loss for 600 MW)

Conductor		Annual cost for loss factor 0.85			
		Capital recovery	O&M	Transmission loss at 600 MW	Total
Name	MVA	[US$/year]	[US$/year]	[US$/year]	[US$/year]
ACSR Finch 564mm^2	2,748	34,616	5,722	16,042	56,381
ACSR Martin 685mm^2	3,006	41,656	6,885	13,217	61,758
LL-ACSR 756 mm^2	3,135	48,437	8,006	11,726	68,169
LL-TACSR 490 mm^2	4,063	31,744	5,247	18,431	55,422
TASCR Condor 403mm^2	3,678	26,854	4,439	22,860	54,152

The above figures show the results of the annual costs for each transmission line for the loss factor 0.40 and 0.85 including the Finch 2-bundle (1374 MVA) under construction as a reference. The ACSR Finch 2-bundle has the cheapest transmission line cost, which has a current carrying capacity of more than 1,200 MW. As can be seen from both figures, however, the annual cost of the Finch 2-bundle faces a rapid cost increase according to the power flow increase due to its higher losses.
When the loss factor is 0.40 for the typical transmission line, the TACSR condor exhibits better performance than others in the range of 600 MW to 1000 MW.

As discussed in the earlier section, the loss factor of this project is expected to be 0.85. For the loss factor 0.85, the most economical transmission line at 600 MW power flow is the TACSR Condor 4-bundle, which has the second lowest transmission line cost. The cost of the TACSR Condor 4-bundle also increases rapidly due to high transmission line loss when the line has more than 600 MW. The other transmission lines could be suitable for this power evacuation line considering the potential of further developments in the same area.

(5) Sensitivity study of the optimum conductor selection
It is highly uncertain, but Bangladesh plans to develop an additional 1,200 MW (2 units × 600 MW) at the Matarbari power station, and the total generation capacity of Matarbari power station could be 2,400 MW. In this case, the power flow of the transmission line per circuit could be 1,200 MW after a half or one decade of the first 1,200 MW development in Matarbari. The table below shows the characteristics of each transmission line at the 1,200 MW power flow.

Table 9.1-10 Characteristics of Transmission Lines at 1,200 MW Power Flow per Circuit

Conductor		Aluminum sectional area	Current carrying capacity	DC resistance at 20 °C	Power flow at 1200 MW		
					Conductor temp.	AC resistance	kW loss
Name	Bundle	[mm^2]	[MVA]	[ohm/km]	[°C]	[ohm/km]	[kW/km]
ACSR Finch 564mm^2	4	564	2,748	0.05144	56	0.0147	143.63
ACSR Martin 685mm^2	4	685	3,006	0.04238	55	0.0121	118.34
LL-ACSR 756 mm^2	4	756	3,135	0.03760	55	0.0107	104.99
LL-TACSR 490 mm^2	4	490	4,063	0.05910	58	0.0170	165.02
TASCR Condor 403mm^2	4	403	3,678	0.07330	60	0.0213	204.67

When the power flow of 1,200 MW is considered, the most economical transmission line is the ACSR Martin 4-bundle, but it needs a high initial investment cost. In considering the initial investment cost and uncertainty of future developments, it is reasonable to select an economical transmission line within the range from 600 MW – 1000 MW.

Table 9.1-11 Annual Costs of Each Transmission Line for 800 and 1,000 MW Power Flow

Conductor		Annual cost for loss factor 0.85					
		Capital recovery	O&M	800 MW		1,000 MW	
				TL loss	Total	TL loss	Total
Name	MVA	[US$/year]	[US$/year]	[US$/year]	[US$/year]	[US$/year]	[US$/year]
ACSR Finch 564mm^2	2,748	34,616	5,722	28,520	68,858	44,562	84,900
ACSR Martin 685mm^2	3,006	41,656	6,885	23,497	72,038	36,714	85,255
LL-ACSR 756 mm^2	3,135	48,437	8,006	20,846	77,289	32,573	89,015
LL-TACSR 490 mm^2	4,063	31,744	5,247	32,767	69,758	51,198	88,189
TASCR Condor 403mm^2	3,678	26,854	4,439	40,640	71,932	63,499	94,792

As a result, the following transmission lines could be options to be selected considering the initial investment cost, annual cost and current carrying capacity:

- ACSR Finch 4-bundle
- LL-TACSR 490 mm^2 4-bundle

The following table shows a comparison of the two transmission lines.

Table 9.1-12 ACSR Finch VS LL-TACSR 490mm^2

Transmission line	ACSR Finch 564 mm^2 4-bundle	LL-TACSR 490 mm^2 4-bundle
Technology	Conventional	New
Weight of conductor	××	×××
Initial investment	××	×××
Loss at 600 MW	××	×××
Loss between 600 – 1200 MW	×××	××
Loss at 1200 MW	×××	××
Current carrying capacity	××	××××

The JICA Study Team and PGCB discussed the conductor to be taken in the project. As a result of the discussion, PGCB will select one of two conductors in consideration of the initial investment cost, cost of losses and the current carrying capacity of the transmission line at the appropriate timing.

9.1.2 Objective of the power system analysis

The main study of the power system analysis is to examine the power system performance with the new power station under the normal operating and N-1 contingency conditions, since it may give a big impact on the existing grid due to its large generation capacity. The following table shows the items to be studied in this study:

Table 9.1-13 Items to be Studied in the Power System Analysis

Power flow analysis	1. Power flow	Power flow balance, Power loss, N-1 contingency (The power flow of each transmission line shall not exceed its limit under N-1 contingency.)
	2. Voltage	Bulk power system voltages under normal and N-1 conditions -Normal condition: ±5% -N-1 condition: ±10%
	3. Fault current	Magnitude of fault current (The fault currents shall not exceed allowable limits of each circuit breaker.)
Power system stability	4. System stability	Stability of generators under N-1 condition

The nearby area of this power station will be a power generation area in the future, and generated power will have to be evacuated to the demand area of Dhaka during both of the peak and off-peak periods. It is necessary to consider power development plans around this area for the power system analysis, because they also require the transmission lines to evacuate generated power to Dhaka. The World Bank has been supporting the 400kV transmission line project between Anowara and Meghnaghat, called NG4, and we will review the project reports of the World Bank's study as a reference.

Since the total generation capacity of this power station is 1200MW, the system requires a 400kV double circuits transmission line with a capacity of more than the 1200MW/circuit in consideration of the N-1 (Normal-1) contingency of the transmission line. Given the uncertainty of the power development plans around the area, this study analyzes the power system under the peak and off-peak load conditions in the commencement year of operations.

9.1.3 Study cases and assumptions

The following figure shows the power transmission system diagram from around 2020 in southern Bangladesh.

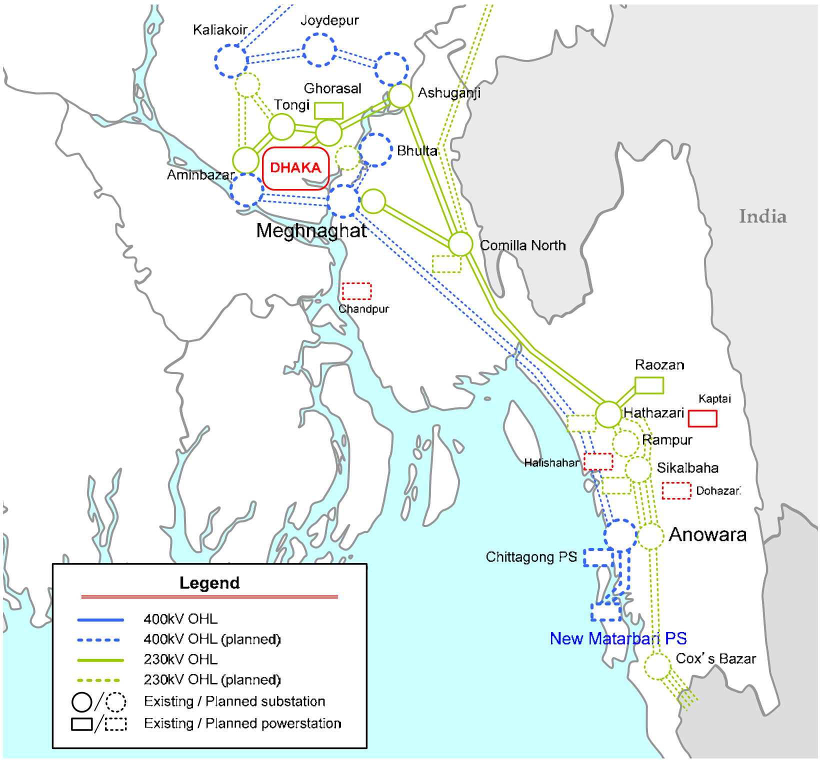


Figure 9.1-4 Power Transmission System from around 2020

The JICA Study Team assumes a couple of generation patterns from around 2020 under the peak and off-peak demand conditions in consideration of generation uncertainty. According to the latest power development plan, the power balance in the nearby area of this power station is as follows:

Table 9.1-14 List of Power Stations in the South of Hathazari from around 2020

Power Stations	Fuel Type	MW
Kaptai	Hydro	220
Raozon	Gas	380
Barobkundo	Gas	22
Shikalbaha	Gas	375
Hathazari	Gas/F.Oil	98
Dohazari	Gas/F.Oil	102
LNG	LNG	225
Chittagong (public + private)	Imp. Coal	1,900
Matarbari	Imp. Coal	2,400
Power import from Myanmar	–	500
Total		6,222

Table 9.1-15 Power Supply Demand Balance in South area of Hathazari from around 2020

Total Installed Capacity	6,222 MW
Peak Demand	1,785 MW
Off-peak Demand	714 MW

(Source: JICA Data Collection Survey on Coal Power Master Plan Follow-up in the People's Republic of Bangladesh)

As shown in the table above, Bangladesh has been planning to install power stations which have the capacity of 4300MW in the southern area as the base generation. Since the peak demand will be 1,785 MW from around 2020, the surplus power during peak demand conditions will have to be sent to Dhaka through the Southeast-Dhaka corridor including the NG4 project done by the World Bank and the 230kV transmission lines. During the off-peak conditions, the demand could be 40% of the peak demand and the Southeast-Dhaka corridor will have a larger power flow compared to that during the peak demand condition. According to the follow-up study, the maximum power flow of the corridor could be about 3,000MW during a certain generation pattern.

On the other hand, early development of Chittagong power station is quite uncertain according to the latest information as of February 2013, and it is supposed to be developed after the commissioning of the new Matarbari power station. It gives a positive impact to the Southeast-Dhaka corridor since the power flow on it is reduced.

In considering these conditions, the JICA Study Team assumes the following generation patterns to investigate the impact to the transmission system provided by the different generation patterns.

Table 9.1-16 Assumed Generation and Demand Patterns from around 2020

Patterns	Pattern 1	Pattern 2	Pattern 3	Pattern 4
Demand	Peak	Peak	Off-Peak	Off-peak
Matarbari	1200	1200	1200	1200
Chittagong	1900	0	1900	0
Sikalbaha	374	374	374	374
Raozan	350	350	350	350
Kaptai	230	230	230	230
Dohazari	100	100	0	0
Halishahar	100	100	0	0
Hathazari	100	100	0	0

The study assumes the following 400kV transmission line constants.

Table 9.1-17 Assumed 400kV Transmission Line Constants

Parameters	Ohm/km	pu/km
Positive R	0.018	0.0000111
Zero R	0.166	0.0001036
Positive X	0.270	0.0001690
Zero X	1.185	0.0007406
Charge	231,806	0.0069023

The following tables show the generator constants used in the transient stability analysis, which are the same parameters used in the Power System Master Plan 2010 supported by JICA exclusive of H (inertia) of the new coal power plant.

Table 9.1-18 Machine

Machine	Power factor	R Source (pu)	X Source (pu)	RG Pos (pu)	XG Pos (pu)	RG Neg (pu)	XG Neg (pu)	RG Zero (pu)	XG Zero (pu)
Hydro plant	0.85	0.00009	0.25	0.00009	0.25	0.00009	0.25	0.00009	0.25
Thermal plant	0.85	0.00009	0.2	0.00009	0.2	0.00009	0.20	0.00009	0.20

Table 9.1-19 Generator

Machine	Model	T'd0	T"d0	T'q0	T"q0	H	D	Xd	Xq	X'd	X'q	X"d	X1	S(1.0)	S(1.2)
Hydro plant	GENSAL	5	0.05	-	0.06	5.084	1	1.5	1.2	0.4	0.4	0.25	0.12	0.03	0.25
Thermal plant	GENROU	6	0.05	1	0.05	3	0	1.4	1.35	0.3	0.6	0.2	0.1	0.03	0.4
New coal plant	GENROU	6	0.05	1	0.05	6	0	1.4	1.35	0.3	0.6	0.2	0.1	0.03	0.4

Table 9.1-20 Exciter

Machine	Model	TA/TB	TB	K	TE	EMIN	EMAX
Hydro plant	SEXS	0.1	10	100	0.1	0	5
Thermal plant	SEXS	0.1	10	100	0.1	0	5

Table 9.1-21 Governor

Machine	Model	R	r	Tr	Tf	Tg	VELM	Gmax	Gmin	TW	At	Dturb	qNl
Hydro plant	HYGOV	0.05	0.5	10	0.05	0.5	0.17	1	0	2	1.2	0.5	0.08
Machine	Model	R	T1	VMAX	VMIN	T2	T3	Dt					
Thermal plant	TGOV1	0.05	0.5	1.5	0	1.8	6	0					

9.1.4 Power flow analysis

The study aims at finding overloaded transmission lines under the N-1 conditions of the 400kV and 230kV transmission lines. The following figures show the power flow diagram of each pattern.

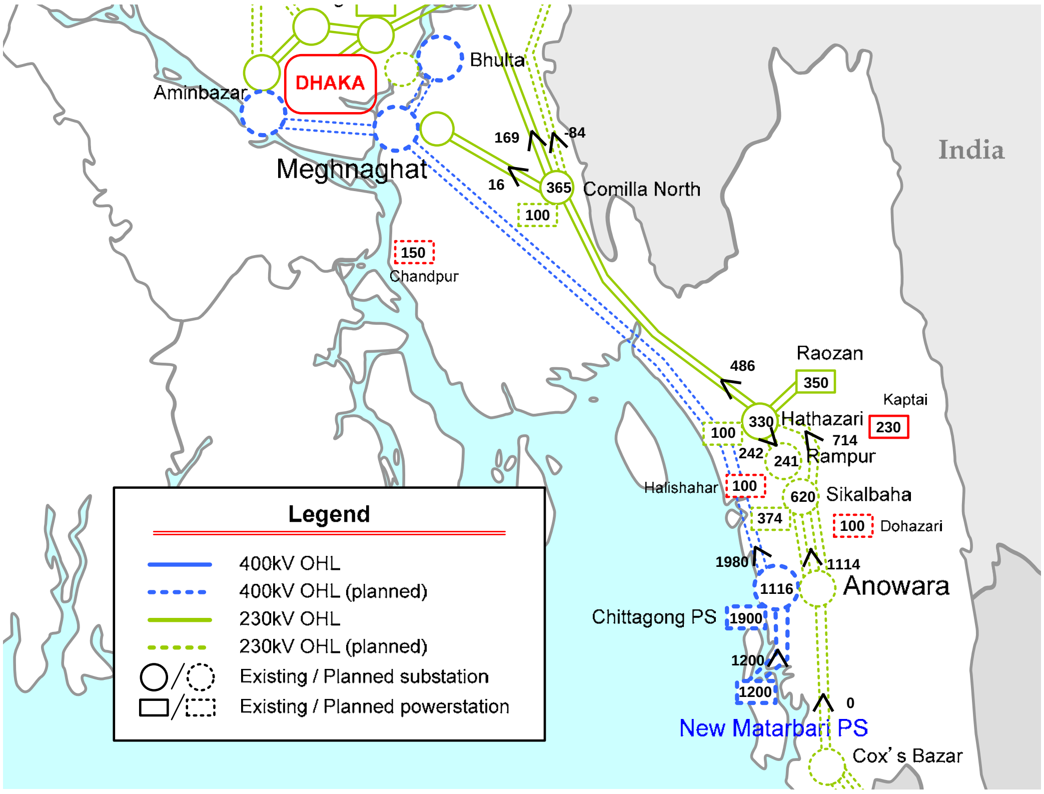


Figure 9.1-5 Power Flow Diagram of Pattern 1 (Mtbr: 1200, Chttgn: 1900MW Peak)

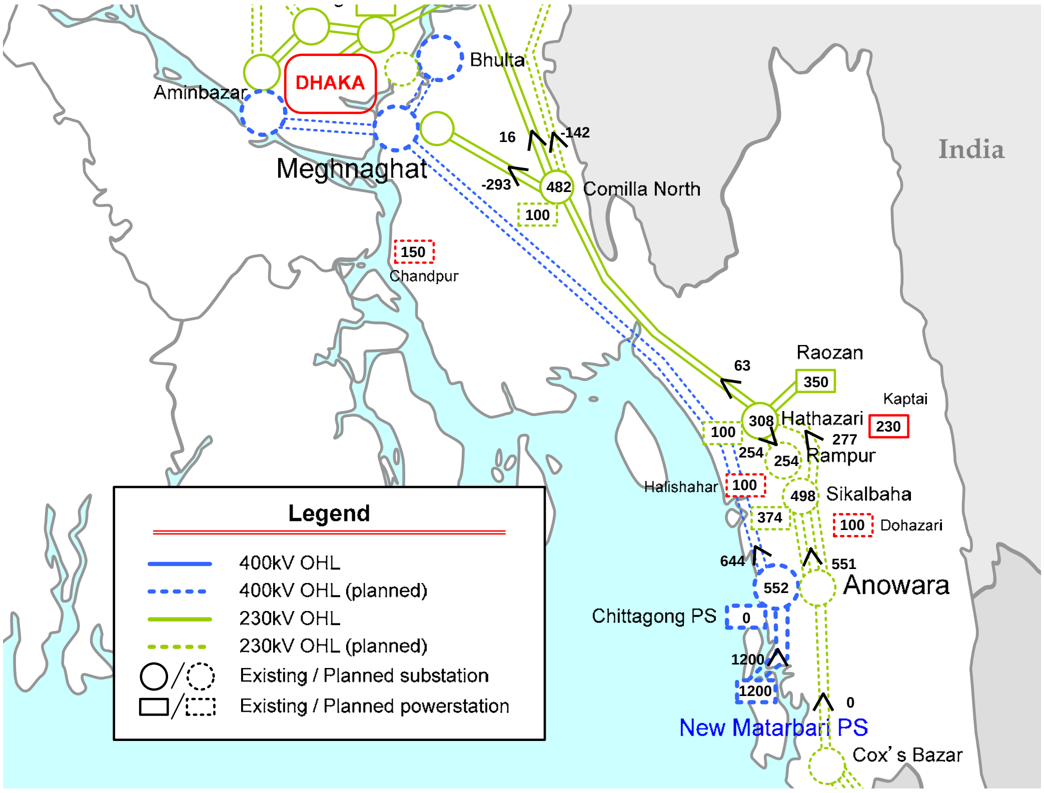


Figure 9.1-6 Power Flow Diagram of Pattern 2 (Mtbr: 1200, Chttgn: 0MW Peak)

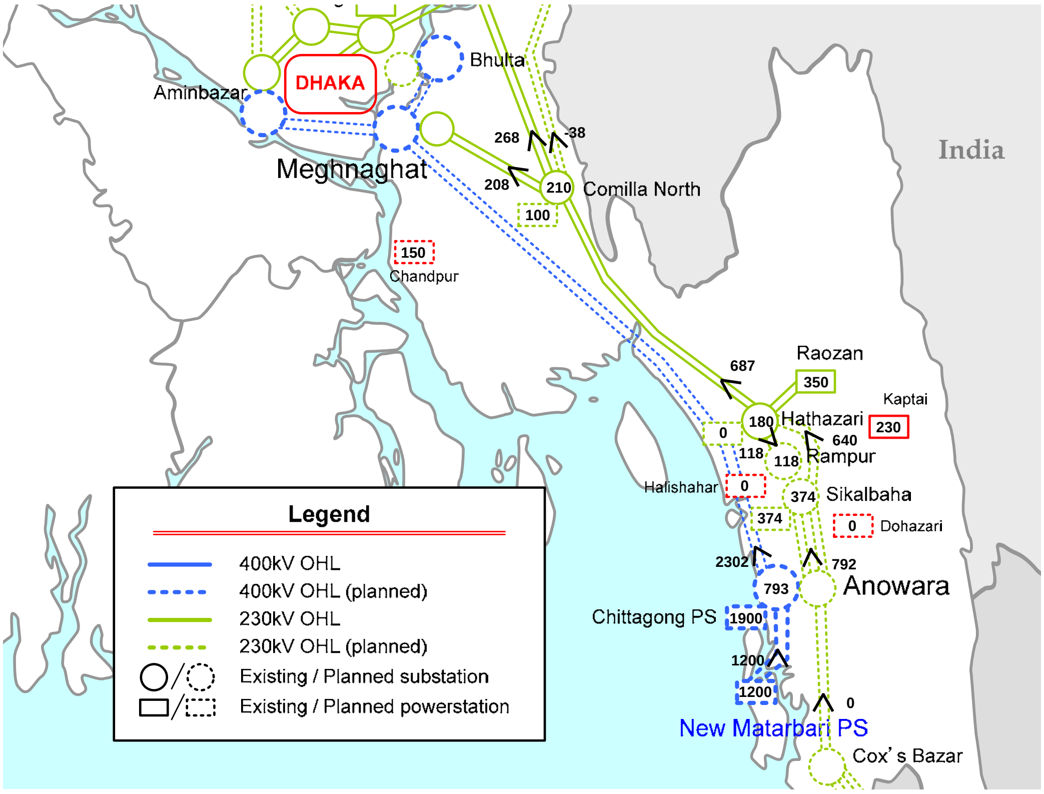


Figure 9.1-7 Power Flow Diagram of Pattern 3 (Mtbr: 1200, Chttgn: 1900MW Off-Peak)

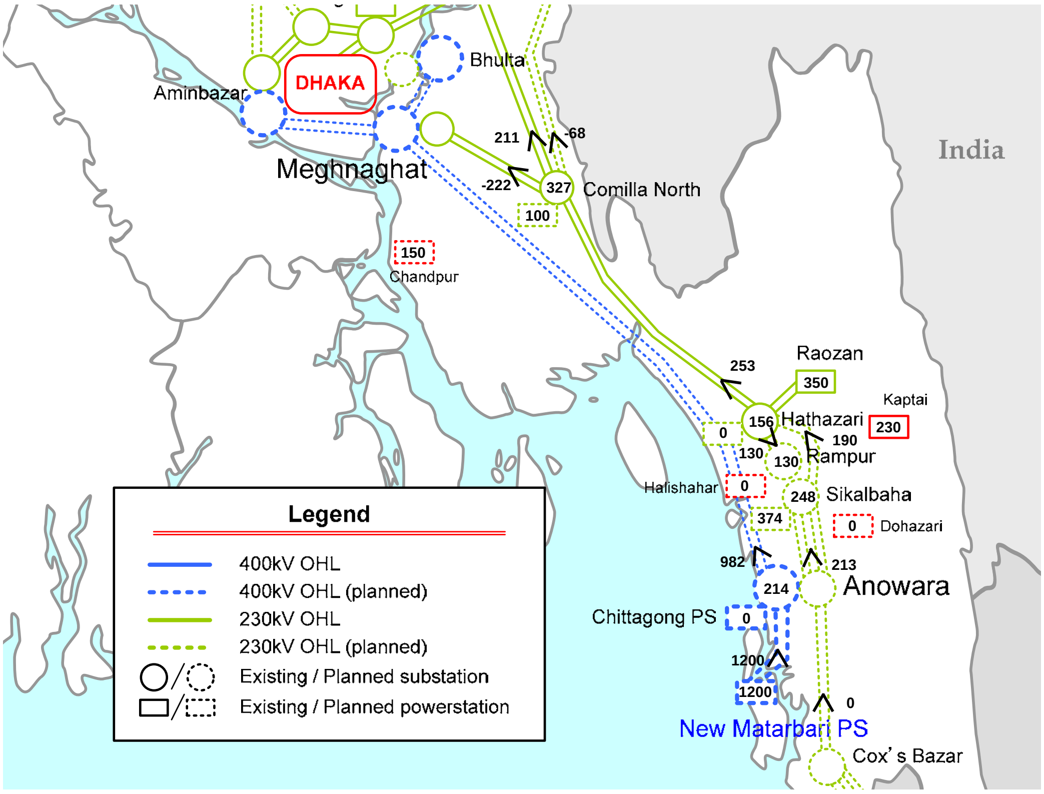


Figure 9.1-8 Power Flow Diagram of Pattern 4 (Mtbr: 1200, Chttgn: 0MW Off-Peak)

As can be seen from the figures, the large power flow of the southern transmission lines are found when the 1900 MW Chittagong power station is developed in general, since it produces surplus power to be delivered towards the Dhaka area. In Pattern 1, the 230kV transmission lines in the southern area face the severest power flow. On the other hand, the largest power flow on the 400kV Anowara – Meghnaghat line is found in Pattern 3 due to the low demand in the southern area.

9.1.5 N-1 contingency analysis

The N-1 contingency analysis is conducted to explore the overloadings of transmission lines under the N-1 conditions. No overloading is allowed under the N-1 contingencies. It should be noted that the study assumes the 4 circuits of the 230kV transmission line between Anowara and Sikalbaha because the large power flow is loaded on the line under the peak demand conditions with 1900MW output at Chittagong power station. The following table shows the results.

Table 9.1-22 Results of the Contingency Analysis

Pattern	Tripped lines	Overloaded lines	Voltage Violation
Pattern 1	400kV Anowara-Meghnaghat	230kV Hathazari-Comilla North 2cct 101.7%	n/a
	230kV Hathazari-Sikalbaha	230kV Hathazari-Sikalbaha 1cct 101.2%	n/a
Pattern 2	–	No overloaded lines	n/a
Pattern 3	400kV Anowara-Meghnaghat	230kV Hathazari-Comilla North 2cct 137.5%	n/a
	230kV Hathazari-Sikalbaha	230kV Hathazari-Sikalbaha 1cct 110.7%	n/a
Pattern 4	–	No overloaded lines	n/a

There are two overloaded 230kV transmission lines under the N-1 contingencies during the peak demand. Since the power generations are located in the south and they are loaded on the 230kV bulk network toward the Comilla area, the 230kv Sikalbaha-Hathazari-Comilla North double-circuit transmission line tends to be overloaded under the peak demand.

These overloadings are not directly related to the feasibility of the 400kV transmission line studied, but it has been proposed to uprate the planned 230kV Hathazari-Sikalbaha line and construct additional circuit(s) between Hathazari and Comilla North to satisfy the N-1 criteria.

The system voltages should be maintained within ±10% of the rated voltage under the N-1 contingencies according to the PGCB’s grid code. No voltage violations are found in each pattern.

9.1.6 Fault circuit analysis

The fault current increases with the increasing number of the connected power generators. This means that the fault currents under the peak demand are high compared to those under the off peak demand. The table below shows the fault current results with the automatic sequencing fault calculation method (ASCC) at each 400kV and 230kV bus in the southern area. It is observed that the fault currents are less than the allowable limit.

Table 9.1-23 Fault Currents

[kA]

Voltage	Buses	Allowable limit	Pattern 1		Pattern 2	
			3LS	1LG	3LS	1LG
400kV	Matarbari	63 kA	17.6	10.2	13.4	8.5
400kV	Anowara	63 kA	24.2	16.5	14.9	11.0
230kV	Anowara	50 kA	29.4	22.8	23.5	20.2
230kA	Sikalbaha	50 kA	28.2	23.8	23.9	21.7
230kA	Hathazari	50 kA	23.8	22.0	21.8	21.0

9.1.7 Transient stability analysis

The study carries out a transient stability analysis to verify whether the generators are being operated under stable conditions during a sudden single circuit trip of the 400kV Anowara - Matarbari - Meghnaghat transmission line. Theoretically, generators in a system with a large power flow travelling through their transmission lines can become unstable under a fault condition. Therefore, the studies are performed in Pattern 1 and 3 as the severe conditions. The study assumes that a faulty 400kV transmission line trips after 100(ms) of the event and the parameters of the generators written in section 9.1.3.

The following table and figure shows the results. As can be seen from the results, the system becomes unstable when the 400kV Anowara-Meghnaghat line is tripped in Pattern 3 since it has a large power flow from the south to Dhaka due to low demand and large power outputs in the Chittagong area.

As the relaxed condition for Pattern 3, the system without generation outputs from Raozan (350 MW) and Kaptai (230 MW) was also studied. The system still becomes unstable when the 400kV Anowara-Meghnaghat line is tripped due to a failure near the Anowara substation.

The past study assumed 3 or 4 circuits of the 400kV Anowara-Meghnaghat line, and the system was stable. The same is true for this study and the system can be stable with 3 or more circuits of the 400kV Anowara-Meghnaghat. Please note that the line has been studied in the project supported by the World Bank, called “NG4,” and it has not been completed yet. These modeling errors including generators may produce misleading results, since the study used the typical parameters but not for particular plants. It is necessary to review the parameters for the transient stability analysis in further studies.

Table 9.1-24 Results of the Transient Stability Analysis

Tripped line	Fault	Pattern	Result
400kV Matarbari – Anowara	near 400kV Matarbari bus on the tripped line	Pattern 1	stable
		Pattern 3	stable
	near 400kV Anowara bus on the tripped line	Pattern 1	stable
		Pattern 3	stable
400kV Anowara – Meghnaghat	near 400kV Anowara bus on the tripped line	Pattern 1	stable
		Pattern 3	unstable
	near 400kV Meghnaghat bus on the tripped line	Pattern 1	stable
		Pattern 3	unstable

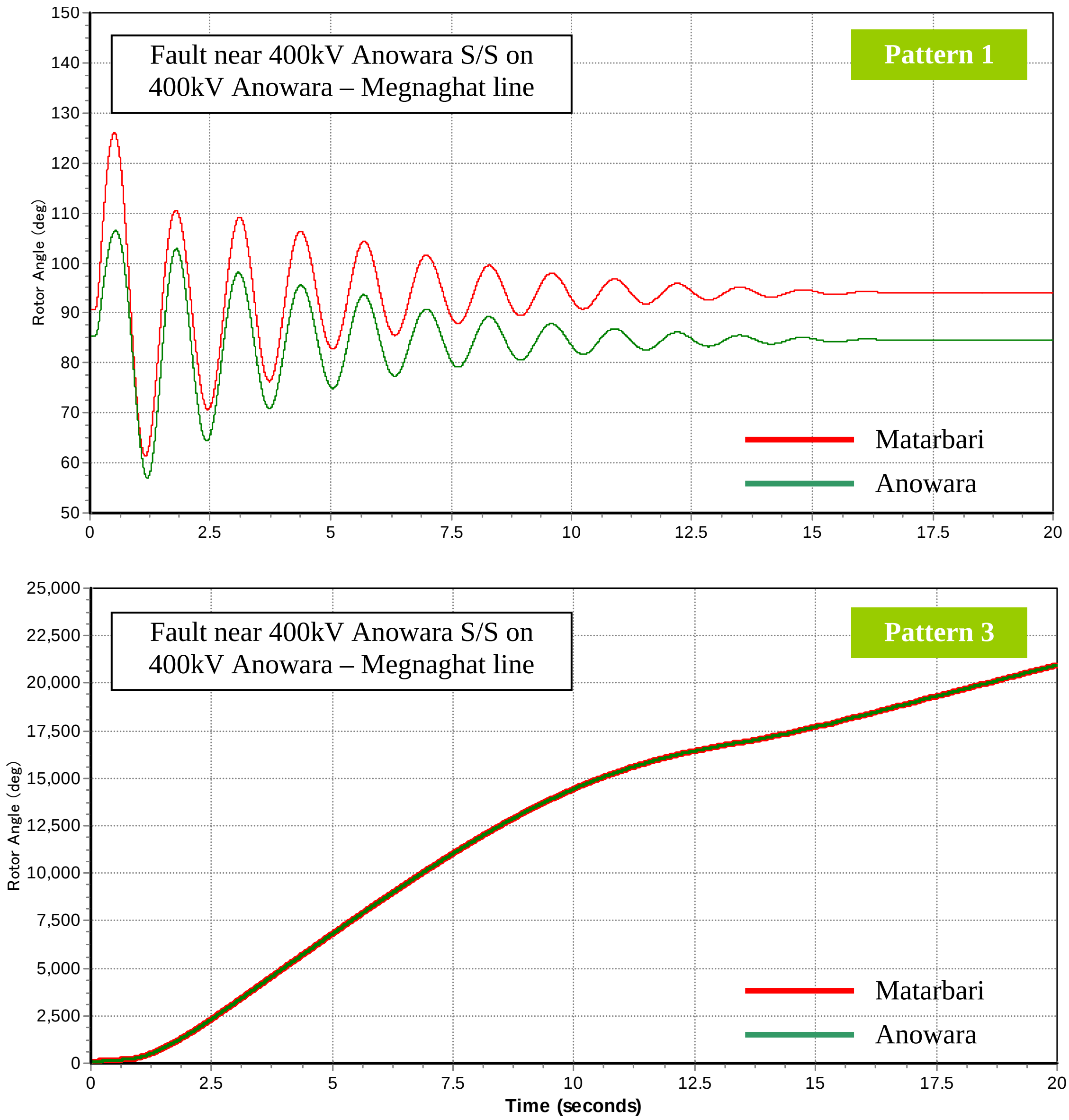


Figure 9.1-9 Rotor Angle of Generators in Matarbari and Chittagong Power Station

9.2 Transmission Line

9.2.1 Outline of the transmission line route

Regarding the transmission line route, the study team conducted field investigations between the expected Anowara substation site (hereafter Anowara substation) and the planned coal-fired power plant site in Matarbari (hereafter Matarbari power station) and had discussions with PGCB in September and November 2012.

Prior to the field investigation, PGCB requested the study team to select a route which avoids the intersection with the planned transmission line between Maheskhali power station and Anowara substation in the future and to secure space for the planned transmission line route.

As a result of the discussions and field investigations, the study team selected the transmission line route in the western side of the regional highway "R170" running parallel to the "R170". This route can avoid crossing with the planned transmission line between Maheskhali power station and Anowara substation in the future and secure space for the transmission line route. Besides, there is no reserve forest and existing extra high voltage transmission line to be crossed over in this area and the "R170" allows for relatively easy construction and maintenance work.

Regarding a route in parallel with the national highway "N1" which is considered as an alternative at first, the study team found the route to be unsuitable because there are reserve forests and an existing 132 kV transmission line along the "N1" and the total route length increases up to approx. 80 km.

- Total transmission line route length: Approx. 61.5 km.

The terrain surrounding the route is mostly flat area and covered with bushes, farmlands and salt fields.

The overview of the selected transmission line route from Matarbari power station to Anowara substation is as follows:

- The transmission line comes out from the eastern side of the switchyard of the Matarbari power station. The northern and eastern area of the switchyard is planned to be the ash disposal pond, therefore the outgoing path travels southeast of the switchyard from the gantry at first and then runs parallel to the boundary of south side of Matarbari power station to the northeast in order to bypass the ash disposal pond. The section of the outgoing path from the Matarbari power station is shown in Figure 9.2-1.

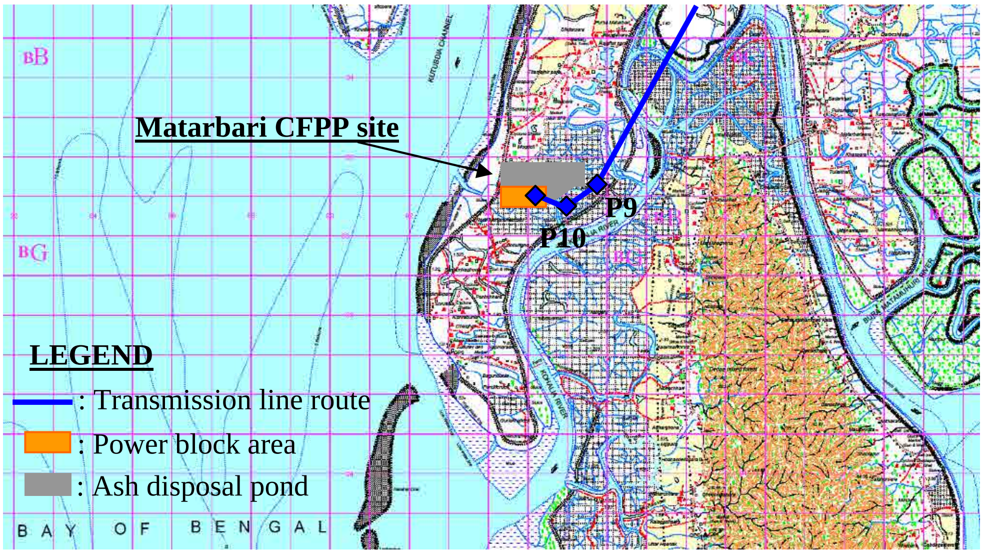


Figure 9.2-1 Outgoing Path from the Matarbari Power Station

- Then the route runs toward the northeast crossing over some channels such as Khalia River and reaches to Upazila Pekua through Upazila Maheskhali in Cox's Bazar District.
- The route runs towards the north in parallel with "R170" being located approximately 2 km west from "R170" through Upazila Pekua and Upazila Banskhali. In this section, the route is located approximately 4 km east from the coast.
- After that the route crosses over the Sangu River, then runs towards the northwest and reaches Anowara substation in Upazila Anwara. The section of the Sangu River crossing and the incoming path to Anowara substation is shown in Figure 9.2-2.

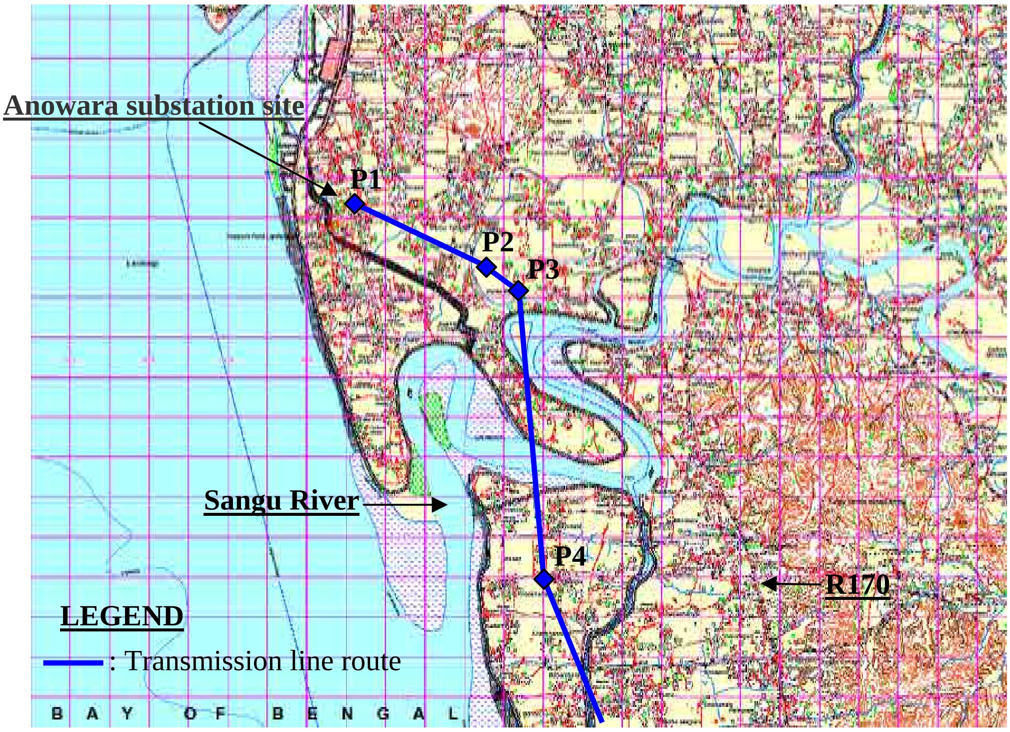


Figure 9.2-2 Sangu River Crossing & Incoming Path to the Anowara Substation

The study team selected the angle points of the route to pass through as few settlements or residences as possible. The following table shows the coordinates of the major angle points of the route.

Table 9.2-1 Coordinate of the Major Angle Points

Major angle points	Coordinate in degrees	
	Latitude	Longitude
P1	22°10’58.51”N	91°50’14.92”E
P2	22°10’16.75”N	91°52’26.63”E
P3	22°09’57.49”N	91°52’42.85”E
P4	22°06’45.38”N	91°53’18.84”E
P5	22°02’29.27”N	91°55’43.48”E
P6	21°50’45.90”N	91°57’19.40”E
P7	21°49’28.90”N	91°56’55.23”E
P8	21°47’11.49”N	91°56’38.30”E
P9	21°42’21.48”N	91°54’11.32”E
P10	21°41’58.06”N	91°53’37.65”E
Gantry (tentative)	21°42’04.41”N	91°53’14.76”E

And the following table shows the rough sectional length of each angle span.

Table 9.2-2 Rough Sectional Length

Section	Route length
P1-P2	4.0 [km]
P2-P3	1.0 [km]
P3-P4	6.0 [km]
P4-P5	9.0 [km]
P5-P6	22.0 [km]
P6-P7	2.5 [km]
P7-P8	4.5 [km]
P8-P9	10.0 [km]
P9-P10	1.5 [km]
P10-Gantry	1.0 [km]
Total	Approx. 61.5 [km]

The circumstances of the surveyed points are as follows.

Anowara power station site

Incoming area of Anowara substation

Land condition around north side of Sangu River (around P2 & P3)

Land condition around south side of Sangu River (around P4)

Sangu River (view from "R170")


Land condition around west side of "R170"

Impassable bridge by car in Upazila Pekua


Matarbari power station site (photo in wet season)

Land condition around P6

Land condition around P8

Land condition of the P8 direction (view from the southwest)

Land condition of the P9 & P10 direction (view from the north)

The selected transmission line route is shown in Figure 9.2-3.

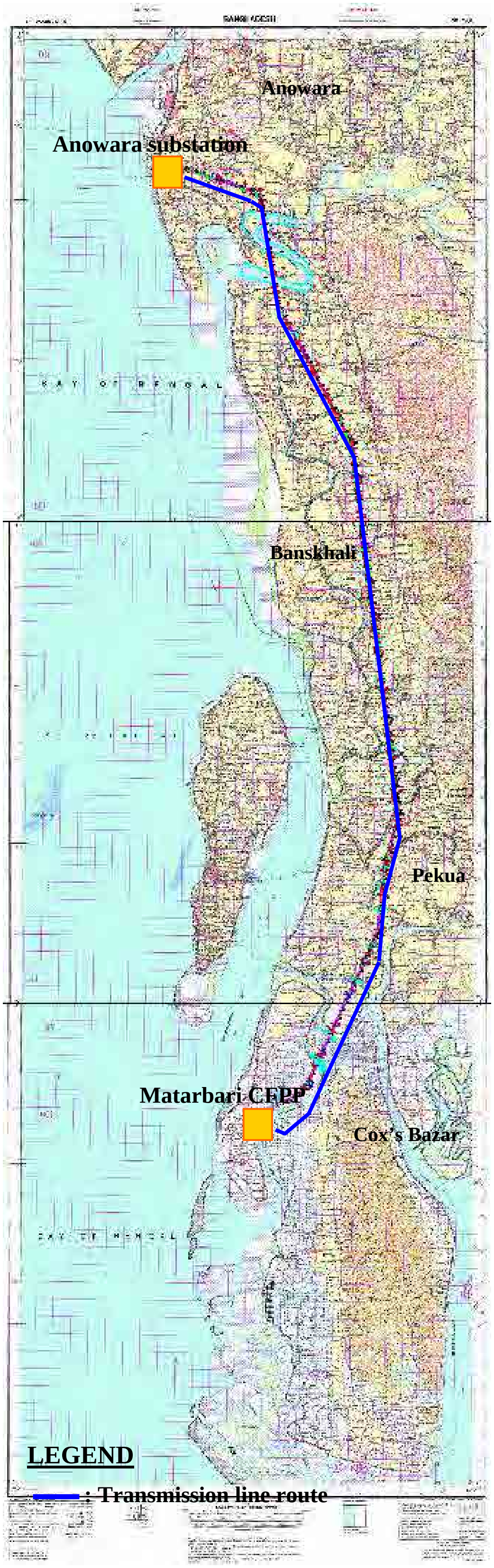


Figure 9.2-3 Outline Route of the Transmission Line

9.2.2 Conceptual design of the transmission line

(1) Outline

In this section, the Study team assumed the design conditions of the transmission line based on the design conditions of the Bibiyana–Kaliakoir 400kV transmission line project which is under construction. After completion of the feasibility study for the NG-4 project (Anowara-Meghnaghat 400kV transmission line), its design conditions will be taken into account and modified accordingly.

(2) Design Conditions

The basic design conditions are mentioned below.

a) Atmospheric Temperature

Maximum air temperature: 40 deg C
Minimum air temperature: 5 deg C
Annual mean air temperature: 35 deg C

b) Wind Velocity

The basic wind speed at Cox's Bazar: 260km/h (based on the BNBC '93)
10 minutes means the wind velocity at 10m height which is converted from the above wind speed will be applied.

c) Stringent (the most severe design) Condition and EDS (Every Day Stress) Condition

Condition	Temperature	Wind
Stringent	05 degree C	Refer to (2) b)
EDS	30 degree C	Still air

d) Maximum Annual Rainfall: 2,500 mm

e) Isokeraunic Level (IKL): 80 days

f) Other conditions assumed

Maximum humidity: 100 %
Average humidity: 80 %

g) Safety Factors

The required minimum safety factors for the transmission line facilities are as follows.

- Conductor/Ground-wire

2.0 to UTS[1] for stringent condition (1.33 to UTS at river crossing)

5.0 to UTS for EDS condition

- Insulator string

2.5 to RUS[2] for maximum working tension at the supporting point

- Tower

1.25 to the yield strength of the material under Normal Conditions (=stringent condition)

1.05 to the yield strength of the material under the Broken Wire Condition (=normal condition + one ground-wire or one phase conductor breakage)

- Foundation

Tower type / Loading case	4DL	4D1, 4D25(4DXP), 4D45, 4DT60
Normal Condition	1.33	1.60
Broken Wire Condition	1.60	1.90

(3) Conductor and Ground Wire Design

a) Design conditions of the conductor and ground-wire for the Project are as follows;

Loading Condition	Wind velocity	Wind pressure	Conductor Temperature	Safety Factor
Stringent condition	Refer to (2) b)	120 kg/m^2	05 degree C	2.0 (50%UTS)
EDS condition	Still air	0 N/m^2	30 degree C	5.0 (20%UTS)

b) Conductor and ground-wire type

Regarding the conductor type, 4-bundle low loss type conductor "LL-TACSR/AS 490mm^2" and the 4-bundle conventional type conductor "ACSR Finch 564mm^2" were selected as the candidate conductor based on the required current carrying capacity and annual costs at present. The aluminum-clad steel core used for the LL-ACSR/AS provides better corrosion resistance than galvanized steel wires used for the conventional ACSR. The technical characteristics of the conductors and ground-wires are as follows.

[1] UTS: Ultimate Tensile Strength
[2] RUS: Rated Ultimate Strength

Table 9.2-3 Technical Characteristics of Conductor

Code/Type	LL-TACSR/AS 490mm^2	Finch
Component of stranded wires	TAL[3]: 12/TW[4] [Nos./mm] TAL: 8/TW [Nos./mm] 14AS[5]: 7/3.5 [Nos./mm]	Al: 54/3.647 [Nos./mm] St: 19/2.189 [Nos./mm]
Overall sectional area [mm^2]	525.8 [mm^2]	636.9 [mm^2]
Overall diameter [mm]	27.0 [mm]	32.83 [mm]
Nominal weight	1,609 [kg/km]	2,131 [kg/km]
Ultimate tensile strength	12,593 [kg] (123.5 kN)	17,800 [kg] (174.6 kN)
Modulus of elasticity	68,900 [MPa]	78,000 [MPa]
Coefficient of linear expansion	21.2 [10^{-6}/ C]	19.6 [10^{-6}/ C]
DC resistance at 20 deg. C	0.0591 [ohm/km]	0.05144 [ohm/km]
Allowable continuous operation temperature	150 [deg. C]	80 [deg. C]

Table 9.2-4 Technical Characteristics of Ground-wire

Code/Type	Dorking	OPGW
Component of stranded wires	Al: 12/3.203 [Nos./mm] St: 7/3.203 [Nos./mm]	AC: 26/2.65 [Nos./mm] OP unit: 1/6.1 [Nos./mm]
Overall sectional area	153.1 [mm^2]	158 [mm^2]
Overall diameter	16.02 [mm]	16.7 [mm]
Weight	708.9 [kg/km]	860 [kg/km]
Ultimate tensile strength	8,490 [kg] (83.3 kN)	10,000 [kg] (98.1 kN)
Modulus of elasticity	10,707 [kg/mm^2]	12,300 [kg/mm^2]
Coefficient of linear expansion	15.3 [10^{-6}/ C]	14.4 [10^{-6}/ C]
DC resistance at 20 deg. C	0.2986 [ohm/km]	0.3230 [ohm/km]
Number of optical fiber	-	48

c) Standard span length

Standard span length between the towers: 400 m

(4) Insulator Design

a) Insulator type and size

The insulator units assumed to be applied to the Project are normal type porcelain suspension insulator with a ball and socket, complying with IEC 60305.

Table 9.2-5 Insulator Size

Conductor	Type	Coupling	Unit Spacing	Shell Diameter	RUS	Insulator set type
LL-TACSR/AS 490mm^2	Normal type	Ball and Socket	170 mm	320 mm	210 kN	Suspension
			195 mm	505 mm	300 kN	Double tension
Finch	Normal type	Ball and Socket	195 mm	505 mm	300 kN	Suspension
			205 mm	550 mm	400 kN	Double tension

3 TAL: Thermal resistant aluminum alloy
4 TW: Trapezoid wire
5 AS: Aluminum-clad steel

b) Number of insulators per string

The numbers of insulators per string were assumed to be from 20 to 26 pieces according to the insulator type and string set type estimated based on the creepage distance of 25 mm/kV which is design requirement of existing substation near sea coast, but the numbers of insulators would be examined based on the adequate creepage distance in the detail design.

c) Mechanical strength of the insulator set

Mechanical strengths of insulator sets are determined so as to satisfy the following minimum safety factor.

Table 9.2-6 Minimum Safety Factors of Insulator Sets

Loading condition	Safety factor
Stringent condition	2.5 (40% RUS)

d) Number of insulator strings per set

Number of insulator strings per set is either single or double, which is determined in accordance with the insulator set type and based on the safety factors shown in Table 9.2-6.

(5) Ground Clearance

The minimum height of the conductor above ground at 400 kV level is defined below.

Table 9.2-7 Minimum Clearances of the Conductor

Description	Minimum Clearance
Ground	11.0 [m]
Buildings and structures	7.0 [m]
Trees and Shrubs	5.5 [m]
Roads	14.0 [m]
Railways	18.0 [m]
River Crossing	22.0 [m]

(6) Tower Configuration

a) Insulation Design of the Ground-wire

Number and shielding angle of the ground-wire are defined below.
Number of ground-wires: 2
Minimum shielding angle: 0 degree

b) Tower Configurations

The towers would normally be the following 6 standard types. The sample tower configurations shown in the Figure 9.2-4 to Figure 9.2-8 are designs for Bibiyana – Kaliakoir 400 kV transmission line.

Table 9.2-8 Tower Types and Applied Conditions

Type	Position of Use	Angle of Deviation/Entry	Type of Insulator Set
4DL	Intermediate	00 - 01	Suspension
4D1	Angle	00 - 03	Heavy Suspension
4D25 (4DXP)	Angle (Transposition)	00 - 25	Tension
4D45	Angle/Reinforcement	25 - 45	Tension
4DT60	Angle	45 - 60	Tension
	Terminal	0 -30 (Angle of Entry)	Tension

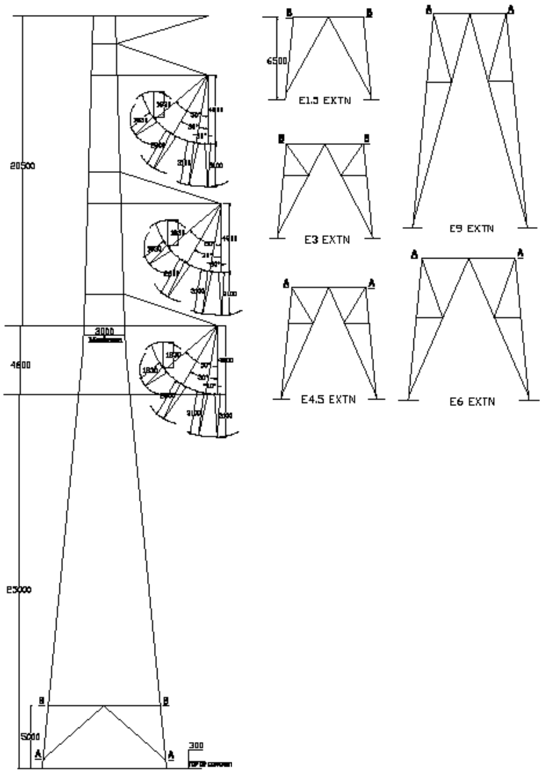


Figure 9.2-4 4DL Type Tower

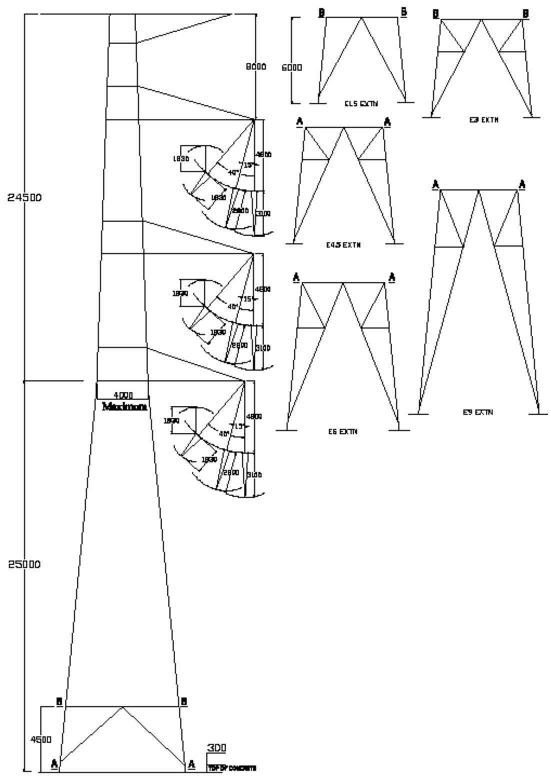


Figure 9.2-5 4DT60 Type Tower

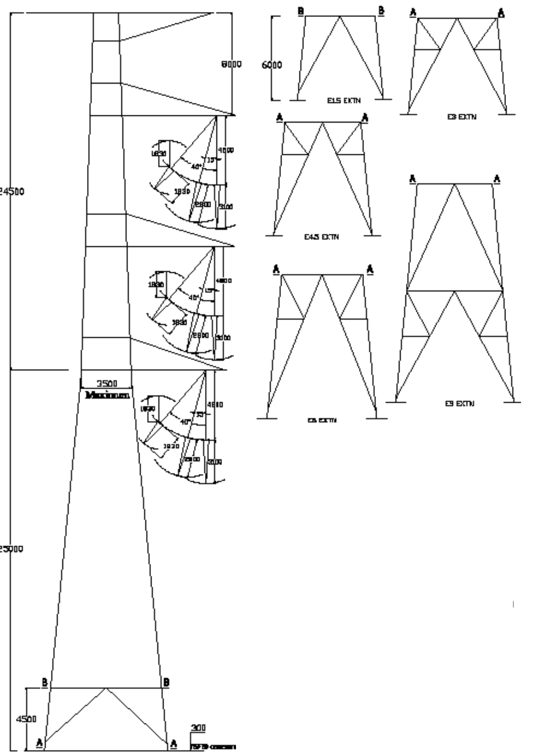


Figure 9.2-6 4D25 Type Tower

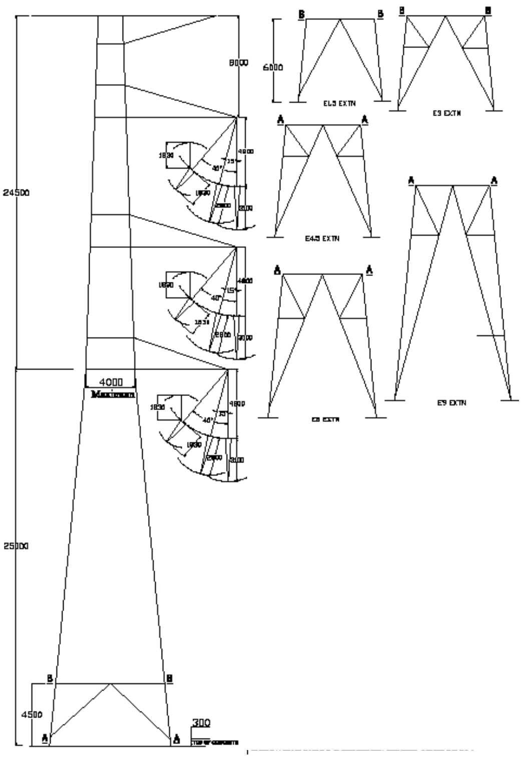


Figure 9.2-7 4D45 Type Tower

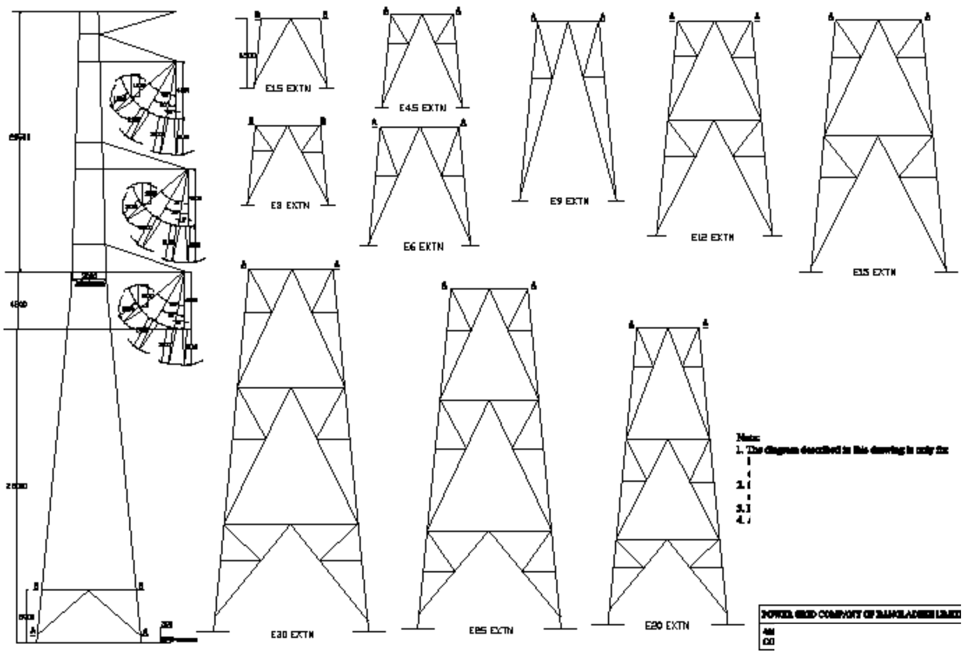


Figure 9.2-8 4D1 Type Tower

(7) Foundation Configuration

The foundation type whether the pad and chimney type or the pile foundation that would be applied to each tower shall be determined based on the results of the geological survey including the boring investigation at the detailed design stage.

9.2.3 Quantities of transmission line materials

(1) Number of Towers and Total Weight of Towers

The number of towers was estimated as following table based on the selected route. The number of consecutive spans between the section points comprised of tension towers shall not exceed 15 spans or 5 km in plain terrain. And a certain level of route alignment to avoid crossing over residences was considered.

Table 9.2-9 Number of Towers

Section	Route length	Number of towers		
		Tension tower	Suspension tower	Total
Matarbari CFPP - Anowara SS	61.5 [km]	37	120	157

(2) Quantities of Conductor and Ground Wire

Quantities of conductor and ground wires for the Project were computed by multiplying the number of conductor or ground wire by the route length, and multiplying that number by 1.05 for the sag allowance and margin for stringing works.

Table 9.2-10 Quantities of Conductor and Ground Wire

Type of conductor / ground wire	Number of bundles	Number of phases	Number of circuits	Route length [km]	Line length [km]
LL-TACSR/AS 490mm^2 or Finch	4	3	2	61.5	1550
Dorking	1	-	1	61.5	65
OPGW	1	-	1	61.5	65

(3) Quantities of Insulator and Insulator Assemblies

Quantities of insulator and insulator assemblies for the Project were computed from number of suspension and tension towers.

Table 9.2-11 Quantities of Insulator and Insulator Assemblies for LL-ACSR/AS 490mm^2

Tower type	Items	Unit quantity	Number of sets per tower	Number of towers	Total
Suspension	210kN Insulator	26	6	114	17,784
	Single string set	1			684
Heavy suspension	210kN Insulator	26*2	6	6	1,872
	Double string set	1			36
Tension	300kN Insulator	21*2	12	37	18,648
	Double string set	1			444
	210kN Insulator	26	6		5,772
	Jumper support	1			222

Table 9.2-12 Quantities of Insulator and Insulator Assemblies for Finch

Tower type	Items	Unit quantity	Number of sets per tower	Number of towers	Total
Suspension	300kN Insulator	21	6	114	14,364
	Single string set	1			684
Heavy suspension	300kN Insulator	21*2	6	6	1,512
	Double string set	1			36
Tension	400kN Insulator	20*2	12	37	17,760
	Double string set	1			444
	300kN Insulator	21	6		4,662
	Jumper support	1			222

9.2.4 Spare parts, tools and measuring devices

Design specifications of the transmission line for the Project are common to the whole line. Since maintenance work of the transmission line after the completion of the Project will be carried out by PGCB branch offices, it is necessary to provide spare parts, tools and measuring devices considering common stock among the branch offices. Although items and quantities thereof will be determined in the detailed design stage of the Project, it is assumed that the principal items are as follows;

a) Transmission line materials for maintenance:

Complete set of standard towers, galvanized steel materials and bolts for replacement of damaged members, spares of conductor, ground wires and their fittings, insulators and their fittings, etc.

b) Tools and measuring devices:

Insulator replacing devices, tools for repair works, insulated earthing rods, insulation resistance testers, equipment for maintenance staffs, vehicles for facilities' inspection, etc.

Estimate cost of spare parts, tools and measuring devices for the Project is assumed to be approximately 5% of the total costs of the transmission line materials.

9.3 400kV Anowara Substation (connection point with the existing network)

9.3.1 Outline of the substation

(1) Objective

In this section, the conceptual design for the extension construction of the 400kV Anowara substation was conducted, since the two 400kV transmission lines from the new Matarbari coal-fired power plant are planned to be connected to the 400kV Anowara substation at the planned Anowara thermal power plant.

In this project, it is assumed that Anowara substation will be constructed on the site of the planned Anowara thermal power plant by 2018 identical to PGCB's original plan.

On the other hand, because the development of the Anowara power plant project has been quite uncertain recently, PGCB has been studying not only the "original plan", but also alternative network plans, as shown in Figure 9.3-1, that a new 400kV substation near the existing 132kV Madunaghat substation supplying power to the Chittagong area will be developed, in addition, the transmission lines from the planned coal-fired power plant in Matarbari is directly connected to the new 400kV substation in the case of a delay in the Anowara power project.

If the Anowara power plant project is delayed, an additional joint study between PGCB and JICA regarding the network plan in the Chittagong area until 2020 will need to be conducted, which also includes an additional transmission line route survey from the Anowara site to the new 400kV substation site and the EIA study in order to deliver the power generated at Matarbari coal-fired power plant.

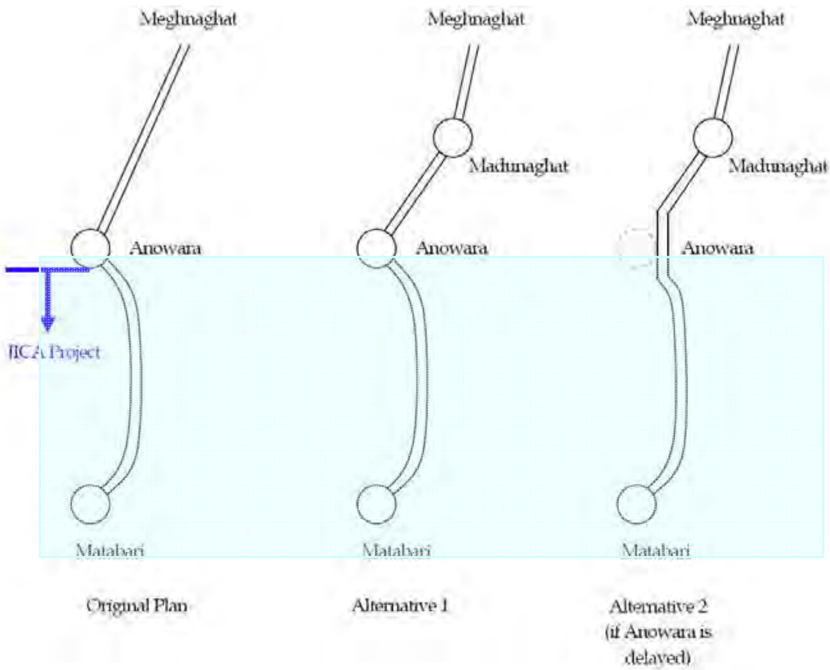


Figure 9.3-1 Study of 400kV Network of Chittagong Area by PGCB

(2) Design concept

1) The extension equipment

The extension facility at Anowara substation shall be only 400kV switching equipments for two incoming 400kV transmission lines from the new Matarbari coal-fired power plant in this project. As for power (600MW) from the new power plant in Matarbari, it is assumed that there is no down-flow to the 230kV network at Anowara substation, and the power is mostly delivered to Meghnaghat substation in Dhaka.

2) 400kV switchyard

The 400kV switching facility of Anowara substation shall be the conventional outdoor type equipment with a double-bus-bar and (1+1/2)-Circuit Breaker configuration.
In this project, two new 400kV bays, which are connected to 400kV Bus for two new transmission line feeders, shall be designed.
Regarding the specifications for the circuit breaker, the value of the rated short-circuit breaking current shall be 40kA according to the result of the power system analysis in this project.

9.3.2 Conceptual design of the substation

(1) Design conditions

The project area is assumed to be a zone of moderate intensity for earthquakes. The seismic factor is 0.2 G. The atmospheric pollution condition are assumed to be moderate and a special insulator design or washing is not required. In addition, other climatic conditions are assumed as the following items as well as that of the 400kV Kaliakoir substation project.

- Maximum ambient shade temperature : 45°C
- Minimum ambient shade temperature : 4°C
- Maximum daily average temperature : 35°C
- Maximum annual average temperature : 25°
- Maximum wind velocity : 160 Km/h
- Minimum wind velocity for line rating purposes : 3.2 Km/h
- Solar radiation : 100 mW/sq.cm
- Rainfall : 2.5 m/annum
- Relative humidity, maximum : 100%
- Relative humidity, average : 80%
- Atmospheric Pollution : light
- Soil type : Alluvial
- Isokeraunic Level (Thunderstorm days/year) : 80 days/year

When a detail design is conducted, all of the above conditions will need to be modified based on that of the Anowara power plant project.

(2) Specification of the equipment

400kV main equipment is described as shown below. They shall be designed based on the IEC standards.

a) Circuit breaker

The 400kV circuit breaker shall be a SF6 gas type, single-pole operated with two interrupters per phase. The circuit breaker shall be designed based on the IEC 60056, 60694, 62271-100 standards.

The main specifications are shown below.

Type	live tank type
Rated voltage	420 kV
Rated frequency	50 Hz

➢ Rated short-circuit breaking current	40 kA
➢ Rated current	2000 A
➢ Rated lightning impulse withstand voltage	1425 kV

b) Disconnector

400kV disconnection switch shall be single pole operated with a horizontal break type motor operated. The Disconnector shall be designed based on the IEC 62271-102 standard.

The main specifications are shown below.

➢ Type	Horizontal center break type
➢ Rated voltage	420 kV
➢ Rated frequency	50 Hz
➢ Rated current	2000 A
➢ Rated lightning impulse withstand voltage	1425 kV

c) Lightning arrester

400kV lightning arresters shall be designed based on the IEC 60099 standard.

The main specifications are shown below.

➢ Type	ZnO type gapless
➢ Rated voltage (r.m.s.)	390 kV
➢ Continuous operating voltage	303 kV
➢ Discharge class	Heavy duty 3
➢ Rated frequency	50 Hz

d) Current transformer

The 400kV current transformer shall be the oil-filled type.

The main specifications are shown below.

➢ Type	live tank type
➢ Ratio	2000/1 A
➢ Class of accuracy	For bus protection: class X For line protection: 5P20 For metering: class 0.2
➢ Burden	30 VA

e) Voltage transformer

400kV voltage transformer shall be of oil filled type.

Main specifications are shown below.

➢	Type	live tank type
➢	Ratio	420/√3 kV / 110V/√3 V
➢	Class of accuracy	For protection: 3P
		For metering: 0.2
➢	Burden	150 VA

f) Protection relay system

The following protection relay system for the 400kV transmission line will be applied to this project.

- ➢ Transfer trip(main), Distance relay(back up)
- ➢ Differential relay(main)

(3) Equipment layout

A single line diagram is studied according to the design concept of 9.3.1. It is shown in Figure 9.3-2. It tentatively reflects only the 400kV equipment, since the original plan is still not determined in Anowara power plant project.

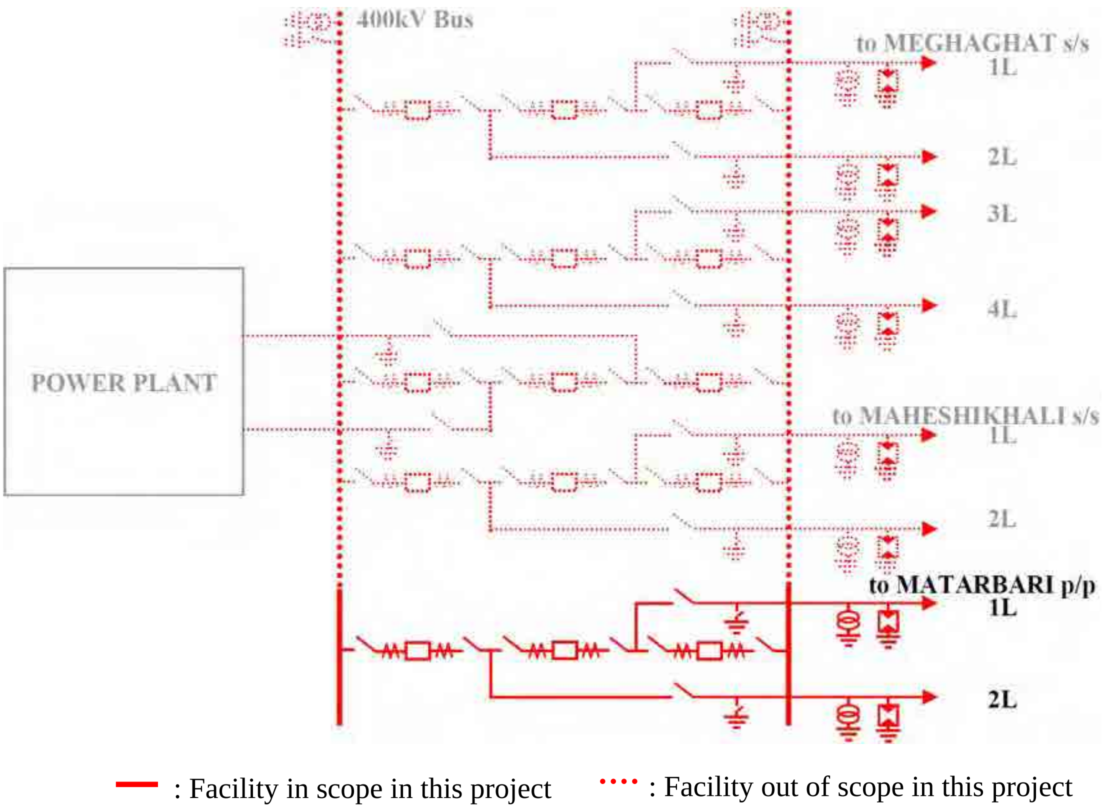


Figure 9.3-2 Single Line Diagram of 400kV Equipment at Anowara Substation

(4) Quantity of 400kV equipment

According to the single line diagram of Figure 9.3-2, the quantity of the main equipment required for this project is shown in the following Table 9.3-1.

Table 9.3-1 Quantity of Main Equipment

No.	Items	Number of unit
1.	400kV Circuit breaker (3-phase)	3 set
2.	400kV Disconnector with earthing switch (3-phase)	2 set
3.	400kV Disconnector (3-phase)	6 set
4.	400kV Current transformer Line (3-phase)	6 set
5.	400kV Voltage transformer for Line protection(3-phase)	2 set
6.	400kV Lightning arrester (3-phase)	2 set

Chapter 10

Project Construction Plan

Chapter 10 Project Construction Plan

10.1 Project Implementation Schedule

CPGCBL is now intending to proceed with the implementation of the Matarbari CFPP Project with the financial assistance of a Japanese ODA Loan in order to meet the increasing power demand in Bangladesh.

The ultimate schedule of this project is construction of 2 x 600 MW coal fired power generating units.

CPGCBL will acquire an area of at least approximately 350 ha, which is planned for the construction of this project.

The Project Implementation Schedule that the JICA Study Team has assumed is shown in Figure 10.1-1 "Tentative Project Implementation for Matarbari CFPP Project and Transmission Line Project".

(1) Site Survey and Collection of Data related to site and surrounding areas

The consulting engineer for ES-I and II selected by CPGCBL will carry out a site survey and collect the necessary data for the project, and will review and study the Feasibility Study Report together with CPGCBL.

(2) Phase I (Pre-Construction Stage)

The consulting engineer will conduct the following work.

a. Preparation of Basic Design Report
b. Preparation of Prequalification and Bidding Documents
c. Prequalification of Bidders
d. Technical and Financial Evaluation of Proposals submitted by Bidders
e. Contract Negotiations with successful Bidder

(3) Phase II (Manufacturing and Construction Stage)

After the contract has been awarded to each successful contractor, CPGCBL/Consultant will hold kick-off meetings to start the project, and indicate the project management systems and procedures.

At the design stage, the Consultant will review and approve the design documents, drawings and calculation sheets submitted by the Contractor. Also, the Consultant will organize design review meetings among CPGCBL, the Consultant and each of the Contractor periodically to settle any discrepancies in design or schedules.

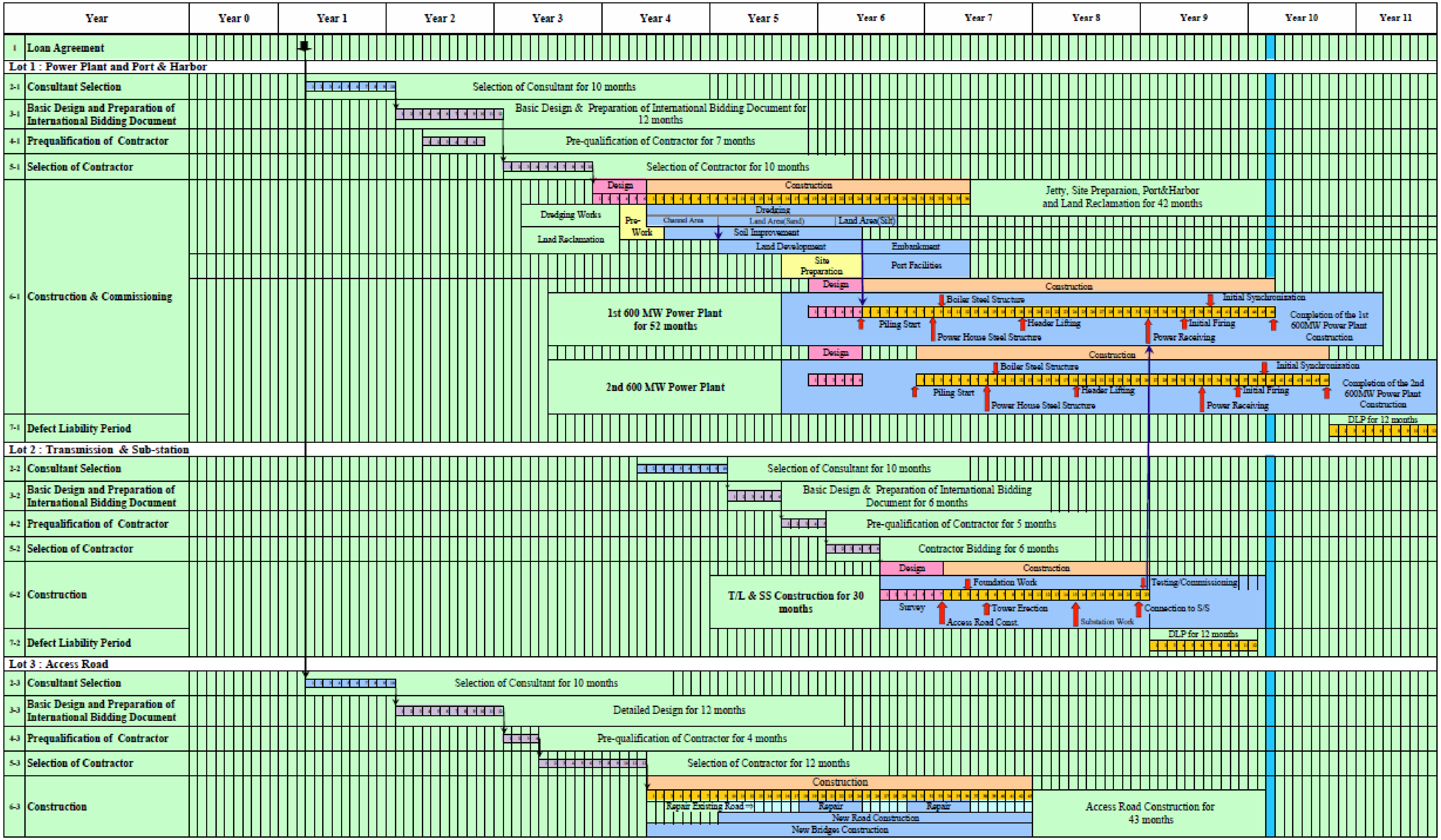


Figure 10.1-1 Tentative Project Implementation for Matarbari CFPP Project and Transmission Line Project

(Source: JICA Study Team)

To ensure the quality control of manufacturing, CPGCBL and the Consultant will conduct factory inspections and witness the manufacturing conditions of major equipment in accordance with the factory test schedule and approved QA/QC Inspection, and Test Plans and their related procedures, submitted by the Contractor at this stage.

At the construction stage, coordination and supervision related to all construction work, including civil work, shall be made by the Consultant. The Consultant will hold weekly construction schedule meetings to check the schedules, including the management of the labor force, and arrangements for construction equipment, tools and materials.

At the commissioning stage, the Consultant will check and approve the schedules and procedures for testing and commissioning of individual auxiliary equipment and facilities.

CPGCBL and the Consultant will witness the tests of mechanical and electrical equipment and confirm important items and test results.

The performance and acceptance tests shall be carried out under the supervision of the Consultant and the Consultant will judge the results and report them to CPGCBL.

CPGCBL will issue Taking Over Certificates (TOC) for the Contractor after the results are confirmed and approved by CPGCBL.

In the warranty period, the Consultant will inspect the conditions of each equipment and facility periodically. After the warranty period, CPGCBL will issue Final Acceptance Certificates (FAC) for the Contractor.

10.2 Project Implementation

10.2.1 Bidding method

It is considered that the following contract packages bidding method is the most appropriate way to execute the Project. Initially, The JICA Study Team considered the power plant block and the port & harbour block by different lot, however, because there are strong technical relationships between them, they were merged as Lot 1. Since it is considered that each company will carry out construction of the transmission line and the access road, respective lots will be separated.

LOT 1 Power Plant and Port & Harbour

It is assumed that the Owner will create the basic design and determine the specifications of the power plant and the port & harbour, while the Contractor will conduct detailed designs for these projects and oversee construction work. Therefore, the JICA Study Team is considering the most effective way for FIDIC Yellow to be involved in the construction of the power plant and port & harbour and for those responsibilities to be specified by contract.

(1) Power Plant – Port & Harbour and Civil Works

a. Jetty
b. Dredging for port & harbour
c. Piling, foundation and structure for unloading berth
d. Revetment
e Channels
f Oil Unloading berth
g Civil and architectural work (Power Plant Block) including Cooling water intake and outlet tunnel
h Additional Civil Works(Land development, Ash pond & Embankment)

(2) Power Plant – Boiler and Auxiliaries

The Ultra Super Critical Pressure Boiler complete with all auxiliaries and equipped as follows:

a. Boiler system (main steam, turbine bypass, auxiliary steam for boiler, feed after last heater to economizer, funs, etc.) and auxiliaries
b. Water treatment plant including desalination and wastewater treatment, etc.
c. Flue gas treatment system
d. Stack and foundation
e. Instrumentation and control (DCS and boiler control)

(3) Power Plant – Turbine, Generator and Auxiliaries

The turbine generator including main and auxiliaries unit station transformer complete with all auxiliaries and with scope as below:

a. Steam Turbine (condensing and condensate systems, feed heating system, extraction system, boiler feedwater pumps and auxiliary steam for turbine, etc.), generator system and auxiliaries
b. Circulating water system, including circulating water pump (“CWP”) house and circulating water pipe (from CWP house to Condenser)
c Electric facilities such as transformers, switchyard equipment, switch gear, etc.
d. Instrumentation and control for steam turbine and generator

(4) Power Plant – Coal and Ash Handling

a. Coal handling system complete with coal receiving (coal unloader and coal transportation conveyer), stackers & reclaimers, conveyers, sampling and mobile systems
b. Fly ash handling system complete, conveying and mobile systems after dust collector hopper and bottom ash handling system after bottom ash silo

LOT 2 400 kV Transmission Line to Anowara Substation

This package, including supply, construction and testing-commissioning, for all equipment:

a. 400 kV Transmission line
 (a) Foundation and Structure for Towers
 (b) Towers and their accessories
 (c) Wires and their accessories

b. Anowara Substation (main facilities)
 (a) 400kV Circuit Breaker (3-phase)
 (b) 400kV Disconnector with earthing switch (3-phase)
 (c) 400kV Disconnector (3-phase)
 (d) 400kV Current Transformer Line (3-phase)
 (e) 400kV Voltage Transformer for Line Protection (3-phase)
 (f) 400kV Lightning Arrester (3-phase)
 (g) Gantry

LOT 3 Access Road

a. Repair existing road
b. Construction of new road and bridges

10.2.2 Procurement package comparison of power plant and port & harbour construction

Two systems of procurement package of Power Plant and Port & Harbour are assumed.

One is a single package procurement, this is the system that one contractor takes all responsibility for the construction of Power Plant and Port & Harbour and gets total control over them.

Another is two packages procurement system, each contractor has a responsibility for the scope of the contract in this system. It is necessary for the Owner to act as a liaison between the Contractor in this case.

The JICA Study Team carried out a comparative analysis of two procurement systems. One package system is suitable for the adoption of this project from both an economic and technical standpoint. Details are shown in Table 10.2-1

Table 10.2-1 Comparative Analysis for Project Packages

No		One (1) Package	Two (2) Packages	
1)	Combination of Contract	Power Plant + Port & Harbour	Power Plant	Port & Harbour
2)	Cost scale (hundred million Yen)	228,783	Higher than 1 package for the following 5) reasons	
3)	Characteristic of packaging	- Possible integrated control of all works	- Individual package	
4)	Merit of packaging	- Ease control of works between Power Plant Block and Port & Harbour Block	- Individual contract may vary the liability capacity depending on the scale of company.	
5)	Procurement of Contract	- Shorter construction period - Simple management by one contract	- With a relatively long construction period, liaising among the contractors by the Owner is required. This is because the Owner has to mediate the exchange of technical information between Contractors and time is required to confirm the accuracy of such information (for example, regarding boundary specifications, site preparation work cannot begin until the finalization of loading data for the power plant facilities or a power plant contractor cannot start construction until conditions for vacant lots are determined, etc.) - Very complex management structure for two separate contracts since it is difficult to clarify the scope of the Contractors' responsibilities. As such, if a defect emerges after the start of power plant construction and it is not clear which Contractor is responsible for fixing the defect, the Owner has to resolve the issue between the Contractors. This not only increases the burden on the Owner, but has the potential to cause project delays. Consultant cost increases as consultant work volume increases	
6)	Work management & supervision	- Possible integrated control of quality, progress and payment for the works	- The Port & Harbour contractor can start the unloading structure/pier design only after receiving the loading data from the Owner after the Owner approves and receives the necessary loading data from the Power Plant contractor.	

			- After the design is finished, the Port & Harbour contractor can start to procure the unloading pier materials/piles. - The total construction period may become longer than the one contact
7)	Benefit. for material and equipment sharing	- Possible sharing for material and equipment in one contract	- Impossible to share materials and equipment among individual contractors (for example; Site office of the Contractor, commuter bus, heavy duty machines used for civil works etc.)
8)	Design component & documentation	- One set contract document - One Supervision team for one contract	- Two sets of contract documents - Two supervision teams responding to two different contract
9)	Overall Evaluation	- Minimum cost and time consuming for management of one contract	- Relatively cost and longer time consuming required for management two individual contracts

(Source: JICA Study Team)

10.2.3 Prequalification(PQ) for the bidders of power plant construction

(1) PQ criteria for candidate bidders to become EPC contractors

The EPC contractor’s project execution capability will be the most important skill to complete this project successfully.

The JICA Study Team considers it necessary for candidates to meet the following criteria as a minimum requirement.

(a) Belong to a consortium of companies that have passed the PQ requirements of USC power plant manufacturers. Requirements for port & harbour construction are the same as for power plant construction.

(b) Experience as an EPC contractor in coal-fired power plant construction, and to be able to appoint highly skilled personnel with experience carrying out projects of the same scale as the project manager.

(c) Provide a bond with appropriate amount for the bank guarantee.

(2) Criteria of PQ for the USC plant suppliers

The JICA Study Team has studied the terms of prequalification for the candidate of the Bidders. USC is state of the art technology for coal fired power generating plants. Boiler and steam turbine manufactures can be engaged in making the design, and in producing critical parts for the plant yet lack long-term experience.

This will be the first introduction of USC technology in Bangladesh. Therefore, the Bidders must have experience exporting their production to facilities overseas based on their original capability of design for USC technology, and prove their reliability as demonstrated by the actual long term operation of the USC facilities they supplied.

For manufacturers to supply a USC power plant, the JICA Study Team believes it is necessary to have the following experience:

(a) The manufacturer has supplied a USC power plant equal to or requiring greater specifications than the plant to be introduced in this project.

(b) Plant operation has been stable after a certain period since it started operation.

The Owner shall determine to its satisfaction whether candidates meet the prequalification criteria specified in Table 10.2-2 based on one of two criteria.

The determination shall be based upon an examination of the documentary evidence of the Applicant's prequalification submitted by the Applicant. Applicants who meet PQ criteria 1–(a) and 1-(b) or 2-(a) and 2-(b) shall be qualified as prospective bidders.

Table 10.2-2 Criteria of Prequalification for USC Plant Suppliers

PQ criteria 1-(a)	PQ criteria 1-(b)
The applicant shall have a proven track record of having supplied to a foreign country to two or more different owners major generating facilities (or at least critical parts of the facilities) of 600MW or larger generation-capacity USC coal-fired power plants, which shall be produced based on his own design and manufacturing technologies.	The power plants of ① shall have been in operation for five (5) years or more after the start of their commercial operation as of the end of June 2015.

PQ criteria 2-(a)	PQ criteria 2-(b)
The applicant shall have a proven track record of having supplied in his country the whole or the critical parts only of major generating facilities of 600MW or larger generation-capacity USC coal-fired power plants, which shall be produced based on his own design and manufacturing technologies and have been in operation for 15 years or more as of the end of June 2015.	The applicant shall have a proven track record of having supplied in the foreign country to one or more owners the whole or the critical parts only of major generating facilities for 600MW or larger generation-capacity USC coal-fired power plants, which shall be produced based on his own design and manufacturing technologies and have been commissioned as of the end of June 2015.

(Source: JICA Study Team)

10.2.4 Expected construction schedule

The estimated completion time for the first unit up to commercial operation will be 52 months after the Contract Award, and the second unit will be put into commercial operation about 6 months after the first unit. The expected construction schedule for the project is shown in Table

10.2-3 "Expected Construction Schedule for the Project".

Table 10.2-3 Expected Construction Schedule for the Project

No.	Item/ Scope of Works		Period	Description
4	JICA Appraisal	Mission	1 week	Consultations toward a final agreement for the implementation of ODA
		Government to government process for N/A, L/A	4 months	Pledge of L/A after 4 months from JICA appraisal mission
6-1,2,3	Consultant Selection (10 months each)	Documentation	3.5 months	Preparing Bidding Documents for Consultant Selection
		Bidding	1 month	EOI/Short-listing and Making Proposal
		Evaluation	3.5 months	Evaluation of Bidding Documents
		Approval	2 months	Approval of Consultant Selection by Owner with JICA Concurrence, and Contract
7-1 (Lot 1)	Basic Design and Preparation of International Bidding Documents (12 months)	Documentation	5 months	Making Basic Design Document with Owner's Approval
		Documentation	6 months	Preparing Bidding Document with Owner's Approval
		JICA concurrence	1 month	-
8-1	PQ of Bidders (7 months)	Documentation	2 months	Preparing PQ Documents with Owner's Approval
		JICA concurrence	1 month	-
		PQ Proposal	1.5 months	Making Proposal
		Evaluation	1.5 months	Evaluation of PQ Documents with Owner's Approval
		JICA concurrence	1 month	-
9-1	Selection of Contractor (10 months)	Bidding	3 months	Making Proposal
		Evaluation	5 months	Evaluation of Bidding Documents with Owner's Approval
		JICA concurrence	0.5 month	Concurrence for Bidding document Evaluation
		Negotiation	0.5 month	Negotiation between Owner & candidate
		JICA concurrence	1 month	-
10-1	Construction of	Design	6 months	Design of Port & Harbour

No.	Item/ Scope of Works		Period	Description
	Power Plant and Port & Harbour	Construction of Port & Harbour (36 months)		Construction of Port & Harbour
		Design (Design of Power Plant will start 18 months after Design of Port & Harbour)	6 months	Design of Power Plant
		Construction of Power Plant (42 months) (No. 2 unit will be put into commercial operation 6 months after No. 1 unit)	32 months	Construction of Power Plant Piling - Steel Structure – Receiving Power
			4 months	Commissioning of Facilities after Receiving Power
			3 months	Commissioning of Plant after Initial Firing
			7 months	Commissioning of Plant after Initial Synchronization - Completion
7-2 (Lot 2)	Basic Design and Preparation of International Bidding Documents (6 months)	Documentation	2 months	Making Basic Design Document with Owner's Approval
		Documentation	3 months	Preparing Bidding Document with Owner's Approval
		JICA concurrence	1 month	-
8-2	PQ of Bidders (5 months)	Documentation	2 months	Preparing PQ Documents with Owner's Approval
		JICA concurrence	0.5 month	-
		PQ Proposal	1 month	Making Proposal
		Evaluation	1 month	Evaluation of PQ Documents with Owner's Approval
		JICA concurrence	0.5 month	-
9-2	Selection of Contractor (6 months)	Bidding	1.5 months	Making Proposal
		Evaluation	2.5 months	Evaluation of Bidding Document with Owner's Approval
		JICA concurrence	0.5 month	Concurrence for Bidding Document Evaluation
		Negotiation	0.5 month	Negotiation between Owner & candidate
		JICA concurrence	1 month	-
10-2	Construction of	Design	4 months	Design of Transmission Line

No.	Item/ Scope of Works		Period	Description
	about 60km transmission line	Construction (30 months)	6 months	Preparation of Construction
			23 months	Tower Erection, Stringing work and Substation work
			1 month	Testing & Commissioning
7-3 (Lot 3)	Basic Design and Preparation of International Bidding Documents (7 months)	Documentation	2.5 months	Making Basic Design Document with Owner's Approval
		Documentation	3.5 months	Preparing Bidding Document with Owner's Approval
		JICA concurrence	1 month	-
8-3	PQ of Bidders (5 months)	Documentation	2 months	Preparing PQ Documents with Owner's Approval
		JICA concurrence	0.5 month	-
		PQ Proposal	1 month	Making Proposal
		Evaluation	1 month	Evaluation of PQ Documents with Owner's Approval
		JICA concurrence	0.5 month	-
		JICA concurrence	1 month	-
9-3	Selection of Contractor (6 months)	Bidding	3 months	Making Proposal
		Evaluation	1 month	Evaluation of Bidding Documents with Owner's Approval
		JICA concurrence	0.5 month	Concurrence for Bidding Document Evaluation
		Negotiation	0.5 month	Negotiation between Owner & candidate
		JICA concurrence	1 month	-
10-3	Construction of new road and bridges, and repair existing road	Design	6 months	Design of new road & bridge
		Construction	42 months	Construction of new road & bridges and repair existing road
11-1,2 (Lots 1 & 2)	Power Plant & Transmission Line		12 months each	Defect Liability Period

*All the schedule regarding JICA/GoJ are subject to the project maturity and GoJ decisions

(Source: JICA Study Team)

10.2.5 Main construction activity

The main construction activities during the stipulated period are outlined below.

However, the actual activities will be subject to modification to meet the Contractor’s plan after the contract is awarded.

(1) Civil Works

- Land Filling / Preparatory works / Mobilization
- Piling Works
- Cooling Water Intake and Discharge Culvert
- Screen Pump Pit
- Mat Foundation
  - Stack Foundation
  - Boiler Mat
  - Turbine Pedestal
  - Building Foundation
  - Equipment Foundation
  - Tank Foundation
- Coal Unloading Berth
- Sewerage / Drainage Works
- Road Construction & Pavement Works in Power Plant
- Planting in Power Plant

(2) Architecture / Structure Works

- Power House
- Control Building
- Administration Building
- Stack
- Warehouse
- Miscellaneous Housing
- HVAC Works
- Plumbing and Sanitary Installation
- Guard House / Fence
- Lighting System for Administration Building

(3) Main Power Plant Construction Works

- Boiler Works
  - Boiler Steel Structure Erection
  - Boiler Separator Lifting
  - Boiler Panel / Boiler Tube Construction
  - Boiler Piping Works
  - Header Lifting
  - Boiler Hydrostatic Test

- Boiler Auxiliary Equipment Installation
- Flue Gas Desulfurization System
- Electrostatic Precipitator System
- Light Oil Tank
- Ducting, Casing, Insulation, Painting Works
- Air Leak Test for Ducting
- Boiler Chemical

➢ Turbine Works
- Turbine Overhead Crane
- Turbine on Base
- H/P, I/P, L/P Turbine Assembling
- Main Piping Works
- Deaerator Lifting
- Condenser Installation
- Cooling Water Pump Station
- Turbine Auxiliary Equipment Installation
- Fire Fighting System
- Casing, Insulation, Painting Works
- Piping Hydrostatic Test

➢ Coal and Ash Handling Works
- Coal Unloading/Handling System
- Ash Handling System

➢ Electrical Works
- Grounding Works
- Generator Installation
- Transformer Installation
- Isolated Phase Bus Duct Installation
- Switch Gear Installation
- Emergency Diesel Generator System
- Cabling and Wiring Works
- Telecommunication
- 400 kV Switchyard (Switch Gear Installation, Control building, Gantry, etc.)

➢ Instrumental and Control Works
➢ Transmission Line Works
➢ Substation Works
➢ SCADA Works

(4) Commissioning

- Overall Trip / Interlock
- Boiler Safety Valve Test
- Boiler Blowing Out
- Boiler Combustion Test
- Condenser Vacuum-up Test
- Turbine Oil Flushing
- Turbine Bearing Metal Inspection
- Turbine No-load Test
- Turbine Over-speed Trip Test
- Load Shut-down Test
- Boiler Automatic Control Test
- Plant Automatic Control Test
- Load Test
- Trial Operation
- Performance Test

10.2.6 Project implementation procedure

The project is to be implemented in the following procedure.

(1) Bid Announcement

After obtaining the approval of the bid documents by JICA, the short-listed bidders are to be invited to the bid.

(2) Bidding Period

The bidding period is to be closed 3 months after the bid announcement.

(3) Bid Evaluation

After the bids close, the evaluation of all bidders is to be carried out by the nominated consultant. The evaluation report shall be approved by JICA.

(4) Award of Contract

The short listed bidders are to be invited to clarify the contents of their bidding document and to be negotiated the contents and price. Through those meetings the proposed successful bidder is to be nominated by CPGCBL. After the approval by JICA, the contract is to be awarded.

(5) Construction

First of all, CPGCBL and Consultant shall hold the kick-off meeting with the contractor to start the construction work and to indicate the project management systems and the procedures.

At design stage, the consultant shall review and approve the design documents, drawings and calculation sheets submitted by the contractor. Also, the consultant shall organize a design coordination meeting among CPGCBL, the Consultant and the Contractor periodically to settle any discrepancy in design or schedule.

To ensure the quality control of the manufacturing and the construction works, CPGCBL and the Consultant will carry out factory inspections and witness tests for the manufacturing of major equipment, as well as carrying out inspections and tests of the site works, all in accordance with the factory test schedule and approved QA/QC Inspection and Test Plans and their related procedures, submitted by the Contractor and approved by CPGCBL.

Coordination and supervision related to all construction works including civil works shall be made by the Consultant. The Consultant will hold construction schedule meetings weekly to check the schedule including arrangement of labor force, construction equipment & tool and material.

(6) Commissioning

The Consultant shall check and approve the schedule and procedures for test and commissioning of individual auxiliary equipment and facilities. CPGCBL and the Consultant will witness the tests of mechanical and electrical equipment and confirm important items and test results. The performance and acceptance tests shall be carried out under the supervision of the Consultant and the Consultant shall judge the result and report to CPGCBL.

(7) Taking Over

The Consultant will issue the Taking Over Certificate for the Contractor after confirmed and approved by CPGCBL.

10.3 The Implementation Plan of Consulting Services for Power Plant and Port & Harbour Construction

10.3.1 Scope of service of the consultant

The services of the Consultant shall encompass the necessary conceptual study, design, engineering, project management and execution; including supervision of construction, commissioning through the pre-construction stage, construction stage and defect liability period of the power plant together with the associated auxiliaries and ancillary equipment to complete the project. The Consultant will be required to offer a comprehensive proposal that includes the following:

A. Review of Preparatory Study

A-1 Review of Preparatory Study

In accordance with the ‘The Preparatory Survey on the Chittagong Area Coal Fired Power Plant Development Project’, the scope of services shall include all design concept studies for construction of the Matarbari Coal Fired Power Plant (Unit 1 & 2) and Port & Harbour. Construction, especially the decision of scope of work to be

executed and design parameters of the main equipment after assessment of CPGCBL's needs and analysis of the problem involved.
The study should also include a value analysis of alternatives if required by The Owner.

The consultant’s duties shall include but are not limited to the following:

a) Collection of all existing engineering design data and other data.
b) Collection of the data necessary for evaluating the approval of contents of the Feasibility Study.
c) Study, comment and recommendation to CPGCBL in connection with the Preparatory Survey prepared by CPGCBL.
d) Preparation of the design concept or the basic study report, discussion and agreement with CPGCBL before establishing the full scope.
e) Preparation of an updated Project Implementation Schedule, Project Cost Estimation and Cash Flow.

A-2 Design and Engineering

Based on the Owner's data already available, such as existing engineering data, environmental report, the Consultant shall execute the design and engineering.
The Consultant’s duties shall include but are not limited to the following:

a) Preparation of design calculations, detailed plans, drawings, all specifications and schedules for bidders and for contract documents. The design shall include calculations to determine size or capacity requirements, layout and detailed arrangement of components, selection of equipment and materials including those related to environmental issues, and where required testing of models and materials and specialized research.
b) Prepare pre-qualification bid documents and bid documents/contract documents.
c) Examination, review and approval of drawings, procedures and designs submitted by or requested from the Contractor. These include drawings and designs requiring approval from regulatory bodies.
d) Based on the operation and maintenance manuals submitted by the contractor, the Consultant shall coordinate proper operation and maintenance procedures integrating the overall operation and maintenance philosophy of the power plant.
e) Review of spare parts requirements and stock level of spares.

B. Economic Evaluation

The Consultant will conduct an economic analysis and prepare a report on the Project by comparing with 600MW USC power plant using the coal specified by CPGCBL.

The Consultant's duties shall include but are not be limited to the following:

1) Conducting comparative analyses, examining financial, economic, environmental and technical points of the Project with a USC power plant with a capacity of 600MW using the coal specified by CPGCBL.
2) Submitting report(s) covering the results of the above mentioned analysis to JICA and CPGCBL

C. Assistance to CPGCBL in International Competitive Biddings for EPC Contractor Selection

C-1 Assistance to CPGCBL in Pre-Qualification (P/Q) for the Bidders

The Consultant sha1l prepare the P/Q Documents subject to approval by the Owner for the Project, taking into account the Guidelines for Procurement as issued by JICA and Bangladesh Regulations.

The Consultant's duties shall include but are not limited to the following:

1) Selecting pre-qualification criteria including eligibility requirements
   a. Joint venture requirements
   b. General experience requirements
   c. Specific experience requirements
   d. Financial capability
   e. Organizational capability, etc.
2) Preparation of P/Q documents.
3) To assist CPGCBL in P/Q announcement
4) Evaluation of all bids against established CPGCBL and JICA approved criteria
5) Preparation of draft P/Q evaluation reports to CPGCBL and assistance to CPGCBL in preparing final P/Q evaluation reports

C-2 Assistance to CPGCBL in Bid Documents

The Consultant shall prepare the Bid Documents for the Project, taking into account the Guidelines for Procurement under JICA ODA Loans and Bangladesh Regulations, and draft General Conditions, Special Conditions and Instructions to Bidders. Once the Owner's approval is obtained, the Consultant shall prepare the Final Master Bid Documents to be included in the Main Contract.

The Consultant's duties shall include but are not limited to following:

1) Preparation of Bid Documents and relevant drawings with due coordination of guidelines of CPGCBL and JICA
2) Attending and assisting CPGCBL for pre-bid conference
3) Assisting CPGCBL in answering Bidder's questions, both Technical and Commercial questions, and in issuing addenda to Bid Documents
4) Assisting CPGCBL in giving technical clarifications to the Bidders and questions on the Bid Documents

D. Bid Evaluation and Contract Negotiation

D-1 Assistance to CPGCBL in checking and reviewing Documents and Drawings submitted by the Bidders

The Consultant shall undertake the following works:

1) Attending the Bid receiving and opening as well as preparing the MOM (Minutes of Meeting).
2) Assisting the CPGCBL in Bid evaluation and tabulation of contents of all bids compliance with the tender specification, reasonableness of prices and proposed time for completion of the work and any other guidelines as required by CPGCBL and JICA. Bid evaluation includes examination and evaluation of the bids received (including technical, commercial and financial concerns, including all financing terms offered by the Bidders) and submission of recommendations to CPGCBL and preparing evaluation criteria under Technical, Commercial and Financial bid evaluation, and preparing evaluation reports and giving recommendations for award of the Contract.
3) Checking and reviewing power plant site surveys, routing the transmission line and investigations conducted by the Bidders.
4) Checking, reviewing and giving recommendations regarding designs and calculations submitted by the Bidders.
5) Checking, reviewing and giving recommendations regarding manufacture, fabrication, shop and installation drawings submitted by the Bidders.

D-2 Assistance to CPGCBL in the Contract Negotiation

The Consultant shall prepare an agenda for negotiations. During the contract negotiations, appropriate assistance shall be rendered to The Owner and on the successful completion of the negotiations, the Consultant shall draft the meeting minutes.

The Consultant shall undertake the following:

1) Preparation of a draft contract agreement issued by CPGCBL to the successful

Bidder.

2) Assist CPGCBL in Contract Negotiation by preparing an agenda for negotiations. During contract negotiations, appropriate assistance shall be rendered to CPGCBL and upon the successful completion of the negotiations, the Consultant shall draft the meeting minutes.

E. Construction Supervision.

E-1 Project Management at all levels including Periodic Review of Budget Estimate and Administration of Project Cash Flows

The Consultant shall establish a project management system acceptable to CPGCBL, which will be used to monitor / track and pin point problems.

The Consultant's duties shall include but are not limited to following:

1) Establishment of the basic overall project construction schedule. Preparation of project PERT (Program Evaluation and Review Technique) / CPM(Critical Path Method) network, budget and cash disbursement schedule for both foreign and local cost.
2) Establishment and implementation of a project management system and procedures to monitor and control the cost and time schedule to enable timely corrective measures.
3) Maintenance of all support. That coordination supervision and decision making actions including engineering and design activities related to the construction activities are to be managed in a manner so as to ensure that quality control and engineering standards are consistently maintained throughout the project and within cost and time constraints.
4) Setting up of an effective reporting system of project progress and status to CPGCBL.

E-2 Assistance to CPGCBL in Construction Supervision

During the construction phase, the Consultant shall carry out construction supervision and management to ensure that the construction activities of the

Contractors are fully in compliance with the Contract.

The Consultant shall undertake the following:

1) Assist in construction to assure compliance with the approved technical specifications and construction drawings.
2) Coordination, supervision and inspection of all construction and erection activities.
3) Coordinate the works among the different Contractors.
4) Assisting the CPGCBL in checking and approving the construction methods and site works carried out by the Contractor.
5) Assisting the CPGCBL in checking and approving the Contractor's quality

assurance and control program.

6) Indicating and approving final reference points for the setting out of all structures.
7) Assisting CPGCBL in checking and approving test procedures for materials and equipment to be tested on site by the Contractor and observing such tests, as well as reviewing and giving recommendations regarding the test results of field test of materials and equipment performed by the Contractor.
8) Providing necessary interpretation to the CPGCBL project manager on technical and commercial issues.
9) Preparing and updating detailed and overall project disbursement schedule.
10) Assisting CPGCBL in the issuance of payment certificates.
11) Monitoring and controlling work progress and initiating corrective measures.
12) Preparing and updating detailed and overall project physical target accomplishment.
13) Checking, examining, and certifying the extent of work performed by the Contractors.
14) Checking, examining and solving claims submitted by Contractors.
15) Assisting CPGCBL in contractual matters (guarantees, performance bonds, insurance, claims, etc.).
16) Inspecting and directing preventive safety and environmental control measures.
17) Assisting the CPGCBL in checking and approving as-built drawings.
18) Checking the issuance of "Certificate of Ready" for commissioning certificates by Contractor.
19) Assisting CPGCBL in supervising Environment, Health and Safety (EHS) construction based on JICA's guideline and Bangladesh's regulations.
20) Assisting CPGCBL in giving proper consideration to the rare species which live in the Project site based on advice from experts.

E-3 Assistance to CPGCBL in Inspection, Testing and Delivery Control during Manufacturing

The Consultant shall undertake the following:

1) Reviewing and approving proposals regarding quality assurance, quality control plans and the delivery schedule prepared by the Contractor.
2) Regular review of the production and delivery schedule by the Contractor.
3) Reviewing and approving factory testing procedures and factory test results submitted by the Contractor.
4) Monitoring manufacturing progress, and conducting testing by regular inspections to ensure compliance with contract documents.
5) Observing factory test for major equipment and preparing corresponding

certificates (planted items and tests to be witnessed are to be agreed between CPGCBL and the Contractor).

6) Reviewing inspection reports on each factory inspection submitted by the Contractor.

E-4 Assistance to CPGCBL in Inspection, Testing and Delivery Control during Manufacturing

The Consultant shall formulate test and commissioning procedures as part of the integrated project management plan. The Contractor's proposals for testing procedures shall be reviewed.

The Consultant shall undertake the following:

1) Formulating test and commissioning procedures as part of the integrated project management plan.
2) Assisting CPGCBL during the various commissioning stages of the plants.
3) Assisting CPGCBL in reviewing and approving the Contractor's start-up and testing procedures, including performance tests in accordance with guarantees.
4) Assisting the CPGCBL in coordinating and supervising all tests according to the Contract.
5) Assisting CPGCBL in reviewing and approving the Contractor's commissioning test report.
6) Reviewing and recommending the tentative taking over and acceptance of certificates for the equipment, subject to prior approval of CPGCBL.

E-5 Assistance to CPGCBL for Environmental Aspects

The Consultant shall supervise/monitor the project from environmental view point disposed soil, noise, vibration, air/water pollution, etc. and additional social and environmental concerns as specified in the Environmental Management Plan (EMP) and as well as any Social issues which have been raised in the social and environmental management reports and shall review draft Environmental Monitoring Report prepared by The Owner.

The Consultant shall undertake the following:

1) Supervising/monitoring the project from an Environmental viewpoint, including disposed soil, noise, vibration, waste, air and water pollution, etc. The Consultant shall conduct Ambient Air monitoring (e.g. S02, NOx, and PM10) around the Project site at three points (the Project site and two nearby villages) once a day for one (1) year (Warranty Period), and prepare an Ambient Air Quality Report every three months.

F. Assisting the CPGCBL in conducting monitoring during the warranty period

G. The Consultant shall supervise/monitor the quality of plant equipment from the completion of the 2nd 600MW Power Plant to final acceptance certificate (FAC).

H. Data on the plant in its initial state is collected as judgment material for the FAC. The Consultant shall assist CPGCBL in order to obtain final acceptance.

10.3.2 Reports and documents

The Consultant will prepare and submit to CPGCBL the following documents and reports:

(1) Inception Report
(2) Geothermal Resource Analysis with Reservoir Simulation Study Report
(3) Engineering Design Report
(4) Pre-qualification Document
(5) Evaluation Report of Pre-qualification
(6) Draft Bidding Document
(7) Master Bidding Document
(8) Bid Evaluation Report
(9) Integrated Project Management Plan
(10) Weekly Cash flow report
(11) Monthly Progress Report
(12) Ambient Air Quality Report
(13) Quarterly Progress Report
(14) Project Completion Report

10.3.3 Expertise requirements

The assumed engineering services for power plant and port & harbour construction (Lots 1) are provided by the foreign and local consultants in the following list, which shall include, but not be limited, to the following:

Total Man-Months: 1960.0MM
Foreign Consultant: 796.0MM

Position	
Power Plant	1) Project Manager
	2) Mechanical Engineer (Boiler)
	3) Mechanical Engineer (Steam Turbine)
	4) Mechanical Engineer (Coal Handling System)
	5) Mechanical Engineer (Balance of Plant)

	6) Electrical Engineer
	7) I&C Engineer
	8) Architectural Engineer
	9) Civil Engineer (Civil Work)
	10) Civil Engineer (Land Development)
	11) USC O & M Expert (1)
	12) USC O & M Expert (2)
Dredging/Port Facility/Land Reclamation Works	13) Dredging Engineer (Team Leader)
	14) Dredging Engineer (Land Area)
	15) Port Facilities Engineer (Structure)
	16) Hydraulic Engineer
	17) Geotechnical Engineer (Port Work)
	18) Land Reclamation Engineer
	19) Geotechnical Engineer (Land Work)
Others	20) Environmental & Social Expert
	21) Economist
	22) Contract Expert
	23) HIV/AIDS Consultant

Local Consultant: 1164.0MM

Position	
Power Plant	1) Deputy Project Manager
	2) Mechanical Engineer (Boiler)
	3) Mechanical Engineer (Steam Turbine)
	4) Mechanical Engineer (Coal Handling System)
	5) Mechanical Engineer (Balance of Plant)
	6) Electrical Engineer
	7) I&C Engineer
	8) Architectural Engineer
	9) Civil Engineer (Civil Work)
	10) Civil Engineer (Land Development)
Dredging/Port Facility/Land Reclamation Works	11) Dredging Engineer (Team Leader)
	12) Dredging Engineer (Land Area)
	13) Port Facilities Engineer (Structure)
	14) Hydraulic Engineer
	15) Geotechnical Engineer (Port Work)
	16) Land Reclamation Engineer
	17) Geotechnical Engineer (Land Work)
Others	18) Environmental & Social Expert
	19) Economist
	20) Contract Expert
	21) HIV/AIDS Consultant

(Source: JICA Study Team)

10.3.4 Requirement(criteria) for the Consultant

The requirements of The Consultant are as follows:

(1) Agree to employ a Consultant based on "Guidelines for the Employment of Consultants under Japanese ODA Loans".

(2) The consultancy firm making the proposal shall indicate its experience regarding the following as it pertains to power plants in its own country and overseas:

- Power sector study
- Feasibility study
- Basic design, detail design for tender
- Engineering service of on-site
- The above-mentioned experience in a coal-fired power plant
- Experience of a USC boiler and a turbine with capacity
- Existence of the consultant experience concerning Japan ODA

(3) The requirements for each Engineer

Qualifications and requirements based on education is not a requirement. However, for the purpose of calculating consultant fees, education and experience are taken into consideration.

- Project Manager:
  Experience of the thermal power plant design or engineering services of above 600 MW
- Coal & Ash handling Engineer:
  Experience of the coal fired thermal power plant design or engineering services of above 100 MW
- Other Machine, Electrical and I&C Engineer:
  Experience of the thermal power plant design or engineering services of above 300 MW
- CIVIL and Architecture Engineer:
  Experience of the thermal power plant design or engineering services of above 100 MW
- Expert:
  Experience of the thermal power plant
- Each Engineer:
  If experienced in USC boiler/turbine and a coal fired plant, the engineer will explain the details of that experience.

(4) The consultant office in a design stage shall be established in Dhaka, and the expense is included in a consultant's expense.

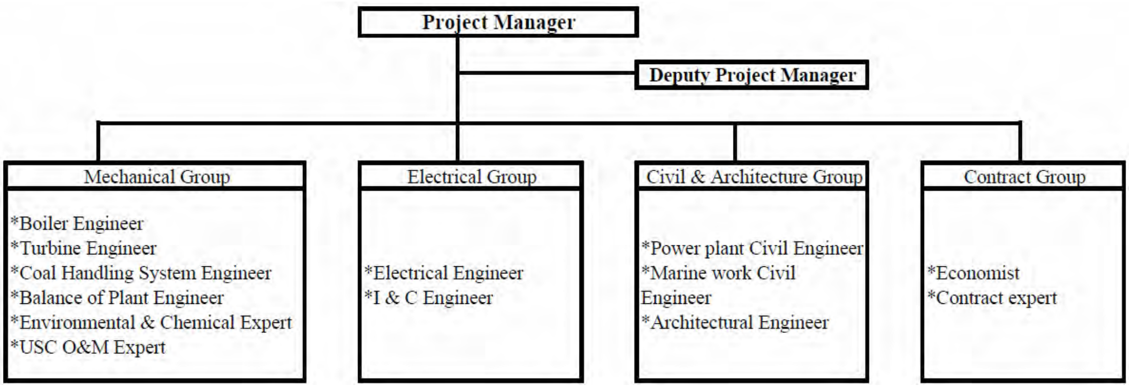
10.3.5 Organization for project implementation

The Engineering Teams working on the project will be organized in a manner commensurate with the requirements of the project.

The Consultant will form the working teams for the project in Bangladesh, and will assign a Project Manager who will be in charge of the overall performance and supervision of the project services including coordination and liaison with CPGCBL and JICA.

For executing the services of the Matarbari CFPP project, working groups such as a Civil and Architecture Group, Mechanical Group, Electrical Group and Contract Group, up to each milestone will be organized under the Project Manager. Group members will be nominated mainly from those who have had experience in Design, Bid Evaluation, Construction, and Commissioning of thermal power plants.

The sample organization charts of the Consultant Engineer for this project are shown in Figure 10.3-1.



(Source: JICA Study Team)

Figure 10.3-1 Expected Project Team Organization Chart for Consultant Engineers of the Matarbari Coal Fired Power Plant Project

10.4 Implementation and Procurement for 400 kV Transmission Line Construction

10.4.1 Implementation policy

(1) Implementation Agency of Bangladesh side

Regarding the 400 kV transmission line from Matarbari CFPP to Anowara substation, PGCB will be the implementation agency of the construction of the transmission line.

PGCB will be responsible for the followings during implementation.

a) Organization a new implementation unit for this project,
b) Coordination among the related ministries and provincial authorities for smooth implementation of the project,
c) Acquisition of the right to enter designated project areas and acquisition of land/compensation of houses within the transmission line’s right of way,
d) Prior securing of the environmental certificate for the project,
e) Appointment of the project consultants, and cooperation with/assistance to them,
f) Close communication with institution(s) of the project fund on bidding, contracts, procurement, project progress and other information,
g) Proper actions for necessary procedures on facility import for the project,
h) Issue of payment certificates for consultants and contractors,
i) Claim management of contractors, local people and others,
j) Prosecution of the commissioning test of the project,
k) Education and training of employees for operation and maintenance for transmission line and substation, and
l) Proper operation and maintenance of the facilities after commissioning.

PGCB should secure budget and staffs to execute the above duties.

(2) Project Consultants

The Consultant will be responsible for the following particulars.

a) Detailed design of the project including a field survey and transmission line route investigation,
b) Preparation of the design report for the project and submission to PGCB,
c) Preparation of the bidding documents for the project and submission to PGCB,
d) Evaluation of proposals forwarded by bidders and assistance to PGCB evaluation committee in selecting prospective bidders for the contracts,
e) Assistance to PGCB in contract negotiations with prospective bidders and in conclusion of the contracts,
f) Examination on manufacturing/working drawings and various communications from the Contractor’s for approval,
g) Inspections and tests for equipment and materials to be carried out at the contractors’ factories prior to shipment,
h) Project management and supervision of the contractors’ field works,
i) Preparation of O&M manuals of completed facilities and the completion report,
j) Inspection on facilities immediately prior to before expiration of the guarantee period for facilities, and
k) Transfer of knowledge to PGCB staffs in charge of the project.

(3) Contractors

The project will be executed in turn-key contracts. Contractors should be fully responsible for the following works in strict compliance with all terms in the contract documents.

a) Design of equipment and materials required for completion of the project,
b) Manufacturing and tests of the equipment and materials,
c) Packaging and transportation to the site of the equipment and materials,
d) All civil/building works and installation of equipment and materials,
e) Verification of proper functions of all the facilities completed,
f) Commissioning of the facilities to PGCB,
g) Transfer of knowledge to PGCB through their working period for construction, maintenance and operation of the project facilities.

10.4.2 Procurement policy

(1) Mode of Procurement

Although the project comprises two components, i.e. transmission line and substation, the project will be executed under one contract of transmission line and substation in principle, and the contractors will be selected through ICB (International Competitive Bidding) mode for turn-key basis.

(2) Procurement sources

The sources of the facilities/equipment for the project will not be limited in principle because of the ICB-based procurement. However, the Contractor should be carefully selected taking into account their qualifications for quality control of goods, production capacities, experience in similar projects, remedial claims of their previous contracts, financial status of the Contractor and their major subcontractors and so on. Bidding documents prepared by the Consultant will specify bidder's qualification and its evaluation criteria.

(3) Guarantee Period of Facilities

It will be specified in the contract documents that the Contractor should guarantee all functions of the facilities provided under the project for a certain period after commissioning. Besides, it is also recommended that the Contractor will train on the job site of PGCB's operators and maintenance staffs during the construction period and a certain period after commencement of substation operations. A special term will be included in the contract documents as one of the Contractor's duties.

10.4.3 Scope of services of the Consultant

The services of the consultant are to undertake necessary design, engineering, project management and execution including supervision of construction, commissioning through the pre-construction stage, construction stage and defect liability period of the transmission line and substation. The consultant will be required to offer a comprehensive proposal to include the following items.

(1) Supervision of Construction and Procurement

a) Detailed Design and Preparation of Bidding Documents

The Consultant will execute the detailed design, cost estimate and detailed implementation plan for the project through discussion with PGCB and in accordance with results of the field survey and investigation. Design report prepared by the Consultant will cover whole results of the design. After approval of the report by the funding institutions or in parallel with the report preparation, the Consultant will produce bidding documents for the project. A team leader, a transmission line engineer, a substation engineer and survey engineer from the Consultant will work at this stage. In the short-term, experts for the environment, communication system and cost estimate will also join the works.

b) Public Bidding and Contract

The Consultant will carry out assistance to PGCB during public announcements of bid, bid opening, bid evaluation, contract negotiation and preparation of the contract documents. A team leader, a transmission line engineer and substation engineer will be in charge of the works.

c) Procurement Management

The Consultant will manage all works for examinations of the Contractor’s drawings and designs, and inspection/tests of equipment/materials at the Contractor’s factory. A team leader, a transmission line engineer and substation engineer will be in charge of the work.

d) Supervision of Contractors’ Field Works

Through the whole period of the contractors’ field works, the consultants will supervise all the field works. The consultants will have responsibility for education of PGCB’s operators and maintenance people for the facilities after completion of the project. A team leader, two transmission line engineers and a substation engineer will be residing at the site through the contractors’ field works. A communication engineer will be assigned for the short term.

e) Commissioning Test and Inspection for Defect Liability Period

After completion of the construction of all facilities, the Consultant will supervise the Contractor’s commissioning tests of individual facilities for the transmission line and substation, and also for the system operation test combining both transmission line and substation. Furthermore, the Consultant will check and approve the project completion report and O&M manuals of the completed facilities to be submitted by the Contractor, and assist PGCB with their procedures for issuing taking over certificates to the Contractor. Immediately before the expiration of the defect liability period of the project facilities, the Consultant in conjunction with PGCB will inspect all the project-related facilities for issuing final certificates to the Contractor.

(2) Quality Control of Equipment and Materials

a) Examination of Design and Manufacturing Drawings

The consultants will examine design, manufacturing drawings and quality control manuals to be submitted for approval by the contractors in accordance with the contract documents for confirming quality of the proposed equipment and materials. The consultants will not approve the proposals of the contractors and order to re-design to fully comply with the contract specifications, if needed.

b) Inspection and Tests of Equipment and Materials

Major equipment and materials manufactured for the project will be inspected and tested at the contractors' factories prior to shipment to the project site for assuring their qualities. PGCB staffs will be witness to those factory inspections and tests.

(3) Quality Control during Construction

a) Construction Drawings

The Consultant will order the Contractor to submit the construction drawings, construction schedules and plans for quality control of the works for the Consultant's approval, and manage quality control and the progress of the works done by the Contractor.

b) Tests of Materials

The Consultant will order the Contractor to test samples of concrete and rebar to be used for foundations and buildings at a reputed local laboratory. The contract documents will specify the duties of the Contractor to be carried out compression tests on concrete pieces sampled by the Consultant from mixing batches.

c) Control of Field Works

During the construction period of transmission line works (foundations, tower erection and stringing operation) and substation works (land expansion, foundations, expansion works of substation building and installation of equipment), the Consultant and PGCB inspectors will care damages on equipment and materials, and order to repair or replacement of the damaged equipment and materials if found. Prior to issuing of payment certificates to the Contractor, the Consultant and PGCB inspectors will inspect not only the construction progress but also quality of all facilities claimed by the Contractor in their application of the payment.

d) Commissioning Tests

The consultants and PGCB will finally confirm the quality of the facilities by the comprehensive commissioning inspection and tests to be carried out before the taking-over of the facilities.

10.4.4 Implementation schedule of the transmission line and substation (Lot 2)

Regarding the planned 400 kV transmission line from Matarbari CFPP to Anowara substation of which the total length is approximately 61.5 km, it seems that it will be completed in 30 months (2 years and 6 months) by one contractor, considering 2 dry seasons and some margins, assuming that there would be no major difficulty in terms of land acquisition and compensation that influences the construction period and considering the aforementioned actual achievement.

The expected implementation schedule of the planned transmission line including extension of the 400 kV Anowara substation from the consultancy agreement till the commencement of operation through the contract with the contractor is shown in Figure 10.4-1.

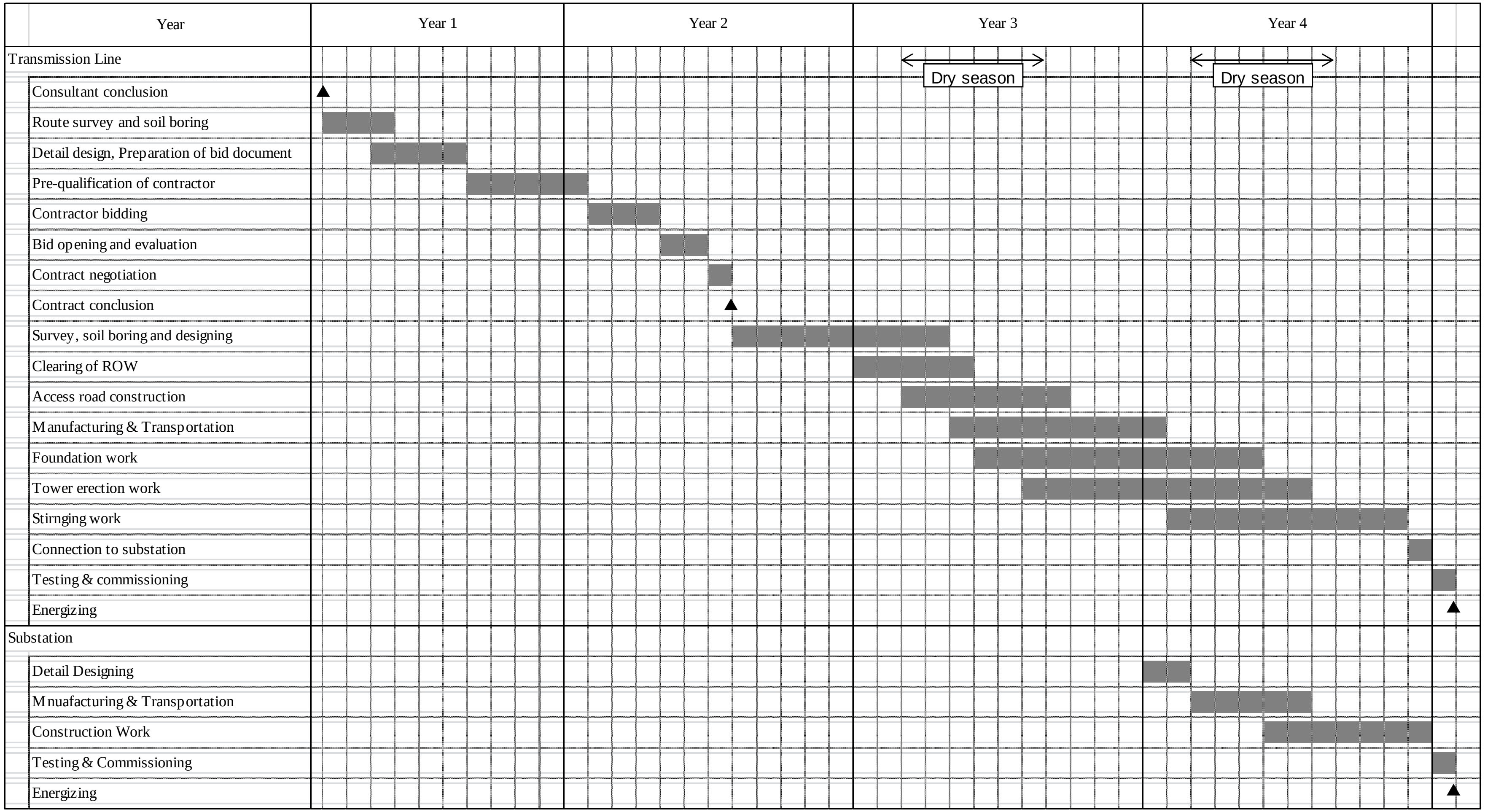


Figure 10.4-1 Assumed Implementation Schedule for the Transmission Line and Substation Construction

10.5 The Implementation Plan of Management Consulting Services

10.5.1 Scope of service of the Consultant

The main service of Management Consultant is making of Business Plan for CPGCBL. Basically, the services are carried out based on the discussion with CPGCBL by reference to the rules and regulations of BPDB or other Bangladesh Power Utilities. The Consultant shall provide necessary support and skill transfer/training include, but not limited to, the following areas:

Part 1: Corporate Management Plan/Human Resource Management Plan for the Company

a) Advisory support for developing the corporate management plan.
b) Develop/Review duty and powers of each division, unit and individual of corporate office and power plants.
c) Develop/Review compensation and bonus system of the company.
d) Develop/Review Welfare programs, Human Capital development policy, Employment schedule (plan).
e) Develop/Review of service rules and Human Resource Management policies.
f) Support CPGCBL to update existing Roadmap and Action Plan of the Company.

Part 2: Preparatory Works for Establishing Financial and Accounting System:

a) Assess and strengthen internal control system.
b) Develop/Review Financial Policies.
c) Develop/Review Delegation of Power.
d) Develop/Review Fundamental Accounting Policies and Accounting Rules.
e) Develop/Review Chart of Accounts.
f) Develop/Review Budget Policy and Processes.
g) Develop/Review Budget Manual.
h) Develop/Review Accounting Manuals, including formats.
i) Design Integrated Accounting Business Processes.
j) Assist CPGCBL Accounting staff and Finance staff to acquire required knowledge and skills to conduct accounting practices defined in the above mentioned rules and processes.

Part 3: Preparatory Works for Establishing Operation and Maintenance System:

a) Develop Operation & Maintenance Manual including data management system.
b) Develop Safety Manual in consideration of Bangladesh Labour Act 2006, the JICA's Safety and Quality Control System Checklist and the contents of the Environmental, Health, and Safety Guidelines published by International Finance Corporation.
c) Develop Basic Education and Training manual.
d) Develop Environmental Management manual
e) Assist CPGCBL O&M staff to acquire required knowledge and skills to conduct O&M works defined in the above mentioned rules and processes.

Part 4: Promotion of TQM (Total Quality Management)

a) Assist CPGCBL in establishing TQM Promotion Office.
b) Assist TQM Promotion Office in preparing TQM Promotion Plan and carrying out TQM promotion activities based on the Plan.
c) Assist TQM Promotion Office in undertaking OJT (On Job Training) for raising awareness.

Part 5: Introduction of the Performance Management System

a) Review available studies and reports to acquire knowledge on the Bangladesh's power sector's current practices in the areas of performance evaluation system and promotion system of individuals.
b) Develop the Performance Management System in line with the Company Vision and Strategy including linkage between the performance evaluation and compensation package.

10.5.2 Expertise requirements

The assumed services for management are provided by the foreign and local consultants in the following list, which shall include, but not be limited, to the following:

Foreign Consultant

1) Project Manager/ Management System Expert
2) Financial & Accounting System Expert
3) Operation and Maintenance Expert
4) TQM (Capacity Building) Expert
5) Performance Management System Expert

Local Consultant

1) Deputy Project Manager/ Management System Expert
2) Financial & Accounting System Expert
3) Operation and Maintenance Expert
4) TQM (Capacity Building) Expert
5) Performance Management System Expert

10.6 The Implementation Plan of Coal Procurement Consulting Services

10.6.1 Scope of service of the Consultant

The services of the Consultant are to procure coal from other countries considering following points.

- To secure a stable supply for the long term
- To procure good quality coal at as low a price as possible
- To secure procurement transparency
- To accumulate knowledge of the coal procurement in Bangladesh in the future

The Consultant will be required to offer a comprehensive proposal to include the following:

Part 1: Set coal procurement condition

a) Review the design of the power plant, and set down the available range of the coal quality (calorific value and contents such as ash, moisture, and sulfur).
b) Review the design of harbour, and set down the use conditions of the harbour equipment (available ship size, required duration for unloading of the coal etc.).
c) Decide the starting time of procurement and the procuring lot (amount of annual procurement and period of year).
d) Decide evaluation criteria.
e) Decide how to check coal quality.

Part 2: Assist CPGCBL in Pre-qualification for Bidders

a) Select pre-qualification criteria including eligibility requirements; joint venture requirements; general experience requirements; specific experience requirements; financial capability; and organizational capability, etc.
b) Prepare Pre-qualification documents.
c) Assist CPGCBL for pre-qualification advertising.
d) Check and review pre-qualification proposals from Bidders with due co-ordination of guidelines of CPGCBL and JICA.

e) Evaluate all Bids in accordance with established CPGCBL and JICA approved criteria.
f) Review and update the draft report based on comments from CPGCBL and JICA.
g) Prepare draft evaluation reports to CPGCBL and assist CPGCBL in preparing final evaluation reports.

Part 3: Assist CPGCBL in International Competitive Biddings

a) Prepare, check and review Bid documents for coal procurement, including general and commercial terms, and conditions for bidding purpose conditions of contracts, technical specifications for bidding purposes, schedules and forms for bidding purposes with due coordination of the guidelines of CPGCBL and JICA.
b) Assist CPGCBL for pre-bidding meetings.
c) Assist CPGCBL in replying to Bidders’ questions and in issuing addenda to Bid documents.
d) Examine and evaluate the Bids received in accordance with criteria established by CPGCBL and approved by JICA.
e) Prepare draft evaluation reports of CPGCBL and assist CPGCBL in selecting technically responsible Bidders.
f) Evaluate and tabulate contents of all Bids for compliance with the Bid documents, reasonableness of price, quality and supply stability of the coal and any other guidelines as required by CPGCBL and JICA.
g) Prepare final evaluation reports and recommendations for awarding of contracts taking into consideration the comments of CPGCBL and JICA on draft evaluation reports.
h) Prepare draft contract agreements issued by CPGCBL to the successful Bidder.

Part 4: Assist CPGCBL in exchanging Contract (as Supporting Agency)

a) Organize Supporting Agency
b) Prepare Fuel Supply Agreement (FSA).
c) Support CPGCBL related to a fuel supply agreement (including annual price negotiation and contract extension, etc.)
d) Prepare Service Contract for coal transportation and support CPGCBL to contract with shipping company.
e) Prepare O&M Service Contract for port and support CPGCBL to contract with port operation company.

f) Support CPGCBL to carry out payment procedures based on the contract

Part 5: Assist CPGCBL in Coal management (as Supporting Agency)

a) Instruction of fuel delivery (amount and time)
b) Instruction of allocation of ships
c) Develop Coal procurement manual.
d) Develop O&M manual in port and coal yard.
e) Operational coordination with port operation company and CPGCBL (or coal yard operation company)
f) Assist CPGCBL coal management staff to acquire required knowledge and skills to conduct coal management works defined in the above mentioned rules and processes.

10.6.2 Expertise requirements

The assumed engineering services for coal procurement are provided by the foreign and local consultants in the following list, which shall include, but not be limited, to the following:

Foreign Consultant

1) Project Manager/ Coal procurement Expert
2) Coal Expert
3) Coal-fired thermal power plant Expert
4) Operation and Maintenance (harbour and coal yard) Expert
5) Economist
6) Contract Expert

Local Consultant

1) Thermal power plant Expert
2) Operation and Maintenance (harbour) Expert
3) Contract Expert

10.7 The Implementation Plan of Consulting Services for Access Road

10.7.1 Scope and service of the Consultant

(1) Objectives of consulting services

The consulting services shall be provided by an international consulting firm (hereinafter referred to as "the Consultant") in association with national consultants in compliance with Guidelines for the Employment of Consultants under Japanese ODA Loans (April 2012). The objective of the consulting services is to achieve the efficient and proper preparation and implementation of the Access Road Project through the following works;

(1) Detailed design
(2) Tender assistance
(3) Construction supervision
(4) Facilitation of implementation of Environmental Management Plan (EMP), Environmental Monitoring Plan (EMoP) and Resettlement Action Plan (RAP)

(2) Scope of consulting services

1) General Terms of Reference

Detailed design

The Consultant shall:

(a) Review and verify all available primary and secondary data collected during the JICA's preparatory survey for the Access Road Project;

(b) Carry out all the required engineering surveys and investigations such as topographical survey, hydrological survey, geotechnical survey, material availability survey, etc., as applicable to the concerned project components.

(c) Prepare detailed work plan, progress reports and implementation schedule for the Access Road Project to ensure effective monitoring and timely project outputs, and regularly update the same; and

(d) Prepare the detailed design of the Access Road Project in sufficient detail to ensure clarity and understanding by RHD, contractors and other relevant stakeholders. All the design should be in conformity with the Bangladesh's Standards (if available), or with the appropriate international standards. The detailed design will, as a minimum, include construction drawings, detailed cost estimates, necessary calculations to determine and justify the engineering details for the Access Road Project, associated contract documentation to include detailed specifications, bill of quantities (BOQ) and implementation schedule for the Access Road Project. Such specifications will contain those in relation to i) quality control of materials and workmanship, ii) safety, and iii) protection of the environment. The detailed design shall be prepared in close consultation with, and to meet the requirements of RHD and will be incorporated into the detailed design report to be submitted for approval of RHD.

Tender assistance

- Assistance in Pre-Qualification (PQ)

The Consultant shall:

(a) Define technical and financial requirements, capacity and/or experience for PQ criteria taking into consideration technical feature of the Access Road Project;

(b) Prepare PQ documents in accordance with the latest version of Standard Prequalification Documents under Japanese ODA Loans;

(c) Assist RHD in PQ announcement, addendum/corrigendum, and clarifications to the applicants' queries;

(d) Evaluate PQ applications in accordance with the criteria set forth in PQ documents; and

(e) Prepare a PQ evaluation report for approval of the PQ evaluation committee.

- Assistance in the Bidding Procedures

The Consultant shall:

(a) Prepare bidding documents in accordance with the latest version of Standard Bidding Documents under Japanese ODA Loans for Procurement of Works together with all relevant specifications, drawings and other documents;
(b) Prepare bidding documents which includes the clauses to have Contractor comply with the requirement of the Environmental Management Plan (EMP) and JICA Guidelines for environmental and social considerations (April 2010) (JICA Environmental Guidelines);
(c) Assist RHD in issuing bid invitation, conducting pre-bid conferences, issuing addendum/corrigendum, and clarifications to bidders' queries;
(d) Evaluate bids in accordance with the criteria set forth in the bidding documents. In such evaluation, the Consultant shall carefully confirm that bidders' submissions in their technical proposal including, but not limited to, site organization, mobilization schedule, method statement, construction schedule, safety plan, and EMP have been prepared in harmony each other and will meet such requirements set forth in applicable laws and regulations, specifications and other parts of the bidding documents;
(e) Prepare a bid evaluation report for approval of the bid evaluation committee;
(f) Assist RHD in contract negotiation by preparing agenda and facilitating negotiations including preparation of minutes of negotiation meeting; and
(g) Prepare a draft and final contract agreement.

Construction supervision

The Consultant shall perform his duties during the construction period in accordance with the contracts to be executed between the Employer and the contractors. FIDIC MDB Harmonized Edition (2010) complemented with the Specific Provisions as included in the Standard Bidding Documents under Japanese ODA Loans for Procurement of Works will be applied to the civil works of the Project. In this context, the Consultant shall:

(a) Act as the Engineer to execute construction supervision and contract administration services in accordance with the power and authority to be delegated by RHD;
(b) Provide assistance to the Employer concerning variations and claims which are to be ordered/issued at the initiative of the Employer;
(c) Issue the commencement order to the Contractors;
(d) Provide recommendation to RHD for acceptance of the Contractor Performance security, advance payment security and required insurances;

(e) Review and approve the proposals submitted by the contractors which include work program, method statements, material sources, manpower and equipment deployment. In light of Section 3.03 of Guidelines for the Employment of Consultants under Japanese ODA Loans (April 2012), the Consultant shall pay attention, in particular, to whether such proposals will meet the safety requirements set forth in the applicable laws and regulations, the specifications or other parts of the contract;

(f) Explain and/or adjust ambiguities and/or discrepancies in the Contract Documents and issue any necessary clarifications or instructions;

(g) Review, verify and further detail the design of the works, approve the Contractors' working drawings and, if necessary, issue further drawings and/or give instructions to the Contractor;

(h) Liaise with the appropriate authorities to ensure that all the affected utility services are promptly relocated.

(i) Carry out field inspections on the contractor's setting out to ensure that the works are carried out in accordance with drawings and other design details;

(j) Regularly monitor physical and financial progress against the milestones as per the contract so as to ensure completion of contract in time;

(k) Supervise the works so that all the contractual requirements will be met by the contractors, including those in relation to i) quality of the works, ii) safety and iii) protection of the environment. In light of Section 3.03 of Guidelines for the Employment of Consultants under Japanese ODA Loans (April 2012), the Consultant shall confirm that an accident prevention officer proposed by contractor is duly assigned at the project site and that construction works are carried out according to the requirements set forth in the applicable laws and regulations, the specifications or other parts of the contract;

(l) Supervise field tests, sampling and laboratory test to be carried out by the contractors;

(m) Inspect the construction method, equipment to be used, workmanship at the site, and attend shop inspection and manufacturing tests in accordance with the specifications;

(n) Survey and measure the work output performed by the contractors and issue payment certificates such as interim payment certificates and final payment certificate as specified in the contract;

(o) Coordinate the works among different contractors employed for the Access Road Project;

(p) Modify the designs, technical specifications and drawings, relevant calculations and cost estimates as may be necessary in accordance with the actual site conditions and issue variation orders (including necessary actions in relation to the works performed by other contractors working for other projects, if any);

(q) Carry out timely reporting to RHD for any inconsistency in executing the works and suggesting appropriate corrective measures to be applied;

(r) Inspect, verify and determine claims issued by the parties to the contract (i.e. RHD and contractors) in accordance with the civil works contract;
(s) Perform the inspection of the works and to issue certificates such as the Taking-Over Certificate, Performance Certificate as specified in the civil works contract;
(t) Provide inspection services during defects liability period and if any defects are noted, instruct the contractor to rectify;
(u) Check and certify as-built drawings for the parts of the works designed by the contractors, if any;

Facilitation of implementation of Environmental Management Plan (EMP), Environmental Monitoring Plan (EMoP) and Resettlement Action Plan (RAP)

The Consultant shall:

(a) Update EMP as appropriate, incorporate necessary technical specifications with design and contract documentation;
(b) During the preparation of bidding documents, clearly identify environmental responsibilities as explained in the EIA/IEE and EMP;
(c) Assist RHD to review the Construction Contractor’s Environmental Program to be prepared by the contractor in accordance with EMP, relevant plans and JICA Environmental Guidelines and to make recommendations to RHD regarding any necessary amendments for its approval;
(d) Assist RHD to implement the measures identified in the EMP;
(e) Monitor the effectiveness of EMP and negative impacts on environment caused by the construction works and provide technical advice, including a feasible solution, so that RHD can improve situation when necessary;
(f) Assist RHD in monitoring the compliance with conditions stated in the EPC and the requirements under EMP and JICA Environmental Guidelines;
(g) Assist RHD in preparation of the answer to the request from JICA’s advisory committee for environmental and social considerations, if necessary;
(h) Assist RHD in the capacity building of RHD staff on environmental management through on-the-job training on environmental assessment techniques, mitigation measure planning, supervision and monitoring and reporting;
(i) Update and/or prepare RAP as necessary based on detailed design in accordance with the agreed resettlement framework, including entitlement matrix and compensation plan; coordinate with various agencies in preparing the procedures for timely land acquisition and disbursement of compensation to project affected persons (PAPs);
(j) Assist RHD in identifying the eligible PAPs, and in preparation/updating of the list of

eligible PAPs and 'Payment Statement' for individual eligible PAPs. The places where each eligible PAPs will relocate to are necessary to be recorded so that RHD could implement monitoring on income and living conditions of resettled persons;

(k) Assist RHD in conducting social assessment during early stage of the detailed design stage and review the existing income restoration plan and special assistance plan for vulnerable PAPs and revise/update the contents of the plans, if necessary based on priorities identified with support of relevant government agencies and Non-Governmental Organizations (NGOs). The following contents should be included in the plans;

   i. Skills Training
   ii. Project related Job Opportunities
   iii. Provision of social welfare grant
   iv. Provision of Agricultural Extension Services
   v. Provision of the special allowance to vulnerable PAPs

(l) Assist RHD to implement the measures identified in the revised RAP;

(m) Monitor land acquisition and compensation activities being undertaken by RHD and/or competent authorities, and report the results in monthly progress reports;

(n) Assist in procurement of implementation NGO (INGO) and external monitoring agency (EMA). Sample ToR for INGO/EMA is attached as XX;

(o) Assist RHD in facilitating stakeholder's participation (including focus group discussions for vulnerable PAPs) and providing feedback their comments on RAP;

(p) Assist RHD in establishment of grievance redress mechanism including formation of Grievance Redress Committee;

(q) Assist RHD to ensure that the PAPs are fully aware of the grievance redress procedure and the process of bringing their complaints, investigate the veracity of the complaints, and recommends actions/measures to settle them amicably, fairly and transparently before they go to the redress committee or the courts of law; and

(r) Provide technical services with grievance redress committee for keeping and updating records when necessary.

2) Specific Terms of Reference

<u>Safety Control of the Project</u>

In an effort to assure the safety during the work of the Project, RHD shall take following actions and the Consultant shall obey the proposal related to the safety control from RHD;

(a) Bidding documents for procurement of works require that;

i) The safety requirements in accordance with the laws and regulations in Bangladesh and relevant international standards (including guidelines of international organization), if any, shall be clearly stipulated in the contract.

ii) Bidders shall furnish a safety plan to meet the safety requirements stipulated in the bidding documents.

iii) The personnel for key positions to be proposed by bidders shall include an accident prevention officer.

(b) The Consultant shall take following actions to secure the safety in the project;

i) When preparing or reviewing bidding documents for procurement of works, the Consultant shall make sure that the requirements stipulated in (a) above will fully be met.

ii) The Consultant shall review the safety plans submitted by the bidders.

iii) During the supervision of the construction work, the Consultant shall confirm that an accident prevention officer proposed by the contractor is duly assigned at the project site and that the construction work is carried out according to the safety requirements stipulated in the contract. If the Consultant recognize any questions regarding the safety measures including the ones mentioned above, the Consultant shall require the contractors to take appropriate remedies.

10.7.2 Reports and documents

Within the scope of consulting services, the Consultant shall prepare and submit reports and documents to RHD as shown in Table 10.7-1. The Consultant shall provide electronic copy of these reports.

Table 10.7-1 List of submission report

Category	Type of Report	Timing	No. of Copies
Consultancy Services	Inception Report	Within 1 month after commencement of the services	10
	Monthly Progress Report	Every month	10
	Project Completion Report (for submission to JICA)	At the end of Services	10
Detailed Design	Project Definition Report	Within 3 months after commencement of the services	20
	Draft Detailed Design Report	Within 11 months after commencement of the services	20
	Cost Estimate Report	Within 12 months after commencement of the services	20
	Final Detailed Design Report	Within 12 months after	20

Category	Type of Report	Timing	No. of Copies
		commencement of the services	
	Final Design Report	Within 12 months after commencement of the services	20
Tender Assistance	Pre-qualification Document Report	Within 12 months after commencement of the services	20
	Bidding Document Report	Within 12months after commencement of the services	20
	Pre-qualification Evaluation Report	Within 1 month after closing PQ	15
	Technical Evaluation Report	Within 1 month after closing Bidding	15
	Tender Evaluation Report	Within 1 month after closing Bidding	15
Construction Supervision	Quarterly Progress Report	Every quarter	10
	Quality Control Report	Every month	10
	Construction Completion Report (and As-built Drawings, if any)	At the end of the Project	20
	Performance report	At the end of the defect reliability period	20
Environment and Social Safeguard	Land Acquisition and Resettlement Monitoring Report	First stage of the Access Road Project	10
	Environmental and Social Plan Report	First stage of the Access Road Project	20
Other Report	Technical Report	As required or upon request	As required

10.7.3 Expertise requirements

The assumed engineering services for Access Road shall be provided by the foreign and local consultants in the following list, which shall include, but not be limited to the following.

Table 10.7-2 Qualification of key Team Members

Designation
International Consultants (Pro-A)
Team Leader/ Civil Engineer 1
Bridge Engineer 1
Local Consultants (Pro-B)
Civil Engineer 2
Bridge Engineer 2
Geotechnical Engineer
Environmental Engineer
Resettlement Specialist
Highway Engineer
Hydrologist
River Training Engineer
River Engineer
Pavement Engineer
Structural Engineer
Quantity Engineer
Quality Engineer
Material Engineer
Electrical Engineer
Cost Estimator
Surveyor
Document specialist

10.7.4 Requirement (criteria) for the Consultant

The requirements of the Consultant are as follows:

(1) Agree to employ a Consultant based on "Guidelines for the Employment of Consultants under Japanese ODA Loans".

(2) The consultancy firm shall have enough experience in study, detailed design, tender assistance and construction supervision in transportation (road and bridge) sector in its own country and overseas

(3) The consultancy firm is preferred to have experience in study, detailed design and construction supervision of hydraulic structures such as embankment in soft soil site condition

10.7.5 Organization for project implementation

(1) Structure of Consultant Team

Detailed Design

- Team Leader/Civil Engineer 1
  - Bridge Engineer 1
    - Bridge Engineer 2
    - Structual Engineer
  - Civil Engineer 2
    - Highway Engineer
    - Pavement Engineer
    - River Engineer
    - River Training Engineer
    - Hydrologist
    - Material Engineer
    - Electrical Engineer
    - Geotechnical Engineer
    - Environmental Engineer
    - Resettlement Specialist
    - Cost Estimater
    - Surveyer
    - Assistant Surveyer
    - Document Specialist
  - Administrator
  - CAD Operator
  - PC Operator
  - Driver
  - Secretary
  - Office Boy

Figure 10.7-1 Structure of Consultant Team in Detailed Design

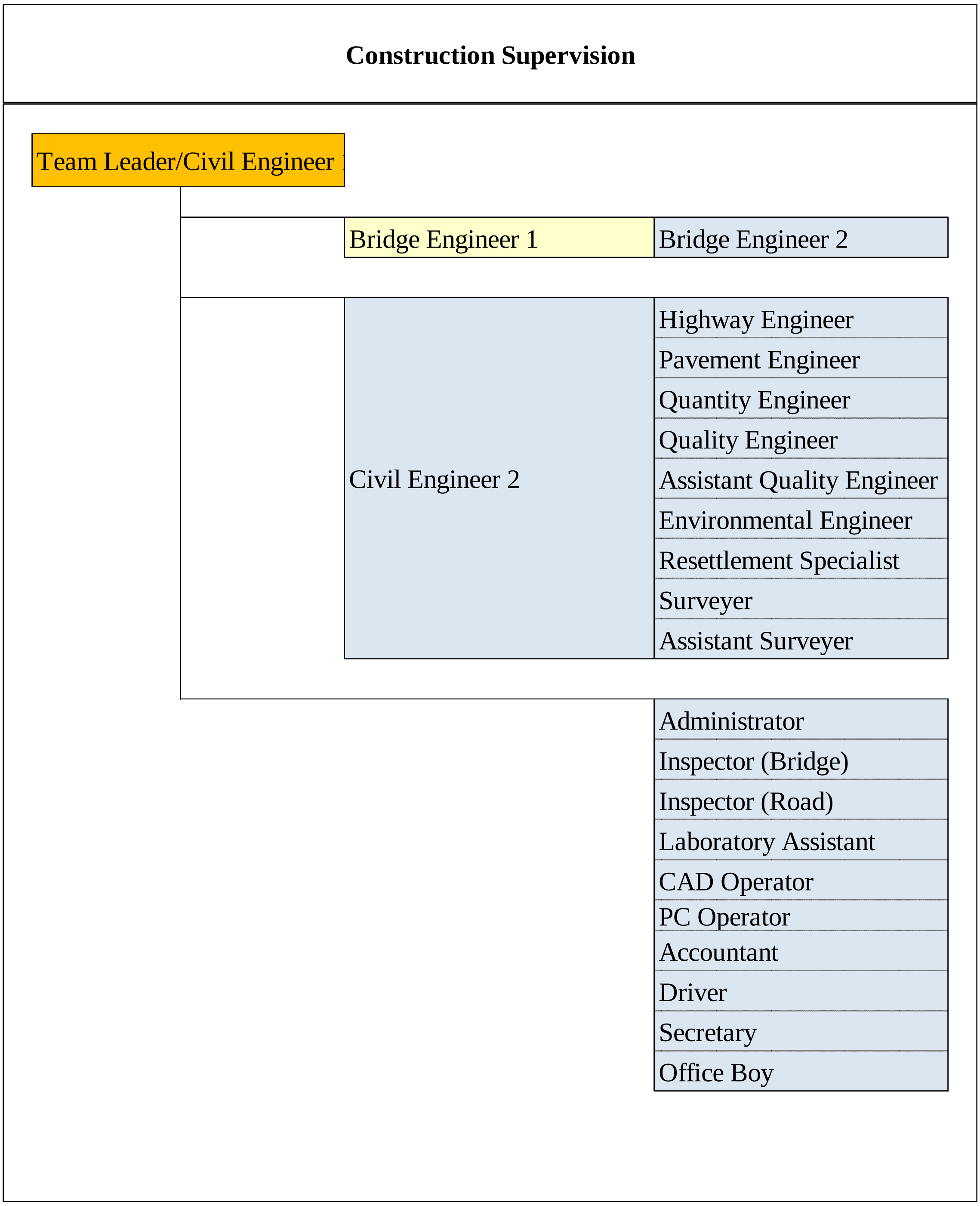


Figure 10.7-2 Structure of Consultant Team in Construction Supervision

Chapter 11

Project Implementation System

Chapter 11 Project Implementation System

11.1 Project Implementation System

11.1.1 Basic policy

Based on the "3-Year Road Map for Power Sector Reform (2008 -2010)" which was issued by GoB on May, 2008, The "Absence of clear organizational goals, adequate financial and commercial autonomy and lack of adequate incentives that resulted in utility management inefficiencies" has been indicated to be a problem. In order to solve this situation, the following roadmap is mentioned for the generation sector,

3-Year Road map for Power Sector Reform (2008 - 2010)

Existing Generation:

1.1 All the existing power plants in the public sector will be converted into profit centers for eventual conversion to a corporatized entity individually or on cluster basis which will be retained by BPDB holding company.

1.3 The business and financial plans will be developed.

1.5 All efforts will be undertaken by GOB so that the emerging entities can start functioning commercially.

1.6 Special plans will be developed to enhance technical and managerial efficiencies and establishing good governance.

1.7 Special attention will be given to Human Resources Development (HRD) program.

New Generation

For public sector new generation, special attention will be given to good governance, efficient O&M and establishing commercial environment.

In addition, as one of the measures to increase generation capability, "Policy guidelines for enhancement of private participation in the power sector, 2008" is formulated for the purpose of introducing competition and enhancing public-private partnership in the power sector.

For the study of implementation system of the project, these concepts should be given sufficient consideration.

11.1.2 Main operator of the project implementation

As mentioned in the “3-Year Road Map for Power Sector Reforms (2008 -2010)”, the power plants required efficient operations, and a visual indication of the situation is necessary. This is so every existing power plant, which belongs to BPDB, formulates a business plan and financial plan and discloses yearly actual unit generation costs in the annual reports. However, these are just the assumed values in BPDB, even though the profits are more than the initial target value as a result of efficient operations. It does not mean that profits can be used at the sole discretion of the plant manager.

On the other hand, for new power plants, the establishment of efficient O&M and a commercial environment is required. In BPDB, under the control and sanctuary of the government, an independent business climate is not sufficient, so it is difficult to achieve these requirements. It is necessary to create an environment where the profits realized as a result of efficient operations could be used only per board discretion, which could be a separate management entity from BPDB like APSCL, EGCB or NWPGCL.

CPGCBL is established mainly for the construction and operation of an imported coal fired power plant, it is most appropriate as the main operator. However, as of Feb. 2013, the official Managing Director has yet to be selected. Hence, the company’s foundation is still completely absent. EGCB and NWPGCL have already started and are making progress steadily as an independent company separate from BPDB, and there are no reasons to reject the project according to the articles of incorporation, so in case it takes a long time to establish the foundation as a company for CPGCBL, it could be an option to let EGCB or NWPGCL conduct the project as the main operator.

11.1.3 Project implementation system plan

The purpose of the project is to construct and operate an imported coal-fired power plant. In order to achieve the purpose, not only the coal-fired power plant (and coal storage facility) and the port facility for coal imports, but also a 400kV transmission line and access road should be constructed. Given that the supervising authorities of the government and required expertise are different, if only one main operator is active, there is a possibility that the management of the transmission line and access road is insufficient.

Considering that the amount of related facilities is big, the project should be conducted per the following formation: supervision by Power Division, CPGCBL operates the main facilities including the generation facilities, coal handling facilities and port facilities, PGCB operates the transmission line, and RHD is responsible for the access road.

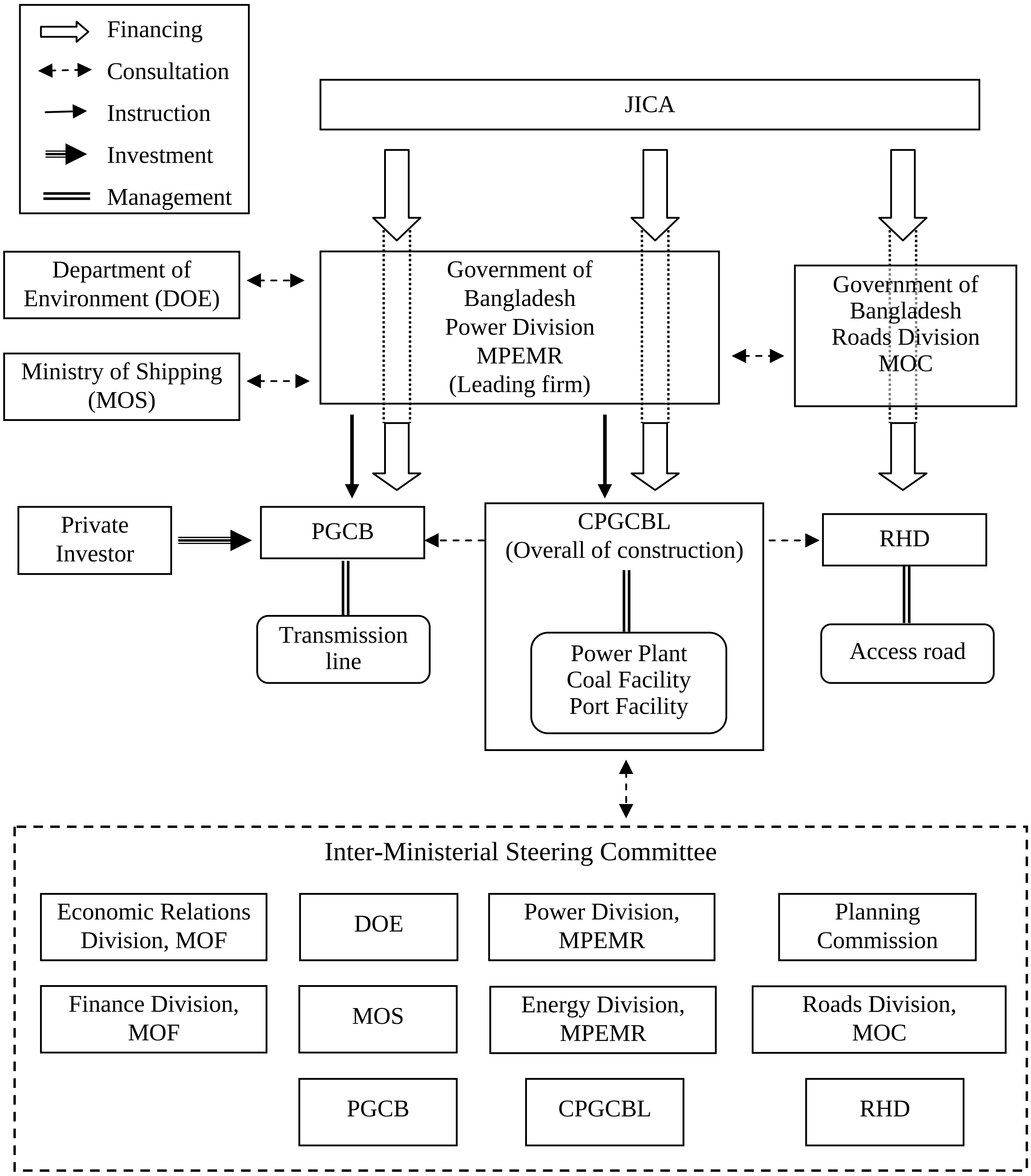


Figure 11.1-1 Implementation Plan during Construction

A lot of ministries relate to the implementation of this Project. In order to promote this Project adequately, it is important to solve the inter-ministerial issues by the related ministries with always cooperating mutually, verifying the progress and sharing the related information. Based on such respect, the Study Team proposes to set up Inter-Ministerial Steering Committee (IMSC) to aim at the mutual cooperation between ministries concerned and to promote this Project steadily. The outline of the IMSC is shown below.

(1) Roles and responsibilities

The IMSC for the Project will be responsible for verifying the progress of the Project and ensuring smooth inter-ministerial coordination of the Project. The IMSC will discuss the overall problems under the Project and play a role in coordination among the IMSC members to resolve them. The first IMSC meeting will be held within two months of loan effectiveness. After the first meeting, the IMSC will convene a regular meeting every six months.

In order to make sure necessary cooperation among the member organizations, IMSC members will sign Memorandums of Understanding (MOU) for cooperation based on mutual agreement before the second meeting. When cooperation issues arise during the Project implementation, Power Division of MPEMR may officially request technical support from any offices of member organizations. This will be implemented smoothly if the MOU has been already signed.

(2) Composition of members

The IMSC will be chaired by the Secretary of Power Division, MPEMR. Its members are shown below.

Table 11.1-1 Composition of Members of IMSC

	Organization	Status in organization	Title in IMSC
1	Power Division, MPEMR	Secretary	Chairperson
2	Power Division	Representative	Member
3	Energy Division, MPEMR	Representative	Member
4	Planning Commission	Representative	Member
5	Economic Relations Division, MOF	Representative	Member
6	Finance Division, MOF	Representative	Member
7	Ministry of Shipping	Representative	Member
8	Department of Environment	Representative	Member
9	Roads Division, MOC	Representative	Member
10	CPGCBL	Representative	Member
11	PGCB	Representative	Member
12	RHD	Representative	Member

During the construction stage, the transmission line and access road should be in service at the required moment by the power plant. For the steady implementation of quality and schedule management, it is important that the reporting line is consistent. So the preferable formation is that, PGCB and RHD is under CPGCBL and CPGCBL would manage all of the facilities including the transmission line and access roads. (In reality, the Power Division will coordinate between the relevant ministries, the consultant in charge of the

Engineering Stage of the power plants will implement overall schedule management by supporting CPGCBL. For the transmission line, PGCB will implement under the consultation with CPGCBL however, not under CPGCBL but as a separate main operator.)

Once commercial operations have started, because neither the transmission line nor access road is for exclusive use for the power plant, it is unfit and also a burden for CPGCBL to implement O&M. Therefore, PGCB and RHD should be responsible for O&M for the transmission line and access road respectively.

11.1.4 Project implementation system plan after commercial operation date (COD)

Operation of each equipment is executed by the following systems.

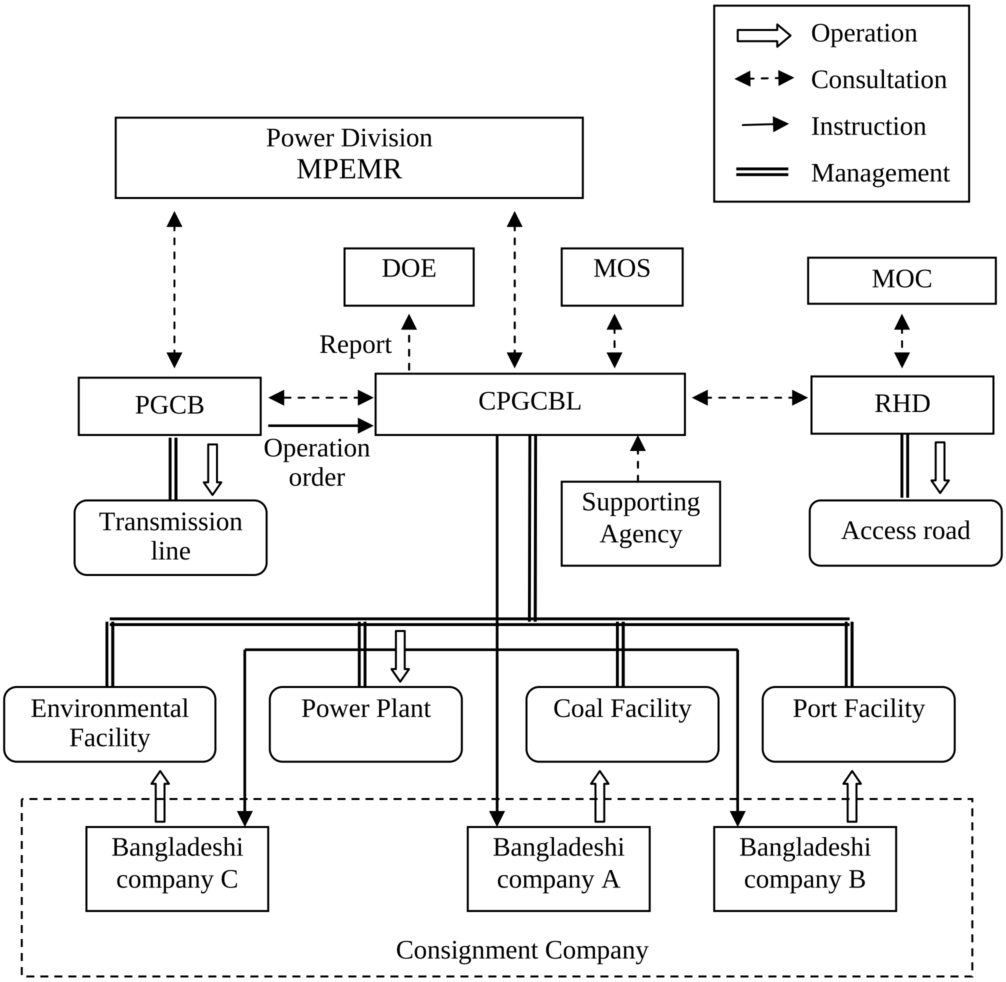


Figure 11.1-2 Implementation Plan after COD

CPGCBL manages power plant, port facility, coal facility, and environmental facility. However, CPGCBL consigns operation of port facility, coal facility, and environmental facility to the consignment company respectively.

11.1.5 Possibility of public-private partnership (PPP) application

According to “Policy guidelines for enhancement of private participation in the power sector, 2008”, GoB wishes to immediately improve power supply via the positive application of PPP to the power plant.. In consideration of this point, the possibility of PPP application for the project is being studied.

The following shows the pros and cons of PPP.

- Merits of PPP
  - Part of the investment is from the private sector, so it leads to a decrease in the total investment from the main operator (Government)
  - Quick construction is possible given the vitality of the private sector
  - Know-how of the private sector could be leveraged inexperienced areas
- Demerit of PPP
  - For the private area, the technical transfer to the main players are difficult
  - In case some part is PPP, given the inconsistent implementation, there is a possibility of a lack of control

The following table shows the options of PPP for the project.

Table 11.1-2 PPP Options for the Project

	Power Plant		Port		Coal (fuel) handling	
Facilities included	- Generation facilities - Environmental facilities - Water treatment facilities etc.		- Channel - Tag boat - Berth - Unloader - Belt conveyer (from unloader to coal yard) - Stacker		- Coal yard - Reclaimer - Belt conveyer (from coal yard to mill) - Oil storage tank	
	Own	O&M	Own	O&M	Own	O&M
Case 1 Only GOB	G	G	G	G	G	G
Case 2: PPP for Power plant	P	P	G	G	G	G
Case 3: PPP for Port	G	G	P	P	G	G
Case 4: PPP for Coal handling	G	G	G	G	P	P
Case 5: PPP for Port and Coal handling	G	G	P	P	P	P
Case 6: GOB only Port	P	P	G	G	P	P
Case 7: PPP for O&M	G	P	G	P	G	P
Case 8: All PPP	P	P	P	P	P	P

(G: Government, P: PPP)

(Source: JICA Study Team)

The characteristics of each option is as follows,

- Case 1: CPGCBL will conduct all of the parts, the amount of cost is the biggest. Measures to support inexperienced areas will be needed.
- Case 2: PPP for the power plant part. Positive participation from the private sector should be expected because of steady income. On the other hand, one Public sector demerit is that it is difficult to obtain technical know-how for future development.
- Case 3,4,5,6: PPP for the port and coal handling part. These parts represent inexperienced areas for Bangladesh, so there is large merit of PPP. For many points, overall management is preferable for these parts, so that Case 5 is most suitable from these options.
- Case 7: Positive participation from private sector should be expected for the O&M part. However, all of the construction costs should be prepared by the Government which is the same as Case 1.
- Case 8: Overall business per PPP. The government need not prepare construction costs. However Government is not able to obtain all of technical know-how.

The realistic option should be Case 1 in the case where there are no major financing problems, and Case 5 in the case where there may be some financing problems. If there are major financing problems, Case 8 could be another option.

As mentioned above, it would be possible for CPGCBL to implement the all components if financing for the construction is secured. CPGCBL intends to learn as much know-how on the handling of import coal as possible in its early stage so that it could develop further thermal power plants fueled by imported coal in future. Therefore, CPGCBL aims to implement all the components by itself.

CPBCBL, however, is not only a newly-established company without seasoned managerial know-how but also has little experience in procuring coal from abroad, which applies also to the country. As seen, there would be various challenges for CPGCBL to implement all the components. Based on the fact, it would be essential to study the application of public-private-partnership (PPP) scheme as an option to utilize private sector's financial resource and know-how and toward the components such as procurement of import coal and the development of deep-sea port, all of which are new to the country.

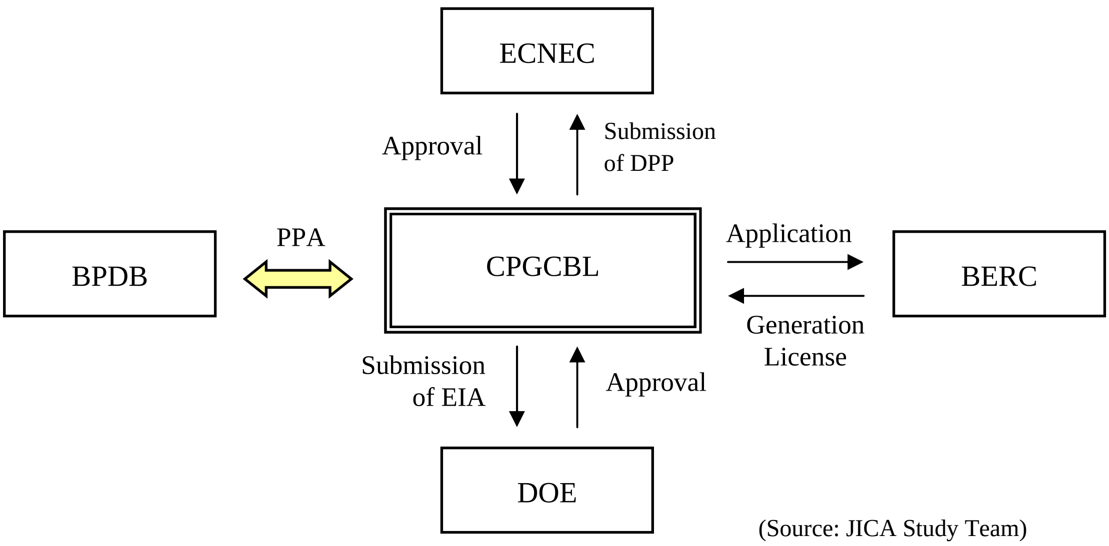
In order to promote PPP scheme and increase the inflow of private capital, it is important for the public sector to finalize the project as well as to show attractive proposal, which would mitigate risk, to private sector. CPGCBL, however, would not be able to learn such private sector's know-how unless the company fully depend on the private sector on the above components. Therefore the Study Team proposes to CPGCBL to adopt schemes like BOT scheme, which transfers the ownership of the asset to CPGCBL after a certain period of time. Once having decided to adopt PPP scheme, the Government of Bangladesh is expected to show terms and conditions as early as possible to public in order to float the tender.

For another option, listing the company to the stock market might be a good idea to raise the fund, though it would not raise enough fund because there would be few investors who would purchase stock of a company whose dividend would not be delivered for several years at least during construction period. The positive aspect in case of listing to the stock market is that the activity would encourage private investors to participate in the company's management, which would lead to efficient management of the company like the other IPPs. Therefore, the Study Team recommends CPGCBL to list the company to the stock market in its early stage after the commission of the power plant.

11.2 Function and Role of each Organization related to the Project

11.2.1 Project promotion

It is necessary to submit an Environment Impact Assessment (hereinafter referred to as "EIA") Report to the Department of Environment (hereinafter referred to as "DOE"), to submit the Development Project Proforma (hereinafter referred to as "DPP") to the Executive Committee of National Economic Council (hereinafter referred to as "ECNEC"), and to acquire the execution permission of the Project from both in the initial stage of Project promotion. Afterwards, the license of power-generation activities should be acquired from the Bangladesh Energy Regulatory Commission (hereinafter referred to as "BERC") and the Power Purchase Agreement (hereinafter referred to as "PPA") should be concluded between the Bangladesh Power Development Board (hereinafter referred to as "BPDB") and Coal Power Generation Company Bangladesh Limited (hereinafter referred to as "CPGCBL") before the test run.



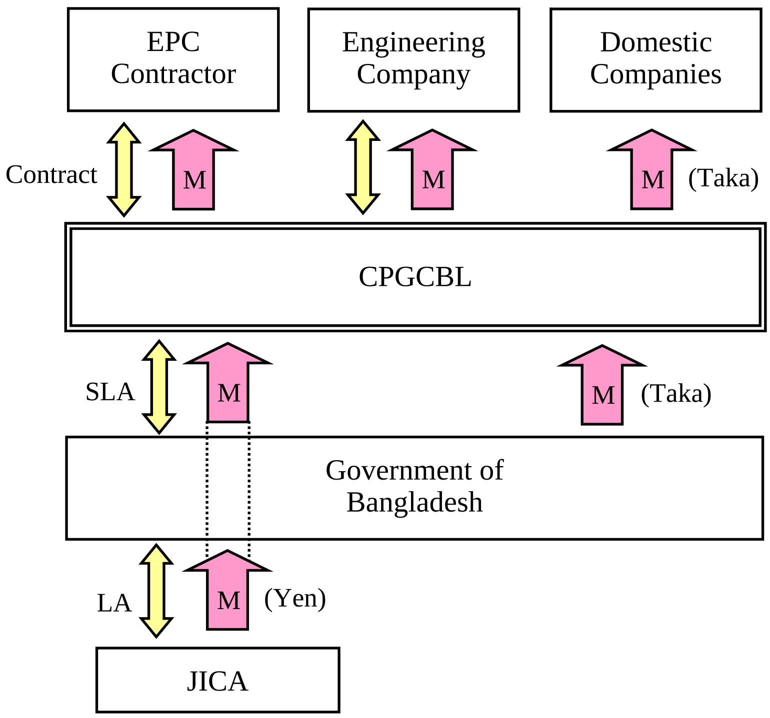
(Source: JICA Study Team)

Figure 11.2-1 Project Promotion

11.2.2 Financing

(1) Project implementation (Construction of the Power Plant)

The construction funds for the power plant are loaned to CPGCBL via a Subsidiary Loan Agreement (hereinafter referred to as “SLA”) between the Government of Bangladesh (hereinafter referred to as “GOB”) and CPGCBL through a GOB based on the Loan Agreement (hereinafter referred to as “LA”) between JICA and GOB. In addition to the yen loan, the GOB supplies domestic currency to CPGCBL via Equity and Loan.

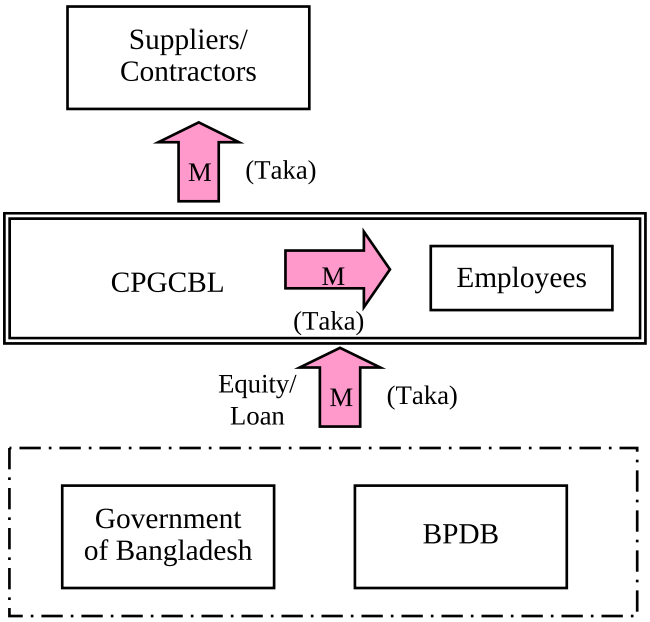


(Source: JICA Study Team)

Figure 11.2-2 Financing during Project Implementation

(2) Expenses prior to Commercial Operations

The CPGCBL is a company where there is no operating income prior to power plant operations. Even at this stage, it is necessary to prepare cash for payment such as a salary to the employees and the costs for various purchasing goods etc. Basically, the capital that Shareholders are offered is allocated. However, if CPGCBL experiences a shortage of funds, this is expected to be covered by BPDB via a loan extension (no interest).

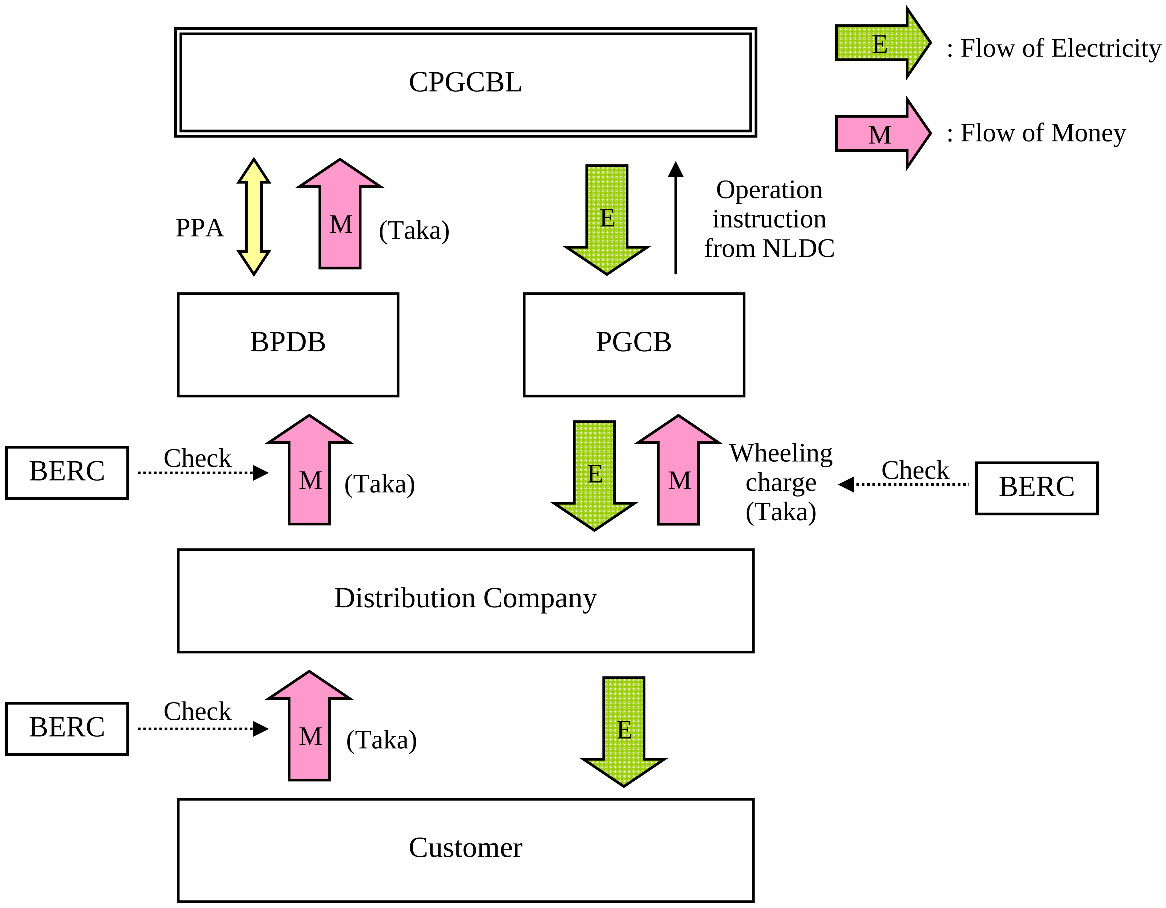


(Source: JICA Study Team)

Figure 11.2-3 Financing for Expenses prior to Commercial Operations

11.2.3 Power sales

The flow of electric power sales and money is shown below.



(Source: JICA Study Team)

Figure 11.2-4 Flow of Power Sales

BPDB purchases all electric power from CPGCBL based on PPA as a single buyer. The generating companies operate their generators based on instructions from the National Load Dispatch Center (hereinafter referred to as “NLDC”) of the Power Grid Company of Bangladesh (hereinafter referred to as “PGCB”), and supplies electric power to the substation of PGCB. PGCB supplies the electric power to each power distribution company, and each power distribution company supplies electric power to the customer.

BERC has the right to check the level of the Bulk tariff (sales unit price from BPDB to the Distribution Company), the Retail tariff (sales unit price to the customer from the Distribution Company) and the Wheeling charge (unit transportation price of the PGCB), and to decide the price level. However, the price at PPA is decided by only a mutual agreement between the generation company and BPDB, and BERC does not take part.

11.3 Comparative Analysis of Financial Conditions of the Public Sector Institutions

11.3.1 Profiles of power sector institutions

The power sector in Bangladesh is structured in three layers of operating entities; generation, transmission and distribution and is placed under the purview of the Ministry of Power, Energy and Mineral Resources through its Power Division. At the generation level, the operating entities are; the government owned ones, i.e. BPDB, Ashuganj Power Plant Company Ltd. (hereinafter referred to as “APSCL”), Electricity Generating Company of Bangladesh Ltd. (hereinafter referred to as “EGCB”), North West Power Generation Company Ltd. (hereinafter referred to as “NWPGCL”), while NWPGCL is yet to come for operation; the community owned ones, i.e. Rural Electricity Board (hereinafter referred to as “REB”) and Rural Power Company Ltd (hereinafter referred to as “RPCL”); the privately owned ones, i.e. independent power producers (hereinafter referred to as “IPPs”), small independent power producers (hereinafter referred to as “SIPPs”), rental power producers (hereinafter referred to as “RPPs”), quick rental power producers (hereinafter referred to as “QRPPs”). At the transmission level, the government-owned but partially publicly invested entity, PGCB, dominates the market with nationwide coverage. At the distribution level, there exist entities of; the government owned ones, i.e. BPDB, West Zone Power Distribution Company Ltd. (hereinafter referred to as “WZPDCL”), Dhaka Power Distribution Company Ltd. (hereinafter referred to as “DPDC”), Dhaka Electricity Supply Company Ltd. (hereinafter referred to as “DESCO”) whose shares are partially listed; and the community based entity of REB.

This sub-section reviews the financial state of conditions at the major public power sector entities for the purpose of examining the financial health of the sector as a whole and the comparative performance of the entities within the power sector. The entities reviewed are; BPDB for generation and distribution, APSCL and EGCB for generation, PGCB for transmission, and DPDC and DESCO for distribution. The table below provides the profiles of the power entities under review;

Table 11.3-1 Power Entities in Public Sector

	BPDB	APSCL	EGCB	NWPGCL	PGCB	DPDC	DESCO
Data as of	2011.6.30	2011.6.30	2012.6.30	2011.6.30	2011.6.30	2011.6.30	2011.6.30
Established	1972.5	2000.6 (*1)	1996.11 (*2)	2007.8	1996.11	2005.10	1996.11
Legal status	Presidential Order No.59 of 1972 for Bifurcation of BWPDA	PLC (*3) under Company Act 1994 (2003.3)	PLC under Company Act 1994 (2009)	PLC under Company Act 1994	PLC under Company Act 1994	PLC under Company Act 1994	PLC under Company Act 1994
Listing	-	-			Dhaka Stock Exchange (2000.5)	Filing done for listing at Dhaka Stock Exchange but no IPO made yet.	Dhaka Stock Exchange and Chittagong Stock Exchange
Main line of business	Generation and distribution in urban areas except Dhaka and West Zone.	Electricity generation	Electricity generation	Electricity generation	Transmission of electricity	Distribution in Dhaka, Narayanganj, Siddirganj, Fatullah, and Mukterpur	Distribution in Dhaka (Mirpur, Gulshan and Tongi Areas)
Installed capacity	Gen: 6,639 MW (*4) T/L: 230kv-2,647c-km 132kv-5,969c-km D/L: 33,364km	Gen: 731MW	Gen: 885MW		T/L: 230kv-2,467c-km 132kv-6,018c-km	T&D Line: 132kv-224 km 33kv- 284km LT- 3,546 km	T&D Line: 33kv-299km 11kv-1,406 km LT-1,717 km
Paid-up capital	118,131	1 (*5)	18 (*6)	0.01	4,190	5 (*7)	2,082
No. of employees	20,755	525		100	1,988	3,901	App. 1,300
No. of consumers (retail)	2,159,891	-	-		-	737,468	449,063
Electricity generated (net: GWh)	14,673 GWh	-	-		-	-	-
Electricity purchased (net: GWh)	16,682 GWh	-	-		-	5,945 GWh	3,123 GWh
Electricity sold (GWh)	Bulk level: 28,627 GWh (*8)	3,398 GWh	-		26,895 GWh (*9)	5,251 GWh	2,848 GWh
Electricity sold (Tk million)	Bulk & retail: 77,304	6,621	-		Revenue 7,242	22,669	12,291
Net profit after tax (Tk million)	▲46,206	616	-		925	2,098	1,478
Generation auxiliary consumption	5.49%		-		-	-	-
T & D system loss	13.06%	-	-		2.72%	132kv-11.68% 33kv-11.14%	8.79%
Remarks			(*10)			(*11)	(*12)

(note) *1: APSCL was incorporated in June 2000 as a private limited company and was converted in March 2003 to a public limited company.

*2: EGCB was incorporated as Meghnaghat Power Company (Pvt. Ltd.), and was renamed in Feb. 2004 as Electricity Generation Company of Bangladesh Ltd. as a private company and was later converted to a public limited company in Jan. 2009.

*3: PLC stands for public limited company

*4: includes IPP, SIPP, RPP and REB.

*5: APSCL has an equity contribution of Tk 11,441 million in addition to the paid-up capital.

*6: EGCB has equity contribution from government for Tk 1,889 million in addition to the paid-up capital.

*7: DPDC has Share Money Deposit (cash received in the form of equity, etc.) for Tk 13,157 million.

*8: Electricity sale at bulk level includes the energy which BPDB distributes through its own retail system.

*9: amount of power transmitted.

*10: EGCB has three plants under construction; Siddirganj 2 X 120 MW Peaking Power Plant completed and started commercial operation in Feb. 2012; Haripur 360MW Combined Cycle Power Plant expected to start operation in July 2013, Siddirganj 335MW Combined Cycle Power Plant scheduled to be completed by June 2015.

*11: DPDC took over DESA on 2008.7.1.

*12: DESCO started operation in Mirpur area in 1998, adding Gulshan area in 2003 and took over Tongi area in 2007 from DESA.

(source) Annual reports of each entity

The table presented above reveals the following features of each entity which is worth noting;

(1) Established year, legal status and listing

Immediately after the country achieved independence, the Presidential Order for the Bifurcation of the Bangladesh Water and Power Development Authority was issued for creation of the Bangladesh Power Development Board (BPDB) in 1972. The Dhaka Electricity Supply Authority (hereinafter referred to as “DESA”) was spun off from BPDB in 1991. Its performance has fallen considerably short of expectations as its governance and operating procedures were basically the same as BPDB. Accordingly, DESCO was created in 1996 to take over some of the service areas in Dhaka from DESA. The new company, wholly owned by DESA, started operations in 1998 after a transfer of the Mirpur service area followed by the transfer of Gulshan, Baridhara and Tongi areas. In the subsequent reform process, DESA was taken over by DPDC in 2005. In 1996, the transmission was separated from BPDB by establishing PGCB. The continued reform efforts materialized in the unbundling of the generation facilities of BPDB by creating EGCB in 1996, and APSCL in 2000. While BPDB maintains its original legal status under the special Order, the other entities are taking the form of public limited companies under Company Act 1994. Among the public limited companies, two, PGCB and DESCO, are listed and their shares are traded in the Dhaka Stock Exchange and Chittagong Stock Exchange.

(2) Primary line of businesses

BPDB is engaged in generation and distribution of electricity while PGCB is responsible for transmission. The distribution of electricity in the Dhaka area is rendered by distribution entities including DPDC, DESCO, and other entities. Besides, BPDB distributes electricity in urban areas other than Dhaka and West Zone. The issue concerning the transfer of the transmission system owned by BPDB to PGCB remains unsettled. The total length of the transmission lines owned by BPDB is almost identical to that of PGCB. The distribution facility of BPDB is far bigger than those of DPDC and DESCO. The retail customer base of BPDB counts over two million households whereas DPDC has 0.7 million and DESCO 0.4 million. BPDB appears to have retained the dominant position in the power sector.

(3) Generation

Electricity is generated by BPDB and other generating entities including the public sector companies, IPPs, SIPPs, RPPs and QRPPs. The electricity generated by the entities other than BPDB is sold to the single buyer, BPDB, under the PPAs. The above table indicates that for the fiscal year of FY 2010-11, the electricity generated by the entities other than BPDB exceeded that of BPDB. The fact implies two major issues of concern; (i) the electricity generated by RPPs and QRPPs included among the purchased electricity is extremely high priced in exceeding by far the average wholesale price of BPDB, (2) the operating rates of IPPs, RPPs and QRPPs are contracted to be maintained at high levels and such facts increase the total cost of electricity in the country as a whole. BPDB plays the role of the single buyer of generated power in addition to the role of generating activity at its own plants and is wholesaling the electricity to distribution companies.

(4) Destiny of a single buyer

The table above reveals the appalling fact that BPDB had to undergo an outrageous amount of deficit of Tk 46,206 million against the total sales of Tk 77,304 million in its income statement for FY 2011 primarily due to its status being a single buyer. The primary cause of the deficit is the purchase price of electricity from those outside entities, in particular, the RPPs and QRPPs that far exceed the bulk tariff as well as the retail tariff. BPDB has been receiving funding support from the government for the deficit created during the past three years starting from FY 2009-10. The amount of the deficit keeps expanding as more of the recently established RPPs and QRPPs are going into commercial operation. To make the situation more serious, the funding support by the government is taking the form of interest bearing loans. Logically, BPDB has no source of funds for repaying such loans borrowed from the government. As an immediate relief action, the government needs to reconsider the form of financial support and change it into grant subsidies to tide over the imminent and seemingly insurmountable financial constraints.

(5) Generation and T&D system losses

The auxiliary consumption at BPDB's generation system including the subsidiaries is recorded at 5.5% which is understood to be leaving some room for improvement. The transmission and distribution losses are recorded by BPDB at 13.1%, DPDC at 11.7% (132kV) and DESCO at 8.8%. DESCO outperforms other entities. BPDB and DPDC needs to exert serious and continuous efforts to reduce the losses. PGCB recorded the transmission loss at 2.7% in FY 2011. The figure is understood to be close to or within a tolerable range.

(6) Lessons learnt

The establishment of CPGCBL is documented by the Articles of Incorporation dated September 5, 2011[1]. Some of the phenomenal points to be noted are;

(i) The document itself appears to be somewhat shorter and the objectives of the incorporation is less in the item numbers than those adopted by sister companies such as NWPGCL;
(ii) The document specifies that the company may take over the existing coal based power plants of BPDB;
(iii) The document fails to specify whether the company will be engaged in the activities for purchasing and importing fuel; and
(iv) The document is not clear whether the company will be engaged in constructing and operating port facilities for fuel imports.

The Articles of Incorporation needs to be examined and an appropriate adjustment should be made to make it operative as the governing rule of the enterprise. The issue has been raised and discussed between the top management of CPGCBL and the Study Team in the occasions of the Field Survey. CPGCBL has cited that it will take note of the issue and necessary steps for adjustment.

In addition, there are some important lessons learned from the sister companies, in particular as to the manner in which the company acquired the existing power plant from

[1] CPGCBL, "Article of Incorporation" September 5, 2011

BPDB. The sister companies had to undergo the transfer of existing power plants while accepting the debt service liability (hereinafter referred to as “DSL”) booked for the specific plants for transfer. The DSL is the overdue liability created by BPDB while operating the plant which should have been repaid by the due dates in appropriation of the accumulated depreciation of the plant. The DSL is understood to be the negative legacy from the past and should not be transmitted to newly born entities but should be settled at BPDB within the reform process. The Study Team is of the opinion that for the newly established company, the start-up with the clear balance sheet is a very important condition and therefore the transfer should be made based on the fair value of the plant without accompanying the DSL with the transfer. In addition, the sister companies used to report their experiences of the actual instances of delays in concluding the transfer documents including the Vendor’s Agreement and PPA and of conducting initial dependable capacity testing of the plant indispensable for starting commercial operations. Besides, the testing and examination ruling on the interpretation of the contracts signed were often times controlled unilaterally by BPDB failed to generate a fair outcome for both parties. The subsidiaries, in those instances, are not necessarily treated as equal partners. A mechanism should be established whereby due consideration is given to the subsidiaries for fair treatment.

11.3.2 Financial performance viewed on management efficiency

The analysis now moves to the financial performances of the power entities. For the same power entities reviewed above, the financial performances are focused including; sales of power, profits, components of the balance sheet, etc. and the various ratios derived from the balance sheet and the income statement figures. The table below provides the summaries of the financial performances at the power entities under review;

Table 11.3-2 Financial Performance of Public Power Entities

	BPDB	APSCL	EGCB	NWPGCL	PGCB	DPDC	DESCO
Data as of	2011.6.30	2011.6.30	2011.6.30	2011.6.30	2011.6.30	2011.6.30	2011.6.30
FINANCIAL RECORDs							
Electricity sold (GWh)	Bulk level: 28,627 GWh (*1)	3,398 GWh	-		Volume transmitted: 26,895 GWh	5,251 GWh	2,848 GWh
Electricity sold (Tk million)	Bulk & retail: 77,304	6,621	-		7,242	22,669	12,291
Net profit after tax (Tk million)	▲46,206	616	-		925	2,098	1,478
Total equity (Tk	86,259	12,601	1,907	352	19,781	▲1,668	9,919

	BPDB	APSCL	EGCB	NWPGCL	PGCB	DPDC	DESCO
million)						(*2)	
Total assets (Tk million)	355,169	32,399	14,159	3,068	74,504	52,071	29,309
Total fixed assets (net: Tk million)	219,558	26,263	13,869	3,034	59,227	31,597	9,665
Total current assets (Tk million)	109,059	6,136	289	35	15,277	20,474	19,643
Total current liabilities (Tk million)	120,400	3,390 (*3)	114	70	7,302	43,519 (*2)	5,627
RATIOs							
Return on equity	▲53.5%	4.9%	-		4.7%	-	14.9%
Return on assets	▲13.0%	1.9%	-		1.2%	4.0%	5.0%
Equity/(Equity+ Liabilities)	24.3%	38.9%	13.5%	11.5%	26.6%	▲2.9%	41.9%
Debt service coverage ratio		3.54 times	-		1.48 times		
A/C receivable days	241 days	124 days	-		61 days	112 days	80 days
A/C payable (trade) to purchase (trade)	60 days	n.a.	-		n.a.	616 days	87 days
Current ratio	92%	181% (*3)	254%	49%	209%	47%	349%
Quick ratio	84%	165% (*3)	254%	49%	191%	41%	278%
PRICEs							
Average sales price (Tk/kWh)	Bulk & Retail: 2.70	1.95	-		Wheeling charge: 0.233	Retail sales: 4.32	Retail sales: 4.32
Ave. generation cost (Tk/kWh)	Gen. cost: 3.95		-			Purchase Cost: 2.79 (*4)	Purchase Cost: 2.82 (*4)
Remarks			(*5)			(*6)	

(note) *1: Electricity sale at bulk level includes the energy which BPDB distributes through its own retail system.
*2: DPDC inherited the legacy of DESA and carries a huge negative surplus for Tk 21,761 million and the liability classified under the current liability which is recorded to be Tk 43,519 million.
*3: Current liability jumps from Tk 290 million in FY 2010 to Tk 3,390 million in FY 2011 due to import L/C. The average current and quick ratios are calculated as 283% for current ratio and 98% for quick ratio.
*4: Purchase cost includes the wheeling charge.
*5: EGCB started commercial operations in February 2012.
has declined from the previous year.
(source) Annual reports of each entity

The table presented above reveals the following features of each entity which is worth noting;

(1) Electricity sales (GWh)

The total bulk sales of electricity by BPDB have been increasing steadily in reflection of the increase in the total demand for electricity in the country as is presented in the following table;

Table 11.3-3 Bulk Sales of Electricity at BPDB

	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Bulk Sales (GWh)	20,398	21,961	22,060	23,433	24,756	26,626	28,627
Increase	-	7.7%	0.5%	6.2%	5.6%	7.6%	7.5%

(source) BPDB, "Annual Report FY 2010-11"

As of late, the total generation and purchase costs of electricity at BPDB are recorded as follows;

Table 11.3-4 Total Electricity Cost at BPDB

	FY 2010-11	FY 2009-10	Increase
BPDB's own generation cost	Tk 3.19/kWh	Tk 2.50/kWh	27.6%
Purchase cost from IPPs	Tk 3.42/kWh	Tk 2.78/kWh	23.0%
Purchase cost from Rental Powers	Tk 8.05/kWh	Tk 4.26/kWh	89.0%
Purchase cost from Public Sector plants	Tk 1.80/kWh	Tk 1.88/kWh	▲4.3%
Total Electricity Cost at BPDB	Tk 3.95/kWh	Tk 2.65/kWh	49.1%

(source) BPDB, "Annual Report FY 2010-11"

For FY 2010-11, the generation cost at the rental power plants, RPPs and QRPPs, jumped from Tk 4.26/kWh in FY 2010 to Tk 8.05/kWh in FY 2011 by as much as 89% and this is the major factor that caused the total electricity costs at BPDB to jump by 49% from Tk 2.65/kWh in FY 2009-10 to Tk 3.95/kWh in FY 2010-11. Against the total costs, including their own generation and purchased electricity, of Tk 3.95/kWh at BPDB, BPDB calculates the average bulk supply cost of electricity as Tk 4.20/kWh by adding the transmission loss. Against these costs, the average price of electricity sold is recorded as Tk 2.70/kWh in FY 2010-11. It is to be noted that BPDB is losing Tk 1.50/kWh for every single unit of electricity it handles.

(2) Net profit after tax

The above table describes the generation companies (herein represented by APSCL), the transmission company (PGCB) and the distribution companies (herein represented by DPDC and DESCO) as making reasonable profits after tax. The profits are ensured by the PPAs signed, the bulk, the wheeling charge and the retail tariff of electricity approved by BERC. BPDB carries enormous deficits in the profit after tax. Such deficit stems from the role and function of the single buyer it plays in the structural set-up of the power sector. BPDB buys the electricity generated by IPPs, SIPPs, RPPs and QRPPs at the prices which far exceed the bulk sales tariff. The government has been extending financial assistance to BPDB to mitigate the impact of the negative margin for a single buyer operation. It only provides BPDB with the interest bearing loans for the gap for which BPDB finds no source of funds for repayment. During the latest fiscal year of 2011-12 alone, BPDB recorded the amount of financial assistance received from the government for the total amount of Tk 63,567 million[2]. The deficits keep snowballing at BPDB and its financial position is worsening without any remedy as time goes on. Meanwhile, at the other power entities, the PPAs, tariffs are structured to assure a reasonable rate of margins on the basis of the return on equity and are approved by BERC for implementation. The entities should be able to increase their profits by reducing the cost and expenses incurred for operation of the plants and the rendering of the services.

(3) Equity and retained earnings

The power sector has been undergoing a long lasting reform process under which a large number of new entities have been created through unbundling and new incorporation. First, BPDB has been created in refurbishment of the Water and Power Development Authority who became the sole power sector player under the new independent government of Bangladesh in the 1970s. Entities other than BPDB were established via the capital injection of a small amount 100% injected by BPDB and built up through the government granting equity funds for new capital projects and the entities' own operating profits during the period of operation. BPDB's paid-up capital has been achieved from the capital injection by the government and from time to time revaluation surpluses made on their plants and assets but have been eroded by the accruing deficits during recent years.

(4) Current assets and current liabilities

The power sector is characteristic of heavy investment in fixed assets. To achieve the efficient management of the entity, the current assets and current liabilities which, in and of themselves, do not generate profit should be contained at a reasonably low level. The levels of current assets and liabilities among those entities are acknowledged to be substantially high and higher than those in advanced countries such as Japan where the power sector's nation-wide average ratio of current assets among total assets and the current ratio stand at 11.2 % and 71.4% respectively in FY 2011[3]. The government is pushing the power entities to enhance efficiency by entering into contracts with power entities for the achievement of the Key Performance Indicators (hereinafter referred to

[2] Interview at BPDB Finance and Accounts Dept. on August 8, 2012
[3] Fiscal Year in Japan runs from April through March next year. FY 2011 stands for the period between April 2011 through March 2012.

as “KPI”) which include, among others, the ratios of power loss, account receivables against annual sales, current ratio, quick ratio and debt service coverage ratio, etc. Management of the entities is acutely conscious of the importance of effective management of the current assets and liabilities. The current assets remain relatively high at BPDB, DPDC and DESCO whereas the current liabilities stand high at BPDB and DPDC. The primary cause of the high level of current assets lies in long standing arrears of account receivables in the distribution business. Large users as well as government entities are reported to be the frequent delayers of electricity bills. Such is acknowledged to be the cause of the high level of current liabilities at BPDB and DPDC.

At BPDB, payment is delayed in the debt servicing of loans taken for the development of various plants due to insufficiency of funds. The government and foreign loans taken are booked as the government loans and foreign loans received at the time of their disbursement. When the due dates come while debt servicing is delayed, the balance of the arrear is transferred to the debt service liabilities accounts (principal and interest). The current liabilities of DPDC are of a complicated nature. When established, DESCO used to acquire the assets and liabilities of the defunct DESA who used to have a large amount of unpaid bills for electricity purchased from BPDB and the debt service liability to BPDB. DPDC has been booking the arrear transferred from DESA under the current liabilities though there exists no definitive agreement on the repayment method thereof. DPDC further records under its current liabilities the balance of debt service liabilities inherited from DESA who received the payable balance from BPDB accompanying the transfer of fixed assets in the past. It appears that the liabilities created behind such a background should rather be booked as the non-current ones and amortized over a reasonable time period. DPDC intends reportedly to reclassify the account payable from such legacy into non-current liabilities from FY 2013.

(5) Current and quick ratios

The ratios are the indicators of the sufficiency of liquidity to imply if the company’s current liabilities, i.e. cash requirement, can be discharged in an orderly manner by appropriation of cash and cash equivalent including account receivables (quick ratio)[4] and through the disposition of the current assets (current ratio). The current ratio can be obtained by dividing the current assets by the current liabilities. Similarly, the quick ratio can be obtained by dividing the cash and cash equivalent by the current liabilities.

[4] Inclusion of the account receivable to the numerator needs a rebuttal as such account contains a significant amount of unpaid or arrear balance. A discounting has to be made for its portion of unpaid and arrear balance to the account receivable before being included into the numerator.

What is generally understood as the minimum rate required that assures the sufficiency of the liquidity are; 150-200% for the current ratio and 100-120% for the quick ratio. For the current ratio, BPDB stands at 92% and DPDC stands at 47% underperforming the commonly understood benchmark for sufficient liquidity. For the quick ratio, similarly, BPDB stands at 84% and DPDC at 41%. At BPDB, the current liabilities are outrageously expanded by the debt service liabilities in its principal and interest, comprising 81% of the total current liabilities and such expansion in the total current liabilities is deteriorating the current ratio. The situation is similar at DPDC whose current liabilities stand at a high level stemming from the legacy liabilities inherited from DESA.

(6) Return on equity and assets (hereinafter referred to as "ROE" and "ROA")

The return on total assets gives a measure of operating efficiency of the total assets whereas the return on equity assesses the return made to the equity holder. The return on assets and the return on equity are found negative at BPDB. The deficit stemming from the single-buyer function mentioned above caused the ratios to appear in the negative. At the companies other than BPDB, reasonable margins are assured enabling the utility entities to make positive profits under PPA and the tariffs concerned (bulk, retail and wheeling charge). For instance, APSCL has been given the assurance of ROE at five percent under its PPA contract signed with BPDB in 2007[5]. APSCL and PGCB are recording reasonable levels of ROA and ROE. DPDC shows a strong ROA but is unable to calculate ROE as the company's net equity remains negative. DESCO enjoys high levels of ROE and ROA which is a surefire sign that the company is operating at a higher efficiency. Under the current tariff regulation system, the companies can expand their profits by improving operational efficiency through cost reduction. The high percentage of ROE recorded at DESCO is the output of such efforts since the inauguration of the enterprise.

(7) Equity ratio (debt: equity ratio)

The equity ratio (debt to equity ratio) is to measure the mix of funds in the balance sheet and to make a comparison between those funds that have been supplied by the owners and those that have been borrowed. The ratio has many ways of calculation but the Study Team employs the calculation of dividing the equity by the sum of equity and liabilities. The higher the ratio, the company is understood to be financially stable and resilient against a turbulent financial environment. The commonly accepted standard

[5] BPDB, "Power Purchase Agreement between BPDB and APSCL (draft)", 2007

requires the ratio to be no less than 25-30%. Among the power entities being studied, EGCB and DPDC stand low recording 13.5% and -2.9% respectively. APSCL and DESCO are revealing their healthy conditions by recording 38.9% and 41.9% respectively. BPDB stands at 24.3% but its ratio is found to be on a declining trend due to the sharp encroachment of the equity via the accumulation of annual deficits.

(8) Debt service coverage

The debt service coverage ratio (hereinafter referred to as “DSCR”) is to measure the company’s ability to produce enough revenue to cover servicing of its financial obligation. The ratio can be calculated by dividing the net revenue (net operating income + depreciation – tax – dividend) by the sum of the principal and interest payments under the financial obligations. The higher the ratio, the financial obligations are assured of the availability of the funds for debt servicing with less apprehension for non-performance. A commonly understood threshold is 1.30 – 1.50 times. JICA maintains no specific level to be achieved in a project’s debt service coverage. In Bangladesh, the actual records of the DSCR are given by APSCL as 3.54 times and 1.48 by PGCB. Other power entities fail to disclose the ratio.

(9) Account receivables to sales

The ratio is to measure the average number of days it takes for the company to collect cash proceeds from the sales of electricity through the account receivables. The less the number, the faster the company receives cash for the sale of electricity. The ratio stands at 241 days at BPDB, 124 days at APSCL, 61 days at PGCB, 112 days at DPDC and 80 days at DESCO. The number of days obtained for the power entities appears larger than the standard settlement period under their billing terms. Take the example of BPDB who sells electricity to distribution companies with the conditions that the invoices are payable within 30 days after the invoiced date. The actual collection is taking an average of 241 days. The figure does not mean that BPDB is slow to collect all of the bills for the calculated number of days but is due to the fact that some of the large consumers are late in making payment or leaving a substantial amount of bills unpaid. APSCL records 124 days for the collection of sales proceeds from its sole buyer, BPDB. Though the terms of payment prescribed under the PPA is 45 days after invoicing, actual payment is taking up to an average of 124 days. PGCB is collecting the wheeling charge in an average of 61 days. DPDC counts an average of 112 days and DESCO in 80 days whereas their standard period payment term under the invoices is within 15 - 30 days after the invoiced dates. The delays are reportedly arising at some of their large consumer accounts including the government sector and this causes the average collection period to be longer than the prescribed ones in the contracts.

(10) Account payable (trade) days in energy purchase

In a similar method, the account payable days in the energy purchase is calculated to measure how long the company is taking in making payment of its obligation of settling the purchase of electricity from generation companies. For BPDB, the account payable is booked for its purchase of electricity from other generation entities of; public sector generation companies, IPPs, SIPPs, RPPs and QRPPs. The PPAs signed with those generation companies provide the payment terms of 45 days for public generation entities and by and large 30-45 days for IPPs and Rental Producers. The actual record of 60 days is insignificantly deviated from the standard conditions and is generally understood to be a punctual payment. DPDC and DESCO are buying electricity from BPDB. Their account payable days are recorded as 616 days at DPDC and 87 days at DESCO. The extraordinary figure at DPDC is due to the inclusion of the unpaid account payable it has inherited from DESA. DESCO is taking the stance that it pays the purchase invoice upon collection of sales proceeds from consumers.

(11) Average energy cost and sales price

The sustainable business activity depends upon the reasonable margin assured between the energy generation or purchase cost and sales price. Under the PPA and tariffs regulated by BERC, power companies other than BPDB are assured of a reasonable margin. On the other hand, the assurance of a reasonable margin is not given to BPDB for its part of the single-buyer function. It is regulated to sell the powers at the bulk tariff for wholesaling and at the retail tariff for retailing, whereas it is bound to purchase the powers generated by IPPs, SIPPs, RPPs and QRPPs whose generation costs far exceed those of the bulk tariff at the price prescribed in the PPAs.

To aggravate the situation, for RPPs and QRPPs based on the furnace or diesel oil, the government commits to providing the petroleum fuels through Bangladesh Petroleum Corporation (hereinafter referred to as “BPC”) and BPDB. The price of petroleum fuel for RPPs and QRPPs are regulated by the government to be far below the market price. BPC is sustaining a huge negative margin between its import price and selling price, in a similar pattern to that of BPDB. The deficits are causing mounting pressure on the national economy by aggravating the fiscal deficit, imbalance of international payment and resultant inflation in the country. The deficit ridden situation at BPDB and BPC cannot be sustained for a long time. Measures are needed to address the issue and correct imbalances and mitigate their impact. In order to sustain the sector, there is an immediate need for making modifications in the structure of the single-buyer function. Should the level of annual deficit recorded in FY 2011 remain lasting, BPDB might see the situation in which its equity is totally eroded and turns negative within less than two years.

(12) Electricity tariff

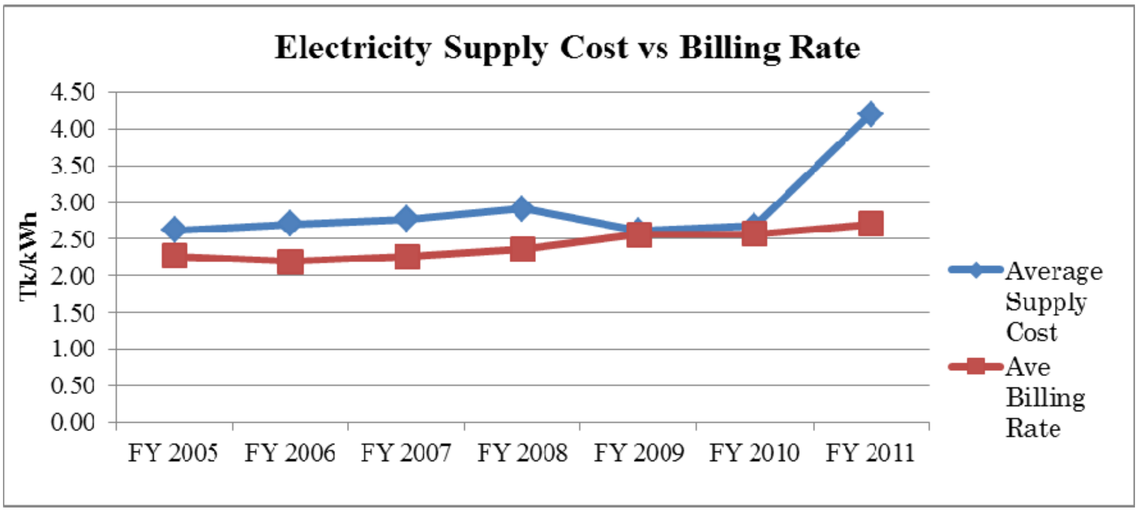
The electricity tariff is regulated by BERC through the approval system of the application to be submitted by the power sector entities based on the actual cost of the supply inclusive of the reasonable margin for the equity employed. BERC has been pursuing the realization of the tariff that assures a full cost recovery for the power entities and the rational rate base attracting new investment into the sector while assuring the consumers a stable supply of electricity at reasonable prices. The efforts of BERC have not yet attained what has been targeted in such policy, though it is providing the transmission company and distribution companies with the relatively stable basis for rational operation with reasonable margins. The single-buyer function of BPDB has been burdened with the constrained setting of the bulk tariff and placed in a chronically deficient position with negative margins between the supply cost and bulk sales tariff.

Table 11.3-5 Average Supply Cost, Sales Price and Bulk Tariff

	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Average Supply Cost (Tk/kWh)	2.70	2.77	2.91	2.61	2.68	4.20
Average Sales Price (Tk/kWh)	2.19	2.26	2.36	2.56	2.57	2.70
Ave Bulk Tariff at the Fiscal Year End (Tk/kWh)		2.04	2.04	2.37	2.37	2.63

(source) BPDB, “Annual Reports” and BERC

The table reveals that the average sales prices at BPDB have been above the bulk tariff rates outstanding at the end of each fiscal year and that the average supply cost which includes the cost of the own generation at BPDB, the purchase cost of electricity, transmission expense and other expenses exceed by far the average sales price. The bulk sales tariff has been placed artificially below the economically justifiable level by BERC distorting the financial position of BPDB for its single buyer function as is presented in the following figure;



(source) BPDB

Figure 11.3-1 Electricity Supply Cost vs Billing Rate

Starting in early 2010, the government has embarked on an ambitious plan to more than double the electricity generation by 2016, relying heavily on private sector participation. BPDB has entered into agreements with plant operators, RPPs and QRPPs, to purchase power at prices profitable to the latters. These arrangements are putting pressure on the adverse margin of electricity pricing at BPDB, and the fuel subsidy costs at BPC, as power generating capacity and related oil imports rise. The average supply cost of BPDB is seen as a sharp increase due to the expansion of power purchases from the high cost rental power plants. The following table shows typical tariff cases contracted with the Quick Rental Power Producers.

Table 11.3-6 Tariffs of QRPPs

Fuel	Name	Location	Capacity (MW)	Current Tariff (Tk/kWh)
<HSD>				
HSD	Aggreko	Ghorasal	100 MW	19.45 *1
HSD	Aggreko	Ghorasal	45 MW	19.45 *1
HSD	Aggreko	Khulna	55 MW	19.45 *1
HSD	DPA	Pagla	50 MW	18,75 *1
HSD	Desh Energy	Shiddirganj	100 MW	17.94 *1
Sub-total			350 MW	18.92
<HFO>				
HFO	Summit	Madanganj	102 MW	15.56 *2

Fuel	Name	Location	Capacity (MW)	Current Tariff (Tk/kWh)
HFO	KPCL II	Khulna	115 MW	15.50 *2
HFO	IEL	Meghnagat	100 MW	15.64 *2
HFO	Dutch Bangla	Shiddirganj	100 MW	15.64 *2
HFO	Khanjahan Ali	Noapara	40 MW	15.65 *2
HFO	Acorn	Julda	100 MW	15.62 *2
HFO	Shina Power	Amnura	50 MW	15.55 *2
HFO	Northern Power	Katakhali	50 MW	15.64 *2
HFO	Powerpac Mutiara	Keranigonj	100 MW	15.69 *2
HFO	Hyperion	Meghnaghat	100 MW	15.60 *2
Sub-total			857	15.61
<Gas>				
Gas	Max Power	Ghorasal	78.5 MW	5.530 *3
Gas	Aggreko	Ashuganj	80 MW	5.533 *3
Gas	United	Ashuganj	53 MW	5.118 *3
Gas	Aggreko	B. Baria	70 MW	5.312 *3
Gas	Aggreko	Ghorasal	100 + 45 MW	5.534 *3
Sub-total			426.5	5.44
Total			1,633.5	13.66

(note) *1: Calculated on the prevailing HSD Tariff at Tk 61/liter and exchange rate of US$ 1=Tk 82
*2: Calculated on the prevailing HFO Tariff at Tk 60/liter and exchange rate of US$ 1=Tk 82
*3: Calculated on the prevailing Gas Tariff and exchange rate of US$ 1=Tk 82
(source) BPDB IPP Cell interview on Aug. 7, 2012

The government became conscious about the seriousness of the issue and now turned the policy direction into the containment of the subsidy growth through the automatic adjustment mechanism for fuel and the frequent increase in electricity tariffs. The government is reported to have committed to adjust the power tariff semi-annually over the next three years[6]. During the calendar year of 2011, the bulk tariff has been revised three times starting in February, followed by the second in August and by the third in December. The action continued into 2012 in which the first of the year's revision was made in February, the second in March and the third in September. The prevailing tariff is the one that has been approved and took effect on September 1, 2012. The following table gives the recent changes of the bulk tariff;

[6] IMF, "Bangladesh: 2011 Articles IV Consultation", November 2011

Table 11.3-7 Changes in Bulk Tariff

	1/3/2007	1/10/2008	1/2/2011	1/8/2011	1/12/2011	1/2/2012	1/3/2012	1/9/2012
Average Bulk Tariff (Tk/kWh)	2.04	2.37	2.63	2.80	3.27	3.74	4.02	4.70
Change (%)	-	16.2%	11.0%	6.5%	16.8%	14.4%	7.5%	16.9%

(source) BERC

The revision of the wholesale tariff has been made against the request filed by BPDB in June 2012 with the contention that the average supply cost at BPDB being recorded at Tk 6.02/kWh. BERC sanctioned the wholesale tariff to be raised to the average of Tk 4.70/kWh while a commitment has been made by the government to provide BPDB with the subsidy (concessionary loan) at Tk 0.99/kWh. The gap between the average supply cost and the wholesale tariff plus the subsidy is assumed to be attributable to the retail business of BPDB. Though BPDB depends still upon the subsidy for a part of the supply cost, the aggregate of the wholesale tariff, government subsidy and the retail tariff has reached the stage of break-even. BERC is stressing that it will further review and revise the tariff aiming at reducing the government subsidy and realizing the cost plus a reasonable margin tariff.

To correspond with the changes in the bulk tariff, the retail tariffs have been amended periodically. The revision of the bulk tariff in September 2012 has accompanied changes in the retail tariff for the distribution entities. The following is the latest and prevailing tariffs for distribution;

Table 11.3-8 Retail Tariff (effective as of September 1, 2012)

BPDB, DPDC, DESCO, WZPDCL			REBs, PBSs		
Category	Slab	Tariff (Tk/kWh)	Category	Slab	Tariff (Tk/kWh)
Domestic - A	0–75 kWh	3.33	Domestic	0-75 kWh	3.36-3.87
	76–200 kWh	4.73		76--200 kWh	4.05-4.63
	201-300	4.83		201-300 kWh	4.18-4.79
	301-400	4.93		301-400 kWh	6.88-7.30
	401-600	7.98		401-600 kWh	7.18-7.62
	>600 kWh	9.38		>600 kWh	9.38
Agriculture - B	Flat	2.51	Agriculture - B	Flat	3.39-3.96
Small Industry – C	Flat	6.95	General Industry	Flat	6.95
	Off-peak	5.96		Off-peak	5.96

BPDB, DPDC, DESCO, WZPDCL			REBs, PBSs		
Category	Slab	Tariff (Tk/kWh)	Category	Slab	Tariff (Tk/kWh)
	Peak	8.47		Peak	8.47
Non-residential - D	Flat	4.53	Charitable Institute	Flat	4.45-4.54
Commercial & Offices - E	Flat	9.00	Commercial	Flat	9.00
	Off-peak	7.22		Off-peak	7.22
	Peak	11.85		Peak	11.85
Medium Voltage – F 11kV General Use	Flat	6.81	Heavy Industry	Flat	6.81
	Off-peak	5.96		Off-peak	5.96
	Peak	9.33		Peak	9.33
Extra High Voltage – G2 132kV General Use	Flat	6.16			
	Off-peak	5.57			
	Peak	8.67			
High Voltage – H 33kV General Use	Flat	6.48	High Voltage 33kV General Use	Flat	6.48
	Off-peak	5.87		Off-peak	5.87
	Peak	9.14		Peak	9.14
St. Light & Water	Flat	6.48	St. Light & Water Pump	Flat	6.48

(source) BERC

In addition to the conventional retail tariff, the government and BERC designed a new tariff system of the Quality Tariff (Q – Tariff) early 2012 in which the power supplier assures the consumers of non-stop supply of electricity by connecting the consumers within a certain specified geographical territories by special feeder lines in exchange for the consumers paying higher tariffs. The distribution companies interviewed by the Study Team responded that no consumers have applied for such a service as of August 2012.

(13) Lessons learnt

From what the Study has seen at public power entities as above, several lessons have been learnt and imply suggestions to the newly created CPGCBL including the ones as follows;

(i) The power entities are guided by MPEMR for improving the operational efficiencies by separately agreeing to MPEMR for establishing annual targets of Key Performance Indicators subject to their post evaluation under a reward system. CPGCBL has to proactively devote itself to join such a program and achieve a high level of achievement in operational efficiency:

(ii) The financial performance of the company may largely depend upon the electricity tariff to be fixed in the PPA to be signed with the single buyer. Every effort needs to be made for negotiating the PPA to the extent that it allows a reasonable and sufficient margin for recovering capital costs and obtaining a stable return on equity and assets;

(iii) Unlike other generation companies based on gas, CPGCBL will have to carry a large amount of fuel stores in advance of the commencement and during the operational period. Financially, the company will have to mobilize a considerable working capital for the storage. It is nothing to say that the storage management should be done in an efficient manner while making sure that the plant's smooth operations are maintained. The negotiation of PPA should reflect such conditions appropriately and BPDB, as the parent company, should be able to assist CPGCBL for providing funding support for fuel storage;

(iv) The terms and conditions contracted under PPA should be strictly obeyed in a fair and disciplined manner. In, particular, both parties should be in strict observance of due dates established for specific activities under contract. The accounts receivable and payable should be controlled within a reasonable range under the contractual terms; and

(v) As has been mentioned before, there should be no inheritance of legacy and/or DSL when the company comes across a situation where any of the existing plants of other entities shall be transferred to the company for operation.

11.3.3 Financial strength of public power entities

The following is the entity specific analysis and review;

(1) BPDB

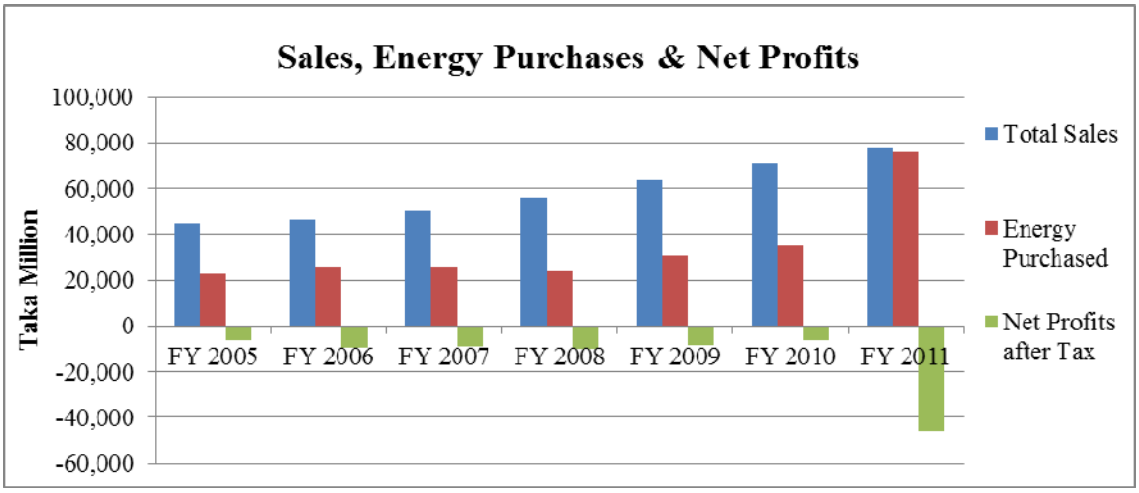
BPDB plays multilateral roles of generation, distribution and the single-buyer of the electricity in the country. The following table describes the track record of its financial performance;

Table 11.3-9 Performance of BPDB

	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Net Generation (GWh)	21,408	22,978	23,268	24,946	26,533	29,247	31,355
BPDB net gen.	13,223	14,456	14,539	15,167	15,449	16,072	14,673
Private gen	8,185	8,522	8,729	9,779	11,084	13,175	16,682
Total Sales (GWh)	19,196	20,954	21,181	22,622	24,757	26,627	28,627
Total Sales (Tk million)	44,706	46,568	49,853	55,943	63,632	71,158	77,304
Net Profit after Tax (Tk million)	▲6,086	▲9,380	▲9,049	▲9,821	▲8,286	▲6,358	▲46,206
Ave Billing Rate (*1) (Tk/kWh)	2.27	2.19	2.26	2.36	2.56	2.57	2.70
Total Ave Supply Cost (Tk/kWh)	2.62	2.70 (*2)	2.77 (*2)	2.91 (*2)	2.61	2.68	4.20

(note) *1: includes both bulk and retail
*2: BPDB’s plants only including its subsidiaries
(source) Annual reports

The above table shows that the country’s net generation increased steadily since FY 2005. Of the country’s total net generation, BPDB’s own plants (including subsidiaries) used to occupy 62% in FY 2005 but declined to 47% in FY 2011. Private sector generation outgrew BPDB during the past seven years. Total sales grew steadily in terms of volume of electricity and value of sales. The average billing rate of electricity including the bulk and the retail used to be Tk 2.27/kWh in FY 2005 and was always in the range of Tk 2.10 – 2.70/kWh till FY 2011. The total average supply cost used to remain in the range of Tk 2.60 – Tk 3.00/kWh till FY 2010 but jumped up to Tk 4.20/kWh. In each of the past seven years, the average billing rates undermined the average supply costs. As a consequence, BPDB recorded negative profits every year and accumulated enormous negative retained earnings resulting in a sharp erosion of equity. The deficit for the years caused the return of assets and return on equity to remain in the negative territory as illustrated in the following figure;



(source) BPDB

Figure 11.3-2 Sales, Energy Purchases and Net Profits

In addition, BPDB is suffering from a large amount of delay and non-paid electricity bills that causes the account receivable days to be unfavorably large. Current liabilities are swollen by the existence of debt service liabilities which results in the low levels of the current ratio and quick ratio. The liquidity is endangered by the above factors but is supported by the government provision of short term loans to cover the adverse gap of the purchase costs and bulk tariff. Unless a fundamental change has to be made in the tariff system and the role of a single-buyer, BPDB may be on the brink of financial insolvency for a short time.

(2) APSCL

APSCL is the second largest power plant. entity in Bangladesh. The company was incorporated in 2000 but started operations in 2003. The total generation capacity is 674 MW comprised of nine units of generation plants. The company is constructing new plants; a 225 MW combined cycle power plant under the export credit agency (hereinafter referred to as “ECA”) backed project financing; 450 MW combined cycle power plant also under ECA financing; 450 MW combined cycle power plant under financing from the ADB and Islamic Development Bank (hereinafter referred to as “IDB”). Besides, the company completed a 53 MW gas engine power plant using its own funds of US$ 41 million and went into commercial operations in April 2011. The following table describes the track record of its financial performance;

Table 11.3-10 Performance of APSCL

	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Total Sales (Tk million)	4,106	4,115		4,920	6,258	6,621
Net Profit after Tax (Tk million)	4	46		30	250	616

(source) Annual report FY 2010-11

The electricity sales and net profit after tax shows healthy growth. The financial ratios reviewed earlier appear to be, by and large, sound with exception of the account receivable days. The debt service coverage ratio stands at an unusually high level which the company contends is maintained to meet the financial obligation under the debt service liabilities. In terms of the depreciation, to the opposite comparison with BPDB, the company is seen to have appropriated in FY 2010-11 an affluent amount equal to 5.4% of the gross value of the plant in operation as of the end of the previous fiscal year.

(3) EGCB

The company was incorporated in 1996 in the name of Meghnaghat Power Company Ltd. Subsequently, it was renamed to the Electricity Generation Company of Bangladesh Limited in 2004 and was converted from a private limited company to a public limited company in 2009. The company is constructing new plants; 2 X 120 MW peaking power plant project under ADB financing; 360 MW combined cycle power plant under JICA financing; 335 MW combined cycle power plant under World Bank financing. Out of the three, the company completed a 2 X 120 MW peaking power plant in November 2011 and went into commercial operation in February 2012. The PPA was signed between EGCB and BPDB in August 2011 and took effect in February 2012. The Revenue was realized from the commercial operation date (hereinafter referred to as “COD”). The company has yet to produce its income statement which will be forthcoming from FY 2012. The evaluation of a company’s financial strength has to wait until the stage when operations reaches full swing.

(4) NWPGCL

NWPGCL was incorporated in 2007. The company is in the stage of developing its first generation plant at Sirajganj followed by the second plant at Khluna and the third at Bheramara. The total generation capacity under development is 660 MW comprised of two units of peaking power plants at Sirajganj and Khluna (150 MW each) and 360 MW of combined cycle at Bheramara. The Sirajganj plant is financed by ADB and expected to be completed in September 2012 while Khluna plant is financed by ADB and GOB and is expected to be completed in May 2013. The Bheramara 360 MW combined cycle is financed by JICA and to be completed in December 2015. The financial statements of the company is yet to show the performance in power generation as the plants are still under construction stage.

(5) PGCB

The company was incorporated in November 1996 as a private limited company and was converted to a public limited company in March 2000. The company is listed with the Dhaka Stock Exchange and Chittagong Stock Exchange. As the sole power transmission company in the country, PGCB is responsible for; transmission lines, sub-stations, load dispatch centers, communication facilities, etc. The following table describes the track record of its financial performance;

Table 11.3-11 Performance of PGCB

	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Transmission Charge (Tk million)	5,030	5,349	5,585	5,855	6,156
Net Profit after Tax (Tk million)	1,254	1,693	1,555	1,607	924

(source) Annual report FY 2010-11

The transmission charge which is the revenue of the company and the net profit after tax shows a healthy performance with the exception of FY2011. The recording of the financial ratios reviewed earlier appear to be sound; the return on equity at 4.7%; the return on assets at 1.2%; the equity ratio at 26.6%; the debt service coverage ratio at 1.48 times; account receivable days at 61 days; the current ratio at 209% and the quick ratio at 191%. While the financial ratios of the company has maintained satisfactory levels during the past several years, a part of the ratios such as; the return on assets, return on equity, equity ratio, current ratio and debt service coverage ratio, shows signs of weakening over the past few years. In terms of the depreciation, in an opposite comparison with BPDB, the company is seen to have appropriated in FY 2010-11 an amount equal to 3.6% of the gross value of the plant in operation as of the end of the previous fiscal year. Alarmingly, the annual FY2010-11report reveals an incident of a large scale of defalcation of PGCB money amounting to Tk 637 million by some high and middle level officers which is construed as an outcome of weakness in internal control.

(6) DPDC

DPDC has been incorporated in 2005 under the Company Act 1994. The commercial activity commenced in July 2008 through acquisition of the assets and liabilities of DESA which at the time was a defunct institution. The company finished its third year of operation in FY 2011. As has been described earlier, the company inherited both the assets and liabilities of the defunct DESA whose strong impact can be seen in the financial conditions of the company. The inheritance of the accumulated deficit causes the company's total equity in the negative balance which might be an element balking the company's listing and offering the shares to the public, although the company is aiming for an initial public offering (hereinafter referred to as "IPO") at an early date. The current assets and current liabilities contain accounts with large balances also inherited from DESA that are not sure if they are to be collected and to be paid. The accounts are swollen by the portion of those inherited balances and the ratios calculated based on those booked records are dubious as to its accuracy. The account receivable days and the account payable (trade) days are also to be questioned. The analysis concludes that the accounts of the company need to be precisely investigated and any balance of doubts should be settled or adjusted with the counter party of the underlying transactions. In terms of the depreciation, the company is seen to have appropriated in FY 2010-11 an amount equal to 2.4% of the gross value of the plant in operation similar to that of BPDB as of the end of the previous fiscal year.

(7) DESCO

DESCO was created in 1996 under the Company Act 1994 as a public limited company for distribution of electricity to consumers. The operational activities commenced in September 1998 when the company took over the distribution network in the Mirpur area from DESA. In subsequent years, the operational area expanded through inclusion of Gulshan Circle in 2003 and the Tongi Pourashava area in 2007. The following table describes the track record of its financial performance;

Table 11.3-12 Performance of DESCO

	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Total Sales (GWh)	1,696	1,897	2,293	2,475	2,674	2,848
Total Sales (Tk million)	6,424	7,381	9,094	9,888	10,911	12,400
Net Profit after Tax (Tk million)					1,789	1,478
System Loss (%)	16.20	13.44	10.91	9.79	8.86	8.79
Account Receivable Days (days)	141	97	77	82	76	73

(source) Annual report FY 2010-11

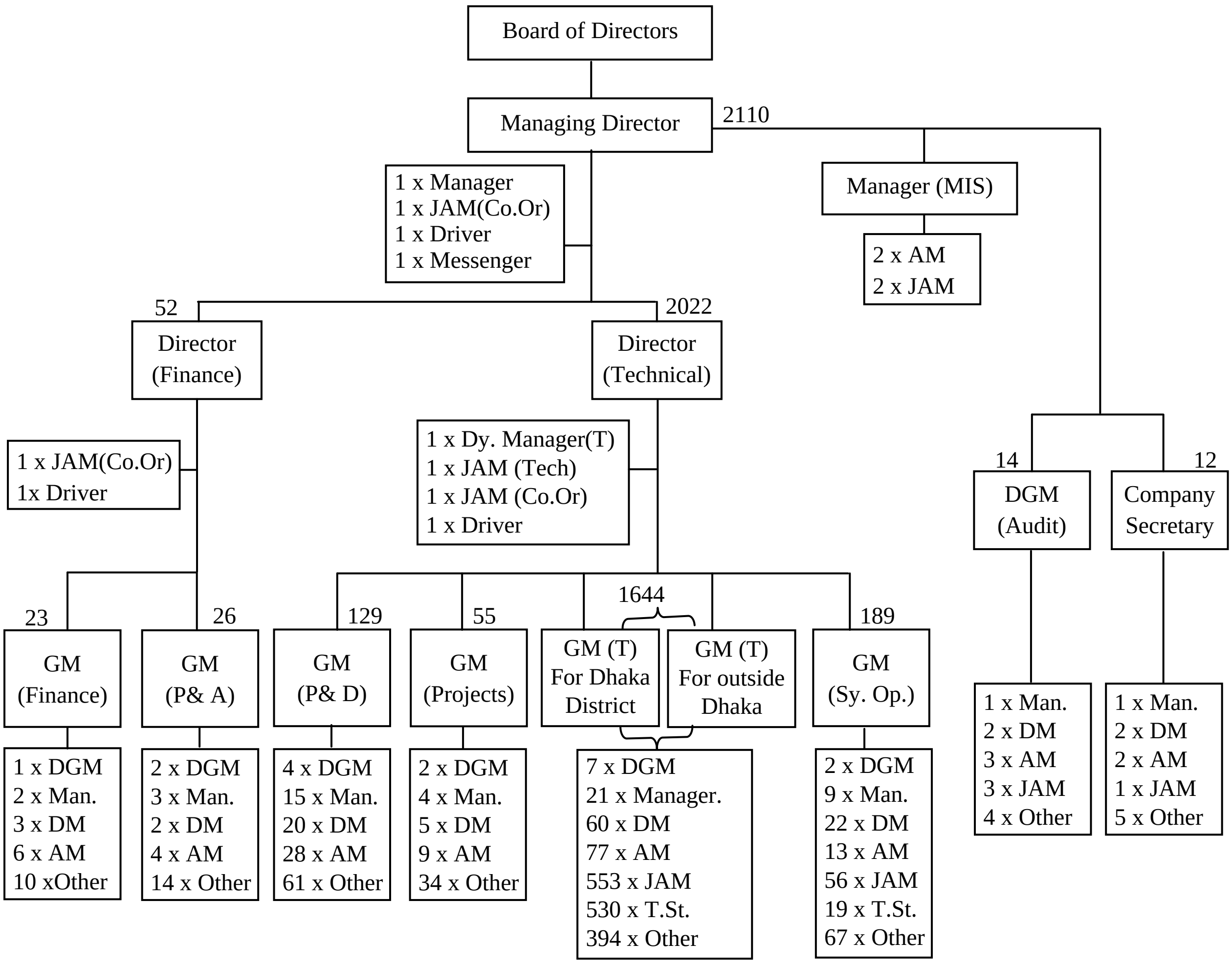
The sales show healthy performances in terms of the volume sold and the amount sold. The recording of the financial ratios reviewed earlier appear to be sound; the return on equity at 14.9%; the return on assets at 5.0%; the equity ratio at 41.9%; account receivable days at 87 days; the current ratio at 349% and the quick ratio at 278%. Another indicator, the system loss shows the track record of the company's historical improvement. The loss ratio is reported to have been at 16.64% in FY 2005 and has improved to the current level of 8.79% in FY 2011. The improvement of efficiency through the reduction of system losses is contributing to the impressive performance in the return on equity and return on assets. The return ratios are indicating that the company is worth investing in. The account payable (trade) matches the account receivable days with the implication that the company can pay the invoice for power purchases upon receipt of the cash collected from consumers without mobilizing its own working capital. The levels of the current ratio and quick ratio indicate that the company is affluent in liquidity that makes the company resilient against in a volatile financial environment. In terms of depreciation, in an opposite comparison with BPDB, the company is seen to have appropriated in FY 2010-11 an amount equal to 5.5% of the gross value of the plant in operation as of the end of previous fiscal year.

11.4 Organogram and Manpower Allocation of main related Organization

11.4.1 PGCB

(1) Whole company

The following is the Organogram and manpower allocation of PGCB.



(source: Company Structure of PGCB, as of December, 2005)

Figure 11.4-1 Organogram and Manpower Allocation of PGCB

The number of total employees is 2,110. Among these, 2,022 employees (96% of the whole) are the subordinate of Director (Technical). Moreover, 1644 persons (78% of the whole) are doing the operation and maintenance on the site in the substation etc. (The total number of employees as of December, 2012 is 1,985.)

(2) Implementation structure for project

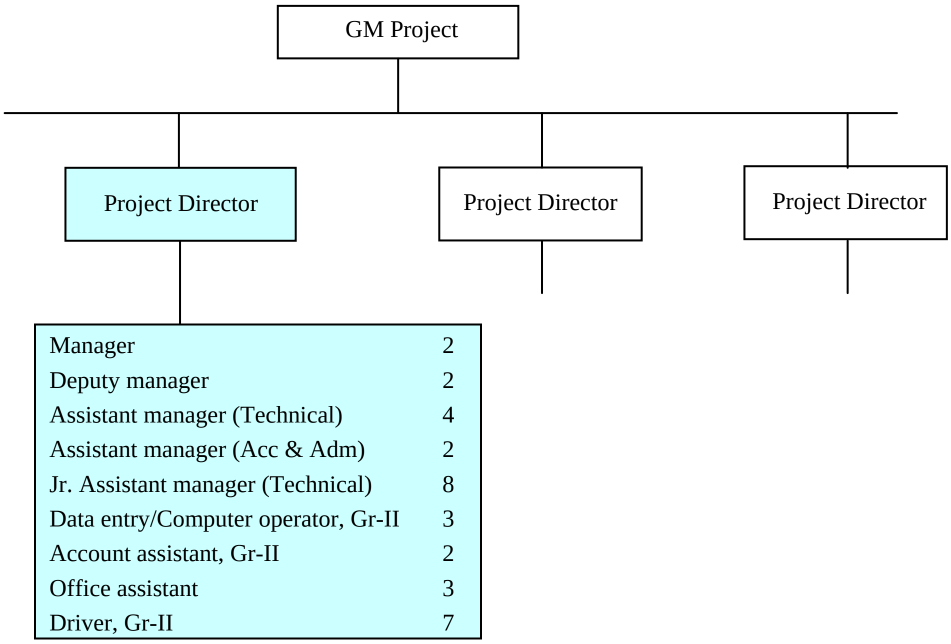
Project Director of each project is nominated, and Project office is established, and the office does the business in the specialty. The on-going projects are as follows.

Table 11.4-1 On-going Projects

Project Name	Finance	Project Cost L: Local F: Foreign	Objective
Meghnaghat-Aminbazar 400 kV Transmission Line (NG1)	ADB	L 17.39 MUS$ F 22.86 MUS$	To evacuate Power from Meghnaghat P/P and to supply reliable power to western part of Dhaka.
Bibiyana-Kaliakoir 400 kV and Fenchuganj-Bibiyana 230kV Transmission Line (NG2)	EDCF Korea & GOB	L: 100 MUS$ F: 146.73 MUS$	To build the power evaluation facilities for upcoming 2X450 MW CCPP at Bibiyana & to evacuate the surplus power of Sylhet area and also to supply adequate power to the northern part of Dhaka city
Construction & Extension of Grid Substations including transmission line facilities (Phase-1)	ADB & JICA	L 45.27 MUS$ F 67.10 MUS$	To meet the growing demand of respective areas.
Aminbazar-Old Airport 230 kV Transmission Line and Associated Substations	ADB	L: 40.03 MUS$ F: 53.22 MUS$	To supply reliable power and to meet the growing demand of western part of Dhaka city.
Transmission Efficiency Improvement through Reactive Power Compensation at Grid Substations and Reinforcement of Goalpara Substation	KfW	L: 13.11 MUS$ F: 20.45 MUS$	To maintain reasonable voltage & to reduce Transmission loss.
Siddhirganj-Maniknagar 230 kV Transmission Line	WB	L: 18.82 MUS$ F: 32.71 MUS$	To evacuate the power generated at Siddhirganj & to meet the growing demand of Maniknagar and adjacent area.
Barisal-Bhola-Burhanuddin 230 kV Transmission Line	Own	L: 28.57 MUS$ F: 42.85 MUS$	To evacuate Power from upcoming Bhola P/P
Grid Interconnection between Bangladesh (Bheramara) and India (Baharampur)	ADB	L: 49.16 MUS$ F: 104.94 MUS$	(i) To Facilitate exchange of electricity between Bangladesh & India. (ii) To establish a Grid interconnection with India. (iii) To minimize the power crisis in Bangladesh to some extent.
Two new 132/33 kV substations at Kulaura & Sherpur with interconnecting lines.	Own	L: 11.5 MUS$ F: 16.65 MUS$	To meet the growing demand of Kulaura & Sherpur
Bibiyana-Comilla(N) 230kV transmission line	GOB & PGCB	L: 24.46 MUS$, F: 29.74 MUS$	To evacuate the surplus power of Sylhet & Fenchuganj area.
Haripur 360 MW Combined Cycle Power Plant and Associated Substation (PGCB Part)	JICA	L: 7.046 MUS$, F: 17.84 MUS$	To evacuate generated power from 360 MW CCPP

(source: PGCB Web site)

The organogram and the number of staff of the Bibiyana - Kaliakoir 400 kV and Fenchuganj - Bibiyana 230kV Transmission Line (NG2) Project office are shown below.



(source: PGCB)

Figure 11.4-2 Organogram of Bibiyana - Kaliakoir Project Office

Bibiyana - Kaliakoir Project Office mainly implements the construction of the following equipment.

- 400kV Bibiyana - Kaliakoir T/L: 168km
- 230kV Fenchuganj - Bibiyana T/L: 33km
- 400kV Kaliakoir S/S and 230kV Fenchuganj S/S

Since this Project office constructs 60km - 400kV transmission lines, the number of members is estimated as one-third of the members above. The following table nominates the thirteen candidates for Project Implementation Unit (PIU), while assuming Project's period as four years, which consists three years of construction and one year for pre-construction.

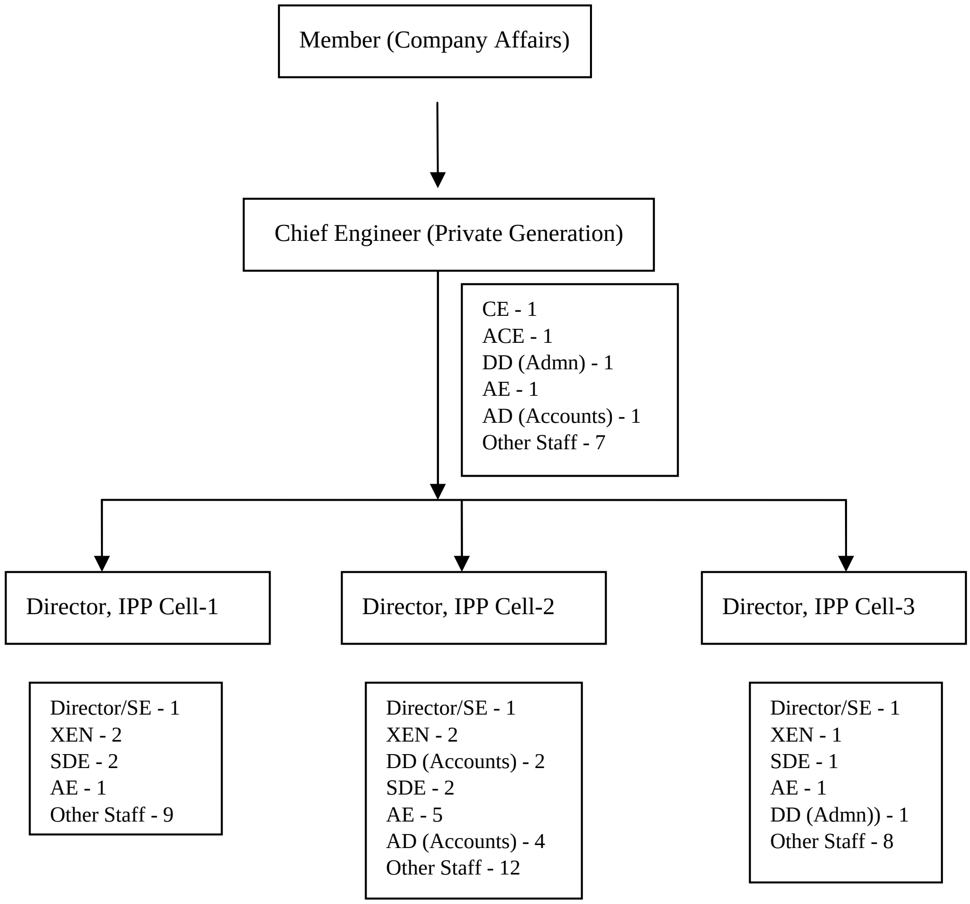
Table 11.4-2 Project Implementation Unit of T/L

	Nos.	MM
Project Director (Manager)	1	48
Deputy manager	1	48
Assistant manager (Technical)	2	96
Assistant manager (Acc & Adm)	1	48
Jr. Assistant manager (Technical)	3	144
Data entry/Computer operator, Gr-II	1	48
Account assistant, Gr-II	1	48
Office assistant	1	48
Driver, Gr-II	2	96
Total	13	624

(Source: JICA Study Team)

11.4.2 IPP cell of BPDB

The following figure shows the organogram and manpower allocation of IPP Cell of BPDB.



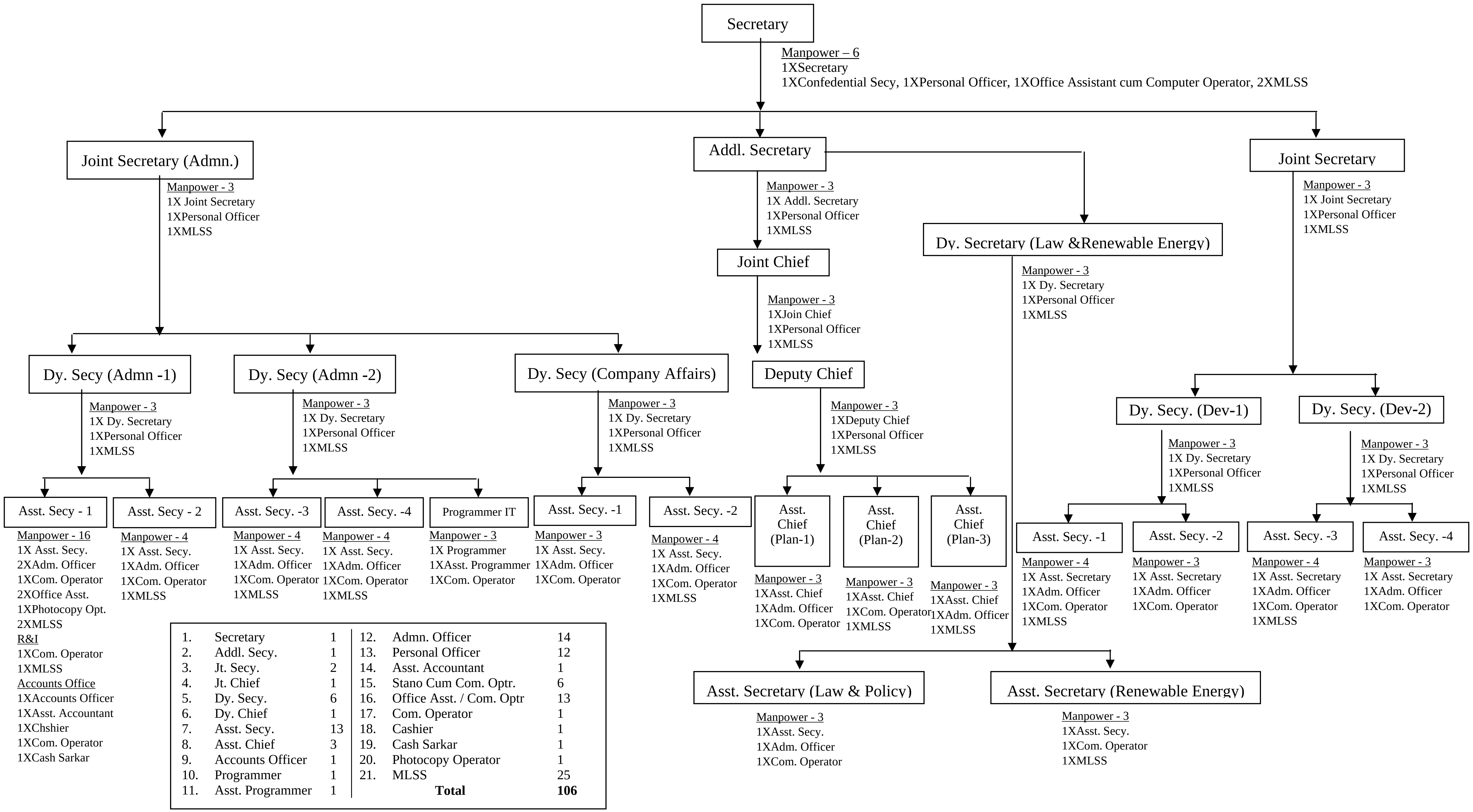
(source: JICA Study Team)

Figure 11.4-3 Organogram of IPP Cell of BPDB

In Member Company Affairs of BPDB, there are three groups engaged in IPP. IPP Cell-1 is in charge of making power purchase agreement (PPA) with power plants whose installed capacity is over 150 MW among BPDB’s subsidiary companies and IPPs. Therefore, IPP Cell-1 will deal with CPGCBL regarding the company’s PPA, too.

11.4.3 Power division

The following figure shows the organogram and manpower allocation of Power Division of MPEMR. The number of total employees is 106.



1.	Secretary	1	12.	Admn. Officer	14
2.	Addl. Secy.	1	13.	Personal Officer	12
3.	Jt. Secy.	2	14.	Asst. Accountant	1
4.	Jt. Chief	1	15.	Stano Cum Com. Optr.	6
5.	Dy. Secy.	6	16.	Office Asst. / Com. Optr	13
6.	Dy. Chief	1	17.	Com. Operator	1
7.	Asst. Secy.	13	18.	Cashier	1
8.	Asst. Chief	3	19.	Cash Sarkar	1
9.	Accounts Officer	1	20.	Photocopy Operator	1
10.	Programmer	1	21.	MLSS	25
11.	Asst. Programmer	1		**Total**	**106**

(source: JICA Study Team)

Figure 11.4-4 Organogram of Power Division

11.5 Roadmap for Corporatization and Project Implementation

11.5.1 Short term

The period until the conclusion of the Loan Agreement is set as a short term, the Study Team proposes a road map that describes the items and the time that should be executed. The Study Team assumed that the Loan Agreement would be concluded by March 2014 at the earliest.

(1) Preparation of corporate governance system

The road map for the preparation of the corporate governance system is shown below. The important execution items are the selection of Board of Directors, the selection of the Top Management Team, and the establishment of various committees.

It hardly advances excluding recruitment procedure of MD and Company Secretary among the action that should be executed in 2012. Therefore, the time that should be executed has already been passed, and the prompt action is necessary.

Table 11.5-1 Short-term Roadmap-1 (Preparation of the corporate governance system)

			2012						2013												2014		
			7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	[Key Benchmark] **Conclusion of Loan agreement**																					L/A	▲
	[Preparation of Corporate Governance System]																						
1	Determination of Job Description and Terms & Conditions for the chairman, and the board of directors	Board of Directors [BOD]																					
2	Determination of Job Description and Terms & Conditions for Top Management Team [TMT]	BOD																					
3	Formation of Compensation/Selection Committee	BOD																					
4	Finalization of Selection Criteria & Selection Process for TMT	BOD (Selection Committee)																					
5	Execution of Selection Process (Advertisement, Initial Screening, Interviews and selection finalization)	BOD (Selection Committee)																					
6	Formation of Audit and Governance Committees	BOD																					
7	Selection of external Directors (to change some Directors)	GOB																					
8	Holding 1st general shareholder's meeting	BOD																					
9	Selection of external auditor	BOD																					
10	Establishment of Corporate Visions	BOD, CPGCBL TMT																					
11	Establishment of Corporate Office (Head office)	CPGCBL TMT																					
12	Establishment of web site	CPGCBL TMT																					

Note: ← shows the delay at original execution time. (Source: JICA Study Team)

1) Selection of the Board of Directors (refer to Table 12.2-2[7])

"Bangladesh Corporate Governance Code 2004" (refer to Chapter 12.2.1) states that "Companies should articulate and implement a nomination programme to enable a majority of board members to be non-executive and independent directors." And also "Articles of association of CPGCBL" states that "There shall be directors from each group representing person(s) specialized in generation, transmission and the distribution of electricity, consumers, business and person(s) specialized in finance." However, all current board members are the persons from the government or from concerned parties of BPDB, so it is necessary to change some directors to non-executive and independent directors.

And also "Articles of association of CPGCBL" states that "A general meeting of the company shall be held within 18 months from the date of incorporation of the Company". It is necessary to change some directors by January 2013 ahead of the 1st general meeting.

2) Selection of the Top Management Team

Openings for the Managing Director (hereinafter referred to as "MD") and Company secretary were advertised, and the application time limit was November 29, 2012. After the selection of both, the person in charge of management of financial affairs and the technology should be selected, and the management team in the company should be composed by January 2013.

3) Establishment of various committees

Compensation/Selection Committee should be established in the Managing Board before the selection of Top Management, and the committee selects the member of the management team including the MD. It is necessary to include independent outside directors in the committee to ensure transparency in selecting suitable persons.

The Managing Board should establish an Audit Committee to supervise the disclosure of financial information, and also establish a Governance Committee to create governance policy.

(2) Human resource management

The road map for human resource management is shown below. An important execution

7 Governance framework of the BPDB subsidiary company is shown in Table 12.2-2. There are some independent Directors in the Board in DESCO, PGCB, EGCB, APSCL.

item is the selection of Key Executive Managers.

Table 11.5-2 Short-term Roadmap-2 (Human resource management)

			2012						2013												2014		
			7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	[Key Benchmark] **Conclusion of Loan agreement**																					L/A	▲
	[Human Resource Management]																						
1	Preparation of Organogram (including Staff number), Functional Description, Job Description, Qualification	CPGCBL TMT							■														
2	Preparation of Salary Structure and Compensation Package	CPGCBL TMT								■													
3	Selection Committee Formation for recruitment of Key Executive Managers [KEM]	CPGCBL TMT								■													
4	Finalization of Selection Criteria & Process for KEM	CPGCBL TMT								■													
5	Execution of Selection Process (Advertisement, Initial Screening, Interviews and selection finalization)	CPGCBL TMT									■	■	■										
6	Conclusion of employment agreement	CPGCBL TMT											■	■									

(Source: JICA Study Team)

When Key Executive Managers are selected, the management team should decide the Organogram (including the Staff number), Functional Description, Job Description, Qualification Standard, and Salary Structure and Compensation Package beforehand, and the necessary staff should be hired gradually.

(3) Application of project approval procedure

The road map for the application of the project approval procedure is shown below. The important execution items are to prepare the EIA and DPP and to obtain approval from the relevant authority.

Table 11.5-3 Short-term Roadmap-3 (Application of project approval procedure)

			2012						2013												2014		
			7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	[Key Benchmark] **Conclusion of Loan agreement**																					L/A	▲
	[Application of Project Approval Procedures]																						
1	Transfer of new Project from BPDB to CPGCBL	BPDB, CPGCBL TMT																					
2	Completion of FS(D/D), JICA Study (Viability Assessment)	JICA, JICA Study Team																					
3	Preparation/Submission of EIA including with SIA	CPGCBL TMT																					
4	Review and approval of EIA/SIA by Directorate of Environment	DOE																					
5	Preparation/Submission of Detailed Project Proforma (DPP)	CPGCBL TMT																					
6	Review and approval of DPP by ECNEC	ECNEC																					
7	Project Appraisal	JICA, CPGCBL																					
8	Confirmation of Power Purchase by BPDB	CPGCBL, BPDB																					
9	Finalization of Loan Agreement (L/A)	JICA, GOB																					

(Source: JICA Study Team)

According to JICA's guidelines for environmental and social considerations, JICA should disclose the EIA reports 120 days prior to concluding the agreement documents at the "category A projects" such as this Project. Therefore, it is necessary to obtain government approval of EIA/SIA four months before the L/A conclusion.

EIA/SIA and DPP are basically made based on the result of the FS. Therefore, CPGCBL will begin to make them after July 2013 when FS will be finalized. However, in considering the evaluation period in the authority, CPGCBL should begin to make them with the support of the JICA Study Team from January 2013 because it is a short duration for preparing these documents.

11.5.2 Middle term

The period until commencement of commercial operations of the power plant is set as a middle term, the Study Team proposes the road map that describes the item that should be executed and the execution time. The Study Team assumed that the commercial operations of No.1 unit would be December 2022 at the earliest.

(1) Application of legal procedures

The road map for the application of legal procedures is shown below. Just after concluding the L/A, it is necessary to conclude a Subsidiary Loan Agreement between GOB and CPGCBL. It is necessary to conclude a Fuel Supply Agreement and Power Purchase Agreement and to obtain the license of the power-generation business from BERC before starting a test run.

Table 11.5-4 Middle-term Roadmap-1 (Application of legal procedures)

[Key Benchmark] **Commercial operation of new P/S**		#1 ▲ (2022 4Q), #2 ▲ ('23 2Q)
[Application of Legal Procedures]		
1	Finalization of Loan Agreement (L/A)	JICA, GOB
2	Conclusion of Subsidiary Loan Agreement	GOB, CPGCBL
3	Conclusion of Fuel Supply Agreement	Coal supplier, CPGCBL TMT
4	Conclusion of Power Purchase Agreement between BPDB and CPGCBL	BPDB, CPGCBL TMT
5	Getting generation license from BERC	BERC, CPGCBL TMT

(Source: JICA Study Team)

(2) Preparation of tender and construction phases

The road map for the preparation of tender and construction phases is shown below. The consultant's selection procedure begins just after concluding the L/A, and the selection procedure of the EPC contractor is executed with the selected consultant afterwards.
In order to confirm the stability at the mixing coal operation, it is necessary to conduct a test run for about seven months.

Table 11.5-5 Middle-term Roadmap-2 (Preparation of tender and construction phases)

[Key Benchmark] **Commercial operation of new P/S**		#1 ▲, #2 ▲
[Preparation of Tender and Construction Phases]		
1	Selection procedures for consultant	CPGCBL TMT
2	Preparation of tender (EPC) by CPGCBL	CPGCBL KEM, Consultant
3	Selection of EPC (Civil) contractor	CPGCBL TMT, Consultant
4	Selection of EPC (Power Plant) contractor	CPGCBL TMT, Consultant
5	Construction	CPGCBL, EPC Contractor
6	Test run (#1, #2)	CPGCBL, EPC Contractor

(3) Coal procurement

The road map for coal procurement is shown below. The selection procedure of the consultant who executes the tender of the coal procurement should begin about 3-5 years ahead of the test run, and the coal supplier's selection procedure is executed with the selected consultant afterwards. The Supporting Agency (SA) composed of the CPGCBL staff and the consultant is established after the selection of the coal supplier, and the Fuel Supply Agreement is concluded with the support of SA.

Table 11.5-6 Middle-term Roadmap-3 (Coal procurement)

			2014				2018				2019				2020				2021				2022				'23	
			1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q
	[Key Benchmark] Commercial operation of new P/S																									#1 ▲		#2 ▲
	[Coal Procurement]																											
1	Preparation of competitive selection of Consultant by CPGCBL	CPGCBL KEM						■	■	■																		
2	Selection procedures for consultant	CPGCBL TMT								■	■	■																
3	Preparation of tender (Coal supplier) by CPGCBL	CPGCBL KEM, Consultant											■	■	■													
4	Selection of Coal supplier	CPGCBL TMT, Consultant														■	■	■	■									
5	Establishment of Supporting Agent (SA)	CPGCBL KEM, Consultant																	■									
6	Conclusion of Fuel Supply Agreement	Coal supplier, CPGCBL, SA																		■	■							

(Source: JICA Study Team)

(4) Reinforcement of corporate framework

The road map for the reinforcement of the corporate framework is shown below. The mid-term management plan is settled just after the conclusion of the L/A, and the Delegation of power is decided. A safety committee is composed before the commencement of the construction work, and the safety committee decides the safety policy. Furthermore, the environment management system is also established.

A regular shareholders' meeting is held every year and an Annual Report is issued.

Table 11.5-7 Middle-term Roadmap-4 (Reinforcement of corporate framework)

			2014				2015				2019				2020				2021				2022				'23	
			1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q
	[Key Benchmark] **Commercial operation of new P/S**																									#1 ▲		#2 ▲
	[Reinforcement of Corporate Framework]																											
1	Formulation of Mid-term management plan (management objective and numerical target)	CPGCBL TMT																										
2	Establishment of incentive and benefit scheme	CPGCBL TMT																										
3	Formulate training policy, Establishment of training system	CPGCBL TMT																										
4	Determination of Performance evaluation method	CPGCBL TMT																										
5	Determination of sharing roles between HQ and PS	CPGCBL TMT																										
6	Establishment of Safety policy & Safety Committee	CPGCBL TMT																										
7	Establishment of Environment management system	CPGCBL TMT																										
8	Determination of delegation of power (Administration)	CPGCBL TMT																										
9	Determination of delegation of power (Finance)	CPGCBL TMT																										
10	Determination of Budget management system	CPGCBL TMT																										

(Source: JICA Study Team)

(5) Selection of new employees for P/P and O&M

The road map for the Selection of new employees for P/P and O&M is shown below. CPGCBL starts the recruitment of power plant staff about one year before the installation of facilities, and the newcomers are trained during the construction and the test run period by OJT.

Moreover, the business execution contract is concluded for the business that should be outsourced before the test run.

Table 11.5-8 Middle-term Roadmap-5 (Selection of new employees for P/P and O&M)

			2014				2015					2018				2019				2021				2022				'23	
			1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q
	[Key Benchmark] **Commercial operation of new P/S**																										#1 ▲		#2 ▲
	[Selection of New Employees for P/S]																												
1	Establishment of manpower planning and employee policy	CPGCBL TMT														■													
2	Determination of organization structure at P/S and new recruits number	CPGCBL TMT														■													
3	Determination of job description, service rules and pay standard	CPGCBL TMT														■													
4	Determination of recruitment method for new employees	CPGCBL TMT															■												
5	Execution of Selection Process (Advertisement, Initial Screening, Interviews and selection	CPGCBL TMT															■	■	■										
6	Conclusion of employment agreement	CPGCBL TMT																■	■										
	[Operation & Maintenance]																												
1	Implementation of OJT training during construction (installation)	CPGCBL																		■	■	■	■	■	■				
2	Implementation of OJT training during test run	CPGCBL																							■	■	■	■	■
3	Negotiation with PGCB（responsibility area, command method)	CPGCBL TMT																				■							
4	Implementation of performance guarantee test	CPGCBL																									■		■
5	Conclusion of contracts for outsourcing works	CPGCBL TMT																			■	■							

(Source: JICA Study Team)

Chapter 12

Management of New Power Generation Company

Chapter 12 Management of New Power Generation Company

12.1 CPGCBL Corporate Directivity

12.1.1 Ideal figures of CPGCBL

The CPGCBL is requested to promote coal thermal power development in Bangladesh for the long term. Carrying out efficient management and human capital development is required in order to develop a company with sustainability. Especially, it is necessary to improve the overall skills concerning the coal-fired thermal power plant.

As indicated in the following table, there are few power sectors, or companies, in Bangladesh, which simultaneously attain Independence of management and Human capital development. The directivity of CPGCBL is to simultaneously attain both the Independence of management and long-term human capital development for sustainable development.

Table 12.1-1 Case of Power Sector Corporatization in Bangladesh until Now

	Independence of management	Long-term human capital development
BPDB P/P	It is completely under the rule of BPDB and all the judgment is based on decision-making by BPDB.	Although maintenance personnel are employed, a systematic training program is not established.
IPP	It is completely based on decision-making by IPP.	Since long-term maintenance service agreement is established with manufacturers, the maintenance personnel are not employed.
Ashuganj P/P	It is a subsidiary of BPDB and important decision-making, such as scheduled outages for inspections, is completely under BPDB control.	Maintenance staff is secured and systematic training program has been started.
PGCB	Although it is a subsidiary of BPDB, the accounting system is clearly divided, and management authority is delegated to the management.	Since it requires special expertise, training programs have been established.
DESCO	Although it is a subsidiary of BPDB, the accounting system is clearly divided, and management authority is delegated to the management.	Some parts of O&M works for distribution line are outsourced.

Considering the conditions discussed above, the following shows the directivity of CPGCBL, showing the relationship between Independence of management and long-term human capital development.

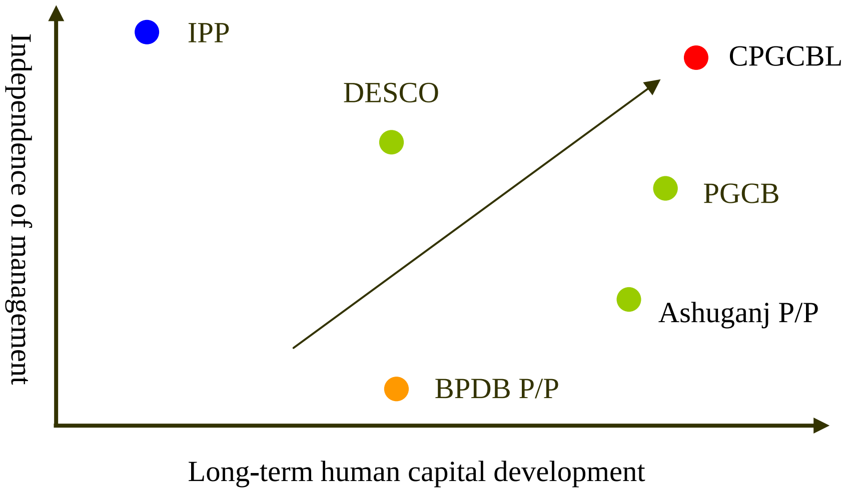


Figure 12.1-1 Directivity of CPGCBL

12.1.2 Vision statement of CPGCBL

"Power Sector Road Map 2008-10" states that "For public sector new generation, special attention will be given to good governance, efficient O&M and establishing commercial environment."

The corporate structure requirements for CPGCBL are first and foremost to develop a Vision Statement for CPGCBL. The vision statements for CPGCBL as a power utility company which have been formulated based on discussion with the key stakeholders of CPGCBL are described below:

The CPGCBL holds up the three pillars of "independence of management", " Highly reliable power supply", and " Sustainable development" as corporate visions, and CPGCBL aims at realizing these pillars with sufficient balance. The relation of the three pillars of corporate vision is shown in the figure below.

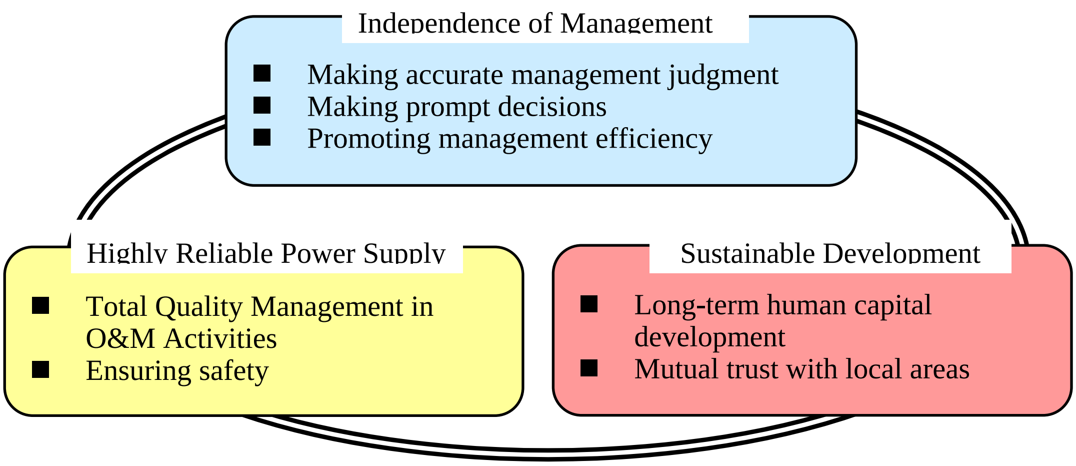


Figure 12.1-2 Three Pillars of Corporate Vision

(1) Independence of Management

In order to realize independence of management, the management needs to conduct an accurate management evaluation, and make a prompt decision. In order to do this, employing excellent personnel having a progressive spirit as a secretary to the top management is important. Also, establishing a management information system (MIS) which extracts important operation and management data at any time for their management decisions, is essential. Furthermore, the necessary investment should be done at the appropriate time. For this, it is necessary to realize a financial structure that makes it possible to secure revenue and expense balance at an early stage.

(2) Highly reliable power supply

The reliability of power supply in Bangladesh is by no means high. A big reason is due to the lack of the absolute number of generation facilities. Another reason is the low awareness of the personnel who belongs to the power sector. At CPGCBL, each worker must be very aware and conscious of delivering highly reliable power. In addition, all the workers shall put Total Quality Management (TQM) to practical use in order to establish an O&M management system based on fact control. This means that technical judgment shall be determined by actual data. Furthermore, considering equipment and human safety, the establishment of a safety management system is a key issue to prevent accidents.

(3) Sustainable development

It is very important for sustainable development and from a long-term viewpoint, that maintenance experts shall be raised in the company, and these personnel shall handle small-scale maintenance work by themselves. The power plant that CPGCBL is scheduled to construct is first a large-scale coal-fired thermal power plant in Bangladesh, and it is possible to establish the position of top runner of technology concerning coal-fired thermal power plant via the accumulation of the technology. It is expected that the accumulation of such a technology will contribute to opportunities to further expand future business.

CPGCBL should consider the development of a new power plant in the vicinity district in the future. In order to promote the new project, it is necessary to think about contributing to the promotion of regional economic development. Therefore, CPGCBL needs to aim at the promotion of local employment and at building good relations with neighbors and the local area.

12.2 Corporate Governance

Effective governance will:

- Allocate responsibilities to parties such as the board of directors and the managers of the organization in such a way as to make them accountable in clear terms;
- Provide the means for setting and pursuing company goals in a transparent and open way; and
- Create the structures to manage risks and monitor performance.

Corporate governance is a system which helps to direct and govern the company so that it can be maintained and prosper. As indicated in the following figure, it is important to separate the execution and supervisory functions of management, and to establish and implement an internal control system. It is also important to undergo external observation.

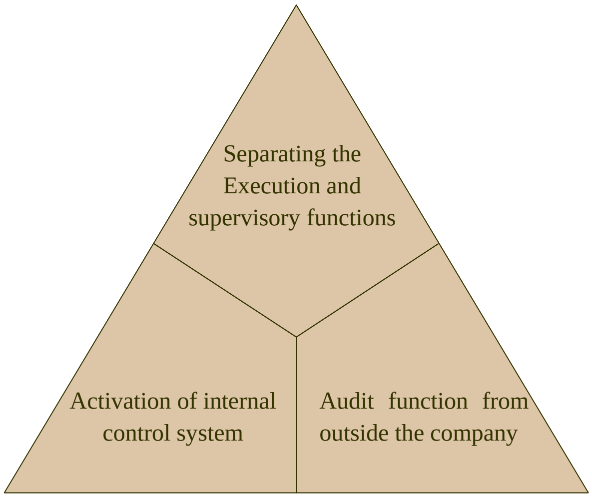


Figure 12.2-1 Fundamental Structure of Corporate Governance System

12.2.1 Applicable laws and regulations in Bangladesh

(1) Corporate Governance Code 2004

As an initial beginning, CPGCBL can draw adequate inspiration from the Bangladesh Corporate Governance Code 2004 which lays out the key aspects of Corporate Governance and also indicates certain specific aspects to be followed for the State Owned Enterprise. The key aspects of Corporate Governance that is relevant and should be adopted by CPGCBL are indicated below.

Table 12.2-1 Bangladesh Corporate Governance Code 2004 Key Highlights

Aspect	Clause Reference	Principles / Guidelines
Duties of the Board	II	▪ Serve legitimate interest of the shareholders and account for them fully ▪ Ensure compliance with all relevant laws and regulations including code of Corporate Governance ▪ Determine, monitor, evaluate strategies, policies, management performance and business plans ▪ Identify and monitor key risk areas ▪ Review and monitor risk management systems ▪ To appoint the MD/ CEO and Top Management Team and set performance criteria for evaluation
Nomination of New Board Members	IV	▪ Nomination Committee not to preclude shareholders from active participation in the nomination process ▪ Candidates nominated by both shareholder and board along with requisite information to be put before AGM for election
Separation of Chairman and CEO	VI	▪ Position of Chairman of the Board and CEO should be filled by different individuals
Board Composition	VII	▪ Membership to be within 7 – 15 Directors ▪ Articulation and Implementation of a nomination programme to enable majority of Board to be non-executive and independent directors ▪ Non-executive directors to be included in committees tasked with decisions involving conflict of interest ▪ Quorum to be arrived only when majority of non-executive or independent directors are present
Board Compensation	VIII	▪ Compensation to be sufficient to compensate directors for time and effort required to complete the duties well
Committees	X	▪ Audit , Nomination to be headed by independent directors ▪ Audit Committee to be headed by an independent director with professional qualification and relevant experience ▪ Quarterly meetings to monitor internal and external audits ▪ Annual reporting to Shareholders
Evaluation of Board Performance		▪ Board to evaluate own performance both collectively and individually including performance of the Chairman at least once a year to ensure it is operating effectively

(2) Bangladesh Companies Act 1994

The Companies Act lays down the framework for corporations to operate in the business environment while laying down certain statutory obligations with regards to institutional process and ensuring transparency towards shareholders investors. The Companies Act was in vogue prior to Corporate Governance and is primarily in the nature of a statutory nature while Corporate Governance is more along the lines of best in class institutional and corporate practices. The Bangladesh Companies Act 1994 also lays out certain specific guidelines that should be followed by CPGCBL over the course of time in order to adhere to good governance principles.

12.2.2 Key findings from corporatization review phase

The findings of the Corporatization Review shall be set out in the section below. In terms of arriving at the key findings, these aspects have been focused on.

- Governance Framework
- Segregation of Ownership & Management
- Board Committees

The as-is analysis indicates the following key findings with regards to the governance mechanisms in place for the various public utilities. DESCO and PGCB are listed companies.

(1) Board Composition

Most of the public utilities in Bangladesh have a board size ranging from 9-11 which is within the range of 7-15 as indicated in Section VII of the Bangladesh Corporate Governance Code of being representative of successful governance mechanisms.

(2) Governance Framework

The Boards of the public utilities have a sizeable representation of independent directors of around 20-30%. And only the MD is a member of the Managing Board from the execution body.
The Top Management Team consists of the Managing Director i.e. the CEO, the Director of Accounts and Finance Department i.e. the CFO and the Director Technical i.e. the COO of the utility. There are no companies that have a Director representing the key areas of Human Resources and Planning & Development.

(3) Segregation of Ownership & Management

In all the cases, there is segregation of ownership and management and the aspect thus duly recognizes the principle set out in Section VI of the Bangladesh Corporate Governance Code of having a separate Chairman and CEO to serve as a check and balance. Thus, in terms of the roles while the oversight of the organization as a whole is managed by the Chairman, the daily affairs of the business and the running of the company is entrusted with the CEO who is separated from the chairman.

(4) Board Committees

The public utilities are in various stages of evolution with regards to the Board

Committees being in place. The listed entities like DESCO and PGCB must necessarily comply with the SEC guidelines which mandate the Audit Committee. However PGCB has also additional committees in place as indicated in the table above.

Table 12.2-2 Comparative Chart on Bangladesh Public Utilities Corporate Governance Practices

Organization / Utility	No. of Directors	Governance Framework		Separate Chairman & CEO	Board Committees	Management
		Independent Directors	Executive Directors			
DESCO	9	3 University (1) Retired engineer (1) Legal enterprise (1)	1	Yes	1 Audit	2 MD, Director (F&A)
PGCB	9	5 University (1) ICAB (1) FBCCI (1) BTCL (1) Advocate (1)	1	Yes	2 Audit Board, Administrative Affairs	2 MD, Director (O&M)
EGCB	10	2 FBCCI (1) Advocate (1)	1	Yes	4 Budget & Audit, Recruitment & promotion, Procurement & Review, Corporate governance	3 MD, Director (Finance), Director (Technical)
APSCL	11	3 University (1) ICMAB (1) FBCCI (1)	1	Yes	3 Audit, Procurement review, Recruitment & promotion	3 MD, Director (Finance), Director (Technical)

(as of August 2012, The Study Team makes it based on the material acquired from each company)

12.2.3 Establishment of fundamental framework in the corporate governance system

Based on the as-is findings by the corporatization review and soliciting feedback from key BPDB counterparts, the Study Team have firmed up recommendations for the Corporate Model for CPGCBL.

(1) Board Composition and Governance Framework

CPGCBL was established in September 2011 in line with Company Act 1994 of Bangladesh. General data for CPGCBL is as follows:

- Establishment: September 5, 2011
- Governing law: Company act 1994

- Authorized capital: 6,000 million Tk
- Paid capital: 10,000 Tk
- Articles of incorporations: determined when company is established
- Founders: BPDB represented by Chairman: 2 shares

Joint Secretary, Development, Power Division:	1 share
Joint Secretary, Development, M & R Division:	1 share
Joint Secretary, Budget-2, Finance Division:	1 share
Joint Secretary, Administration, Ministry of Shipping:	1 share
Managing Director, PGCB:	1 share
Member, P & D, BPDB:	1 share
Member, Company Affairs, BPDB:	1 share
Deputy Secretary, Company Affairs, Power Division:	1 share
Total	10 shares

- General shareholders meetings: It is required to hold the 1st general shareholder meeting within 18 months after incorporation procedures. Holding a meeting once a year is required henceforth.
- Number of directors: 9 - 12
- Directors: From each group representing person(s) specialized in generation, transmission and distribution of electricity, consumers, business and person(s) specialized in finance

(2) Composition of board of directors

For a current director, the Chairman of the board is the Chairman of BPDB and the other eight directors are the persons related to BPDB or governmental officials. “The Bangladesh Corporate Governance Code 2004” recommends that “majority of Board to be independent directors.” According to this code and the Articles of incorporations, some directors should be replaced in the near future.
If four independent directors are arranged among the nine directors, it becomes the same number of dependent directors except the Chairman. If securing independence to the management by independent directors, the managing board can monitor and supervise the business situation based on the business report from the executing body effectively.

(3) Principle of Segregating Execution and Supervisory Functions of Management

“The Bangladesh Corporate Governance Code 2004” says that the “Position of Chairman of the Board and CEO should be filled by different individuals.” Separating the execution and supervisory functions of management creates independent management, and the promotion of decision-making and the acceleration of operating activities becomes increasingly important.

Usually, a board of directors consists of the executing directors and non-executing directors. A non-executing director is a director who does not take charge of the execution of day-to-day operations. Their main responsibility is to supervise the executing director’s activities. The executing director is the only person who belongs to the board of directors, and has full responsibility for the management activities of the company on a daily basis, giving instructions to employees. The corporate officers are not a member of the board of directors, but provide appropriate instruction to employees as the head of each department, having responsibility for each operating activity under the executing director.

Moreover, the execution function of management and the ownership function of the company shall be clearly separated. At the early stage of corporatization, when the company is still small in scale, an owner of the company is a director of the management of the company, so the owner function of the company and the execution function of management are done together. However, in order to seek sustainable development of the company, which is one of the corporate visions, the owner of the company shall delegate all the administrative powers to an administrative professional. This is because the administrator is expected to have great knowledge and experience.

Referring to the other companies' board structure, the MD becomes the member of Managing Board and takes charge of the execution of daily business, and offers information on the execution situation of the business to Managing Board.

(4) Reinforcement of Audit Function

It is important to understand well the functions of the supervisory function centering on the chairman, and the management execution function centering on the managing director, and to implement the separation of these functions into practice. For reinforcement of the supervisory function of the company, the Study Team proposes setting up three board committees. Each committee shall be made of three or more persons, and more than half of the members shall be from the external directors and experienced or academic experts in order to secure management transparency.

1) Audit committee

The role of the audit committee is the oversight of the company’s financial reporting process and the disclosure of its financial information to ensure that the financial statement is correct, sufficient and credible.

2) Governance Committee

The governance committee shall develop and recommend Governance Policies to the Board of Directors, and recommend Director qualification criteria and identify individuals qualified to become Board members.

3) Compensation/Selection Committee

The purpose of the Compensation/Selection Committee is to discharge the responsibilities of the Board of Directors relating to compensation of the Company's executive officers and to review Company strategy for recruiting, retention and employee development.

(5) Reorganization to Clarify Management Responsibilities

In order to successfully implement corporatization, a large portion of the authority of power from the Managing Director to each Division and the power plant shall be delegated, and when the managerial resources are categorized into three components: human, structural (facilities) and financial, the organizational structure shall be established in order to clarify managerial responsibilities for each activity of human, structural (facilities) and financial issues. The delegation of power to be institutionalized at CPGCBL will be discussed later in 12.4.2 (3).

1) Capacity Building for Human Capital Management

Human capital is the most important management source among the three components (human, structural (facilities), and financial) because of increased value after usage. The key issue is for the personnel manager to have full responsibility for developing and maximizing personnel capabilities. Therefore, the capacity building for human capital management is recommended via the creation of the Chief Human Capital Officer (CHCO) position as a core leader, by introducing a human capital management system (Performance evaluation system, and Human capital development).

2) Capacity Building for Financial Management

Due to corporatization, the power plant shall transform into a Profit Center to produce profits. When the power plants becomes a Strategic Business Unit (SBU), the plant shall implement not only cost and earnings management, but also capital control, since the plant will need to evaluate the financial feasibility of investment activity, including rehabilitation and repairs, independently. Therefore, in order to cope with these environmental changes, capacity building for financial management is recommended via the creation of the Chief Financial Officer (CFO) position as a core leader.

3) Capacity Building for Information Management

The individual division manages information and data, so that no specific division comprehensively manages such dispersed data in a cross-sectional manner. The MD’s office should have full responsibility to strengthen information management capability. The MD’s office will have the ability to gather, analyze, and compile managerial information and data in a comprehensive manner via a database. The MD’s office should also be responsible for providing such information promptly and adequately to not only the directors, but to other departments upon request.

(6) Internal Rules and Regulations

Being a newly established company, CPGCBL has institutionalized no internal rules and regulations. CPGCBL may have needs to introduce appropriate rules and regulations which will include but not be limited to the following ones;

Table 12.2-3 Rules and Regulations to be Introduced at CPGCBL

	Rules and Regulations	Purpose	Time Limit for Introduction	Party for Drafting
General	Labor Regulations	To define the terms and conditions for the employees of the company.	Before recruitment of employees	CPGCBL
	Board Member Role and Structure	To define the role, conditions and structure for efficient management.	As soon as possible	CPGCBL
	Company Policy	To define the company policy for efficient management.	Before recruitment of employees	CPGCBL
	Office Organization and Administrative Authority	To define the office organization and administrative authority for controlling job quality and efficient management.	Before recruitment of employees	CPGCBL
	Safety Management	To define the safety management system for efficient management.	Before Construction start	CPGCBL
	Safety Education and Training	To establish the safety education and training system for preventing labor's accidents.	Before Construction start	CPGCBL
	Control of Labor Health and Hygiene	To define the structure of labor health and hygiene control for labor's health and hygiene work space.	Before Construction start	CPGCBL

	Rules and Regulations	Purpose	Time Limit for Introduction	Party for Drafting
General	Basic Social Insurance	To define the basic social insurance for protecting the rights of labor.	Before recruitment of employees	CPGCBL
	Data management system	To establish the data management system for efficient job condition and preventing the information leakage.	Before Commissioning Date	CPGCBL
	Control of Environmental Condition	To define the environmental condition control for preventing environmental pollution.	Before Commissioning Date	CPGCBL
	Basic Education and Training	To establish the education and training system for improvement human capacity.	Before Commissioning Date	CPGCBL
	Technical Qualification and Competency	To establish the technical qualification and competency system for improvement human capacity.	Before Commissioning Date	CPGCBL
	Operation and Maintenance	To establish the operation and maintenance system for efficient operation and maintenance of power plant facility.	Before Commissioning Date	CPGCBL
Financial and Accounting	Accounting Policy	To establish the company’s policy to be adhered to in performing the accounting function of the company’s business activities.	Before Procurement Contract	CPGCBL
	Accounting Manual	To establish the rule and procedures for performing the accounting function of the company’s business activities.	Before Procurement Contract	CPGCBL
	Charts of Accounts	To facilitate the record keeping process for accounting, all ledger accounts are assigned a descriptive account title clearly defined..	Before Procurement Contract	CPGCBL
	Delegation of Power	To define the limits of authority delegated to the officer occupying each designated positions.	Before Procurement Contract	CPGCBL
	Budget Control Management	To prepare, compile, finalize, implement, monitor and control the utilization of the budget in appropriate manner.	Before Procurement Contract	CPGCBL
	Internal Audit	To assess and evaluate if the company’s business operations are conducted in proper manner vis-à-vis the corporate policy, business plan and rules and regulations.	Before Procurement Contract	CPGCBL
	Purchase Management	To establish the rule and procedures for performing the purchasing function of the company.	Before Commissioning Date	CPGCBL
	Store Control & Management	To establish the rule and procedures for controlling the inventory and store managing function of the company.	Before Commissioning Date	CPGCBL

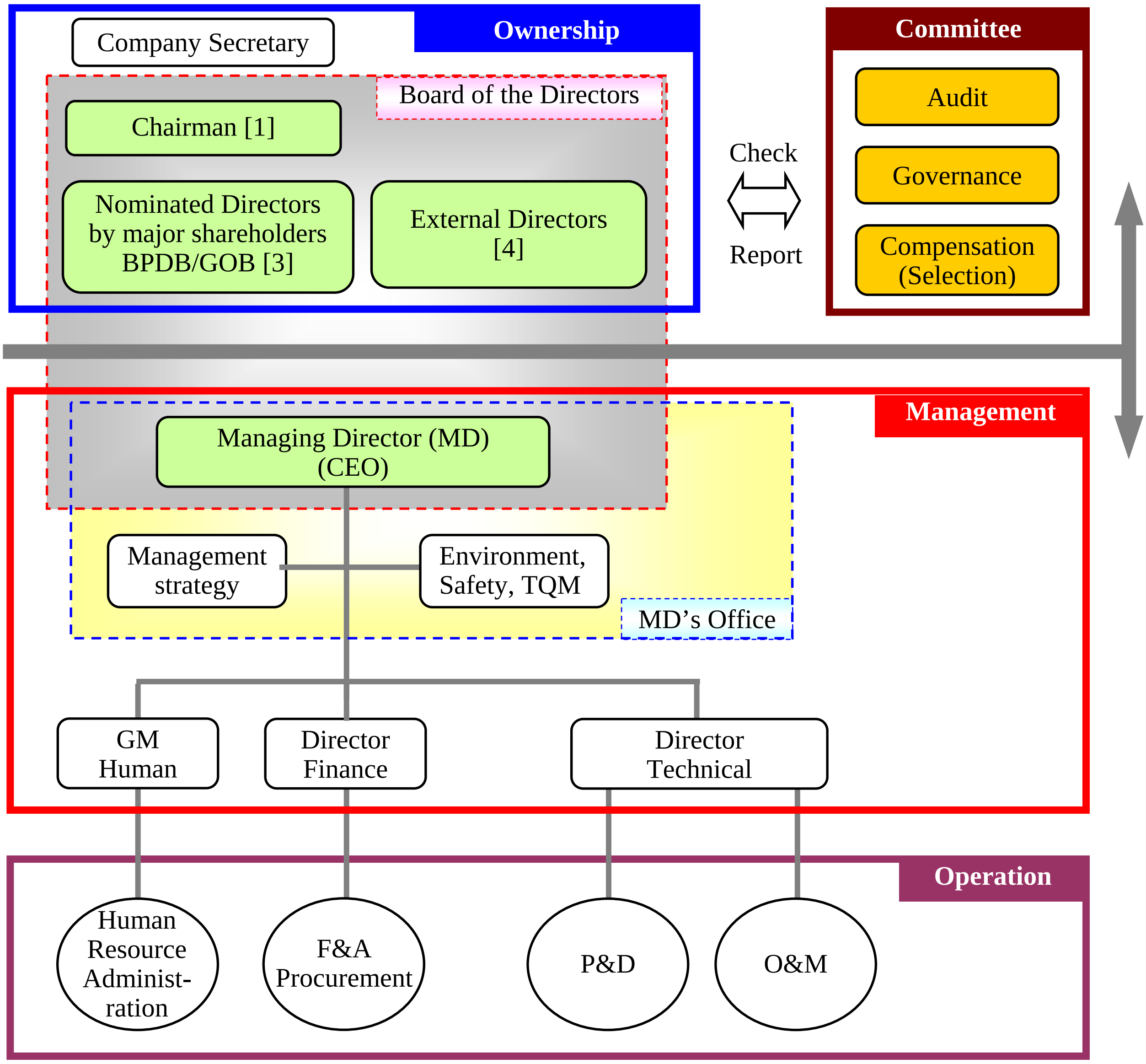
	Rules and Regulations	Purpose	Time Limit for Introduction	Party for Drafting
Financial and Accounting	Fixed Assets Management	To establish the rule and procedures for controlling the fixed assets managing function of the company.	Before Commissioning Date	CPGCBL
	Billing & Account Receivable Management	To establish the rule and procedures for controlling the billing and account receivable managing function of the company.	Before Commissioning Date	CPGCBL
	Standards for Tax Practice	To establish the tax practice system for preventing the misconduct.	Before Procurement Contract	CPGCBL
	Consignment Contract	To establish the consignment contract system for efficient job condition and preventing the misconduct.	Before Procurement Contract	CPGCBL
	Construction Service Contract	To establish the construction service contract system for efficient job condition and preventing the misconduct.	Before Procurement Contract	CPGCBL

(source: JICA Study Team)

The rules and regulations listed above are such that BPDB and its subsidiary companies have precedent cases of introduction and that the preparation and adoption can be done at the full discretion of CPGCBL who should be staffed properly so that it can prepare all of the above rules and regulations by the time limit specified above.

(7) Corporate governance system

Based on the above-mentioned discussion, the Study Team proposes the corporate governance system of the CPGCBL as follows.



(Source: JICA Study Team)

Figure 12.2-2 Corporate Governance System based on the Principle of Separating the Execution and Supervisory Functions of Management

If the number of the power plants increases, the Director Technical is separated into the Director P&D and Director O&M in consideration of the amount of the business.

12.3 Human Resource Management

12.3.1 Policy of human resource management

(1) Direction in Human Capital Management which should be aimed for by CPGCBL

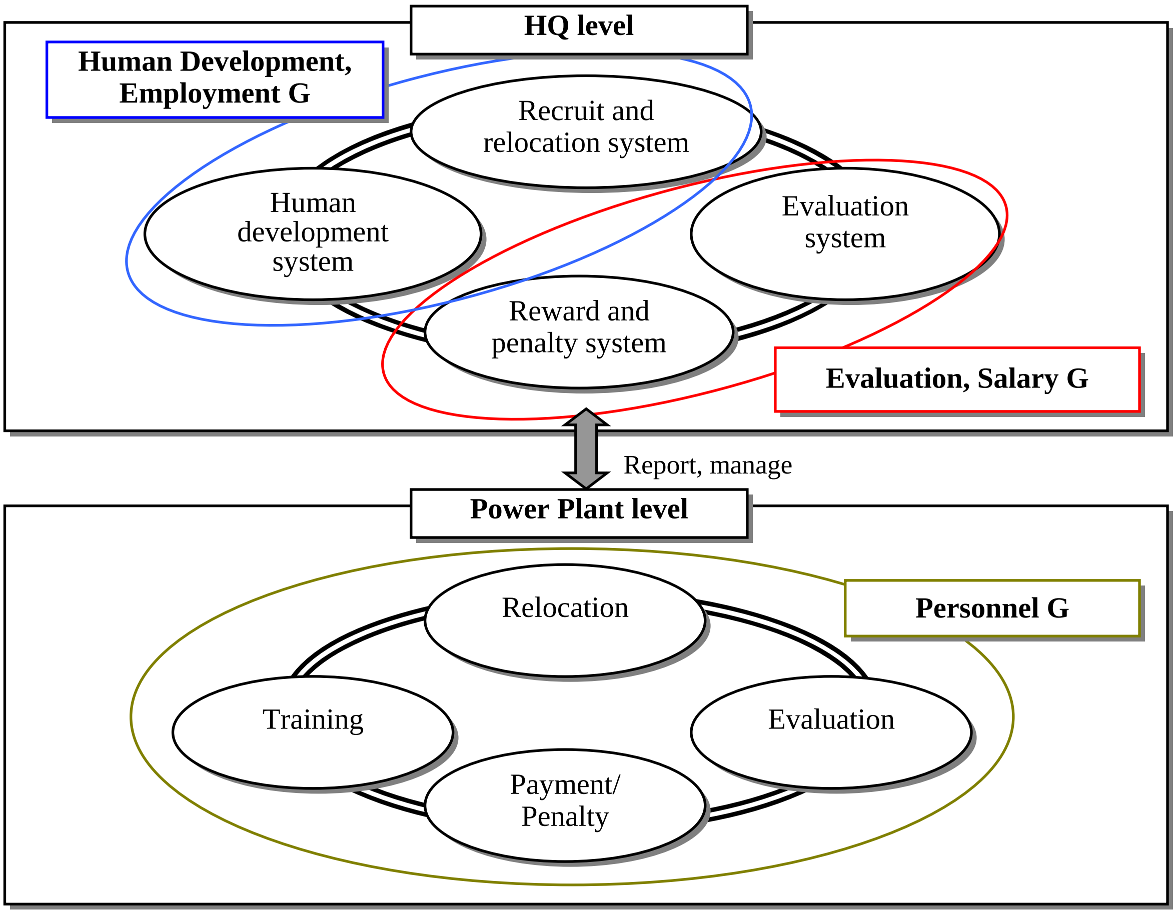
The direction of human resource management aimed for by CPGCBL should keep an eye on growth potential of human resources in order to secure independent business operations and to conduct management as an organization having high management capabilities and technology based on the local community.

Therefore, the human resource management of CPGCBL should clarify the roles and responsibilities of each individual, evaluate the working performance via a transparent and fair process, pay compensation properly according to the evaluation, see the human resource as an asset, invest into and maximize the assets and thus maximize the organization’s value.

(2) The Job Description concerning the Career Development Program of the Headquarters and Power Station

A career development program consists of four systems shown in the following figure. These 4 systems, such as what kind of talented person are being secured, arranging the right man in the right place, and what kind of standard evaluating capability and achievements, and proper remuneration based on the evaluation results, collaborate with each other and enable the achievement and realization of management visions.

Among these, as a headquarters function, from a broad perspective, a personnel training plan and an employment plan are to be established, and the arrangement of personnel, performance evaluation, determination of remuneration, and the implementation of training are performed as a power plant function. All of the data regarding human capital shall be kept and managed by the headquarters.



(Source: JICA Study Team)

Figure 12.3-1 Functions between HQ and P/P for Human Resource Management

12.3.2 Organizational management system

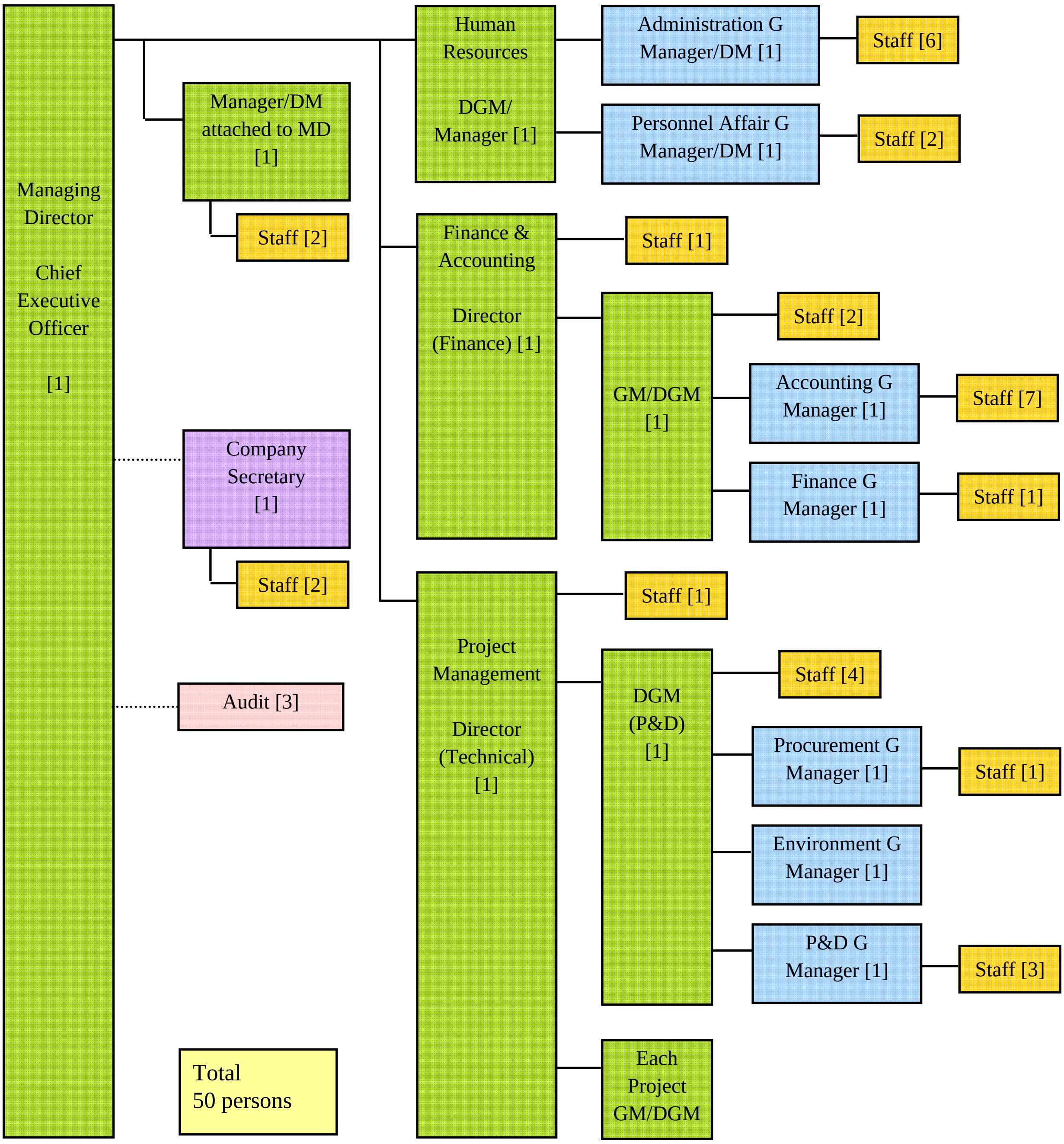
There are EGCB, APSCL, and NWPGCL in the BPDB subsidiary company that carries out power generation business same as CPGCBL. Among these, the EGCB's case becomes good reference in studying the organization of CPGCPL's headquarters based on the following reason.

- The size of company is almost similar.
- The function of headquarters and power plant is clearly divided.
- The organization of the headquarters has been almost well-established.

Referring to the EGCB case precedent, the Study Team proposes an organizational chart of the headquarters of the CPGCBL. The CPGCBL is a company that has just been established and is now gradually increasing its number of staff. The Study Team proposes the number of necessary staff at each step.

(1) EGCB case

The organizational chart of the EGCB headquarters at present (as of August, 2012) is shown below. The number of employees is 50, excluding the number of employees who are promoting each project. The driver and attendant are excluded from the number of employees.



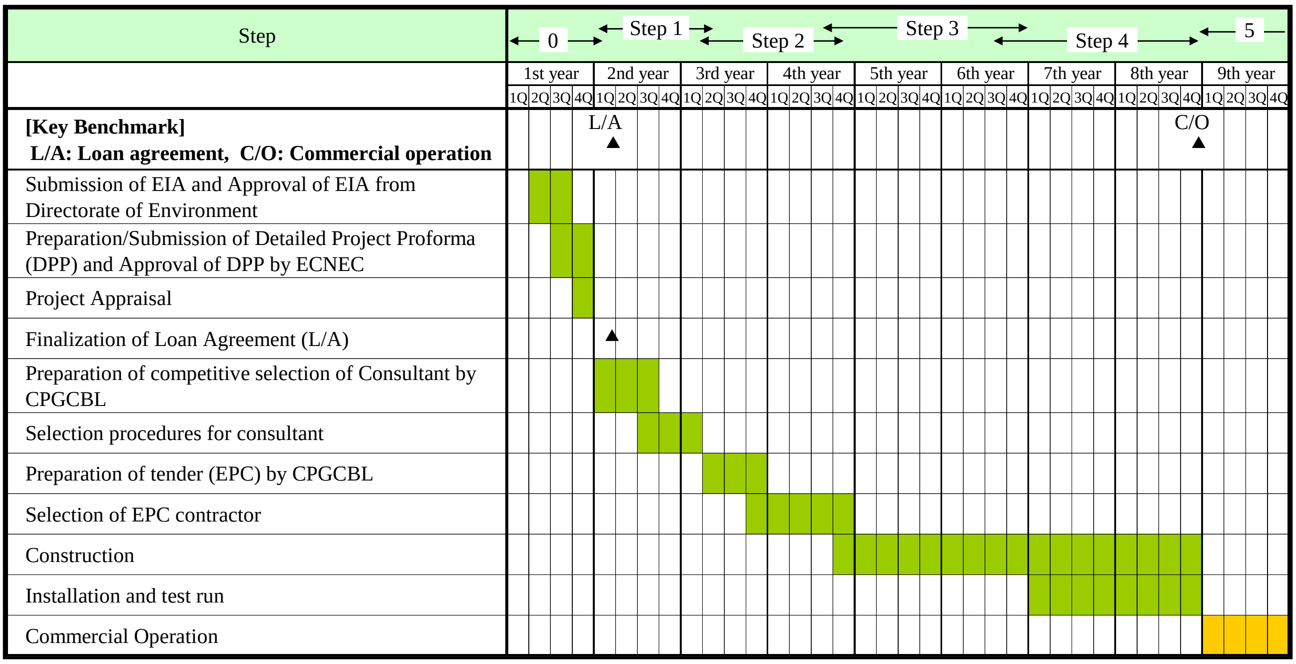
(Source: EGCB, modified by JICA Study Team)

Figure 12.3-2 Organizational Chart of the EGCB Headquarters (as of August, 2012)

(2) Schedule of Each Step

The following table shows the time frame in each step.

Table 12.3-1 Schedule of Each Step



(Source: JICA Study Team)

The main execution work in each step is as follows.

- Step 0: Creation of EIA and DPP and getting approval of them
- Step 1: Selection of Consultant
- Step 2: Selection of EPC Contractor
- Step 3: Construction (mainly civil work)
- Step 4: Construction (mainly installation and test run)
- Step 5: Commercial operation

(3) Necessary staff and organizational chart of CPGCBL headquarters at each step

The contents of the execution work in each step are shown below.

Table 12.3-2 Content of the Execution Work in Each Step

<table>
<tr><th rowspan="2"></th><th>Step 1</th><th>Step 2</th><th>Step 3</th><th>Step 4</th></tr>
<tr><th>Selection of Consultant</th><th>Selection of EPC contractor</th><th>Construction</th><th>Installation & Test run</th></tr>
<tr><td>MD’s staff</td><td colspan="4">Editing bureau of annual report, Inspector of operation of each department, Guidance and advice for head of each department in a position across boundaries as the MD’s staff</td></tr>
<tr><td>Administration</td><td colspan="4">Planning of Organizational Management System, Window of external negotiation, Administration of power plant site and security</td></tr>
<tr><td rowspan="2">Human Resources</td><td colspan="2">Personnel recruitment: Headquarter 20 staffs + core staffs in power plant</td><td colspan="2">Personnel recruitment: Headquarter 30 staffs + power plant 130 staffs</td></tr>
<tr><td colspan="4">Creation and development of training plan for new staffs</td></tr>
<tr><td>Financing & Accounting</td><td colspan="4">Financing and accounting, Creation of balance sheets for construction period and after commencement of commercial operation</td></tr>
<tr><td rowspan="2">Procurement</td><td colspan="2">Window of procurements exclude main plant</td><td colspan="2">Selection of equipment exclude main plant
Creation of order specification sheets</td></tr>
<tr><td colspan="2"></td><td colspan="2">Examination of consignment contract for ordinary operation, Conclusion of consignment contracts for ordinary operation</td></tr>
<tr><td rowspan="2">(Fuel)</td><td></td><td>Creation of tender documents for coal procurement</td><td colspan="2">Evaluation of technical and financial proposal
Conclusion of coal procurement contract
Decision of concrete schedule of coal transportation ship</td></tr>
<tr><td colspan="2"></td><td colspan="2">Examination of candidates and transportation method of auxiliary fuel procurement</td></tr>
<tr><td rowspan="3">Planning & Design (P&D)</td><td>Creation of tender documents
Evaluation of technical and financial proposal
Selection of consultant</td><td>Discussion of plant specifications with the consultant
Creation of tender documents
Evaluation of technical and financial proposal
Selection of EPC contractor</td><td>Supervising of civil works
Designing of facilities
Planning of technical transfer using drawings, technical documents and manual from manufacturer</td><td>Supervising of facility installment
Acquirement of technical skill trough troubleshooting in construction period</td></tr>
<tr><td colspan="2">Study of operation and maintenance work of similar specification power plant (including site survey)</td><td colspan="2">Establish a material center
(Adopting centralized management system for drawings, sequence diagrams, technical documents and manual from manufacturer)</td></tr>
<tr><td colspan="2"></td><td colspan="2">Study of the power plant maintenance skill level in Bangladesh</td></tr>
<tr><td>Operation & Maintenance (O&M)</td><td colspan="2"></td><td colspan="2">Acquirement of technical skill using drawings, technical documents and manual from manufacturer
Planning of training curriculum using simulator
Creation of database for structural drawings, intensity calculation and of the sequence diagrams, technical documents and used material from manufacturer
Creation of necessary main and auxiliary parts</td></tr>
</table>

	Step 1	Step 2	Step 3	Step 4
	Selection of Consultant	Selection of EPC contractor	Construction	Installation & Test run
			list for repairing	
				Acquirement of technical skill through facility installation and test run

(Source: JICA Study Team)

The main execution work in step 0 is the creation of EIA, creation of the DPP, and the conclusion of L/A.

The main work contents in Step 5 of the Technical section (After commercial operations) are shown below.

- to support issue solving concerning the power plant maintenance
- to manage the power plant operating situation
- adjustment of the scheduled outage plan
- mid/long-term maintenance plan
- replacement plan for the high temperature high-pressure material (a mid/long-term budget plan)

The Study Team proposes the number of staff for each step referring to the amount of execution work in each step and an example of EGCB as follows.

Table 12.3-3 Staff Number List of Each Step (Draft)

Domain	Step 0	Step 1	Step 2	Step 3	Step 4	Step 5
Managing Director	1	1	1	1	1	1
MD's staff	1	2	2	2	2	2
Director	2	2	2	2	2	2
Administration Department	7	13	15	16	19	19
Administration	1	3	4	4	4	4
Finance & Accounting	3	4	4	4	4	4
Human resource management	2	4	4	4	4	4
Fuel, Procurement	1	2	3	4	7	7
Technical Department	3	6	11	23	23	23
Planning & Design	3	6	11	11	11	11
Operation & Maintenance				12	12	12
Total	15	24	31	44	47	47
Audit	1	1	1	3	3	3

(Source: JICA Study Team)

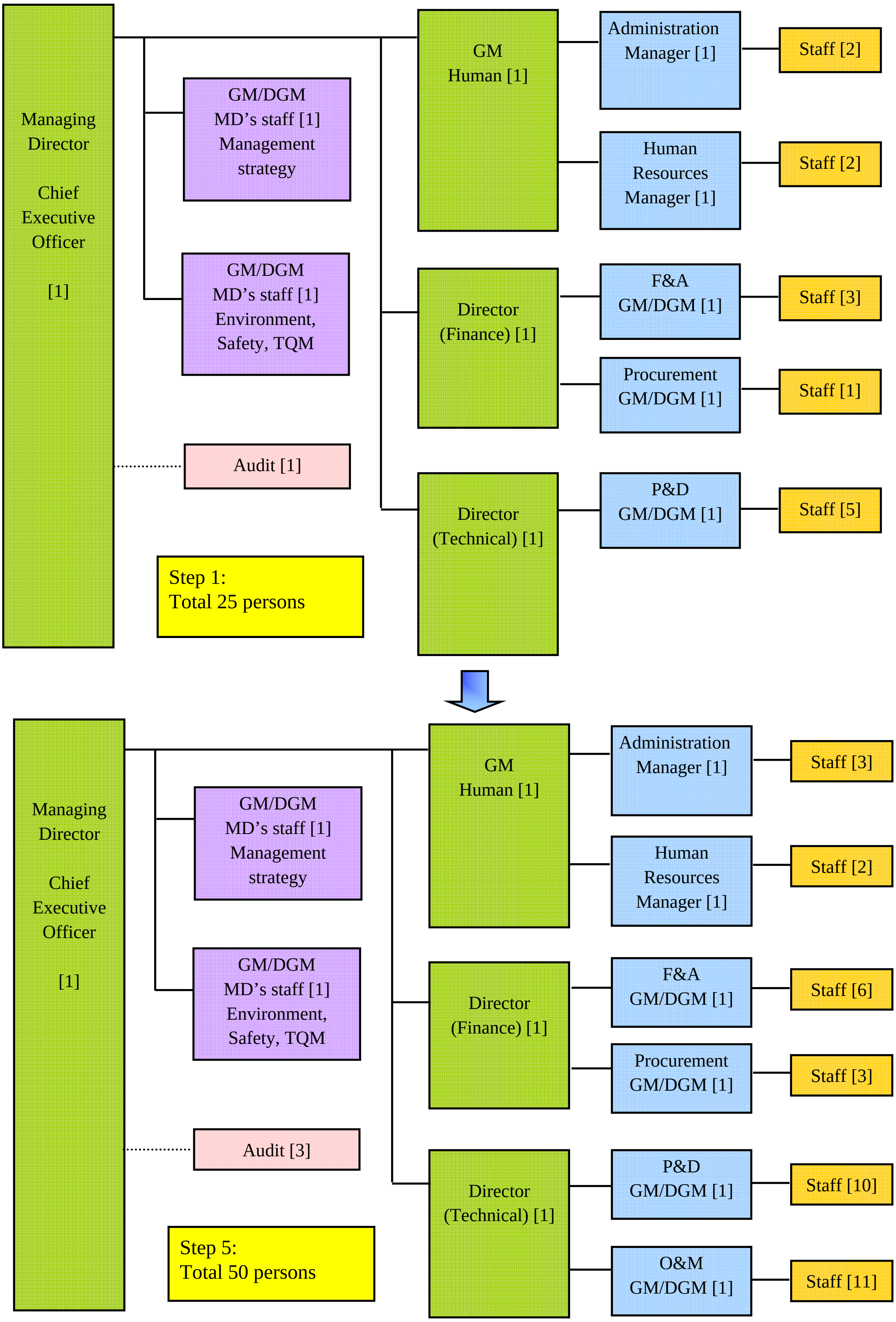


Figure 12.3-3 Organizational Chart of the CPGCBL (Step 1 & Step 5)

12.3.3 Recruitment

In order to fill the positions that are identified based on the organizational structure and manpower estimation, it is necessary to recruit persons from various sources. The selection of the right choice of candidates in the organization plays a vital role in its effective functioning. The recruitment system in the new power plant under CPGCBL is proposed by referring to some of the best recruitment practices prevailing within various public utilities as detailed below.

(1) Comparison of the recruitment process and the employment conditions of the Bangladesh Public Utilities

The recruiting methods, the selection process, the employment conditions and the selection committee of the Bangladesh Public Utilities are summarized in the following table.

Table 12.3-4 Comparison of the Recruitment Process and the Employment Conditions of the Bangladesh Public Utilities

Company	Recruiting methods	Selection process	Employment conditions	Composition of selection committee
BPDB	▪ Recruitment begins after advertising the position(s) in daily newspapers. ▪ The Positions are filled through Direct Recruitment and Promotion except for entry level posts.	Candidates need to appear for Written, Oral and practical examinations and tests (wherever necessary), decided by the Selection Committee. Candidates are selected based on: ▪ Comprehensive marks given by the Members of the Selection Committee and their marks from written, oral and practical examinations & tests ▪ Candidates (except Class IV posts) also need to clear a Physical Fitness test, conducted by a Medical Officer, nominated by the appointing authority. Before appointment, candidates also need to obtain a satisfactory report from the police about his antecedents	▪ Candidates selected for appointment by direct recruitment is generally appointed on probation for a period of one year (subjected to extension) ▪ A candidate should be aged between 18 – 30 years to be considered for appointment (the Board may relax the upper age limit if the candidate has special technical qualifications or experience	▪ Class I Officers are selected by Board Members ▪ Class II Officers are selected by a Board Member & 2 senior officers nominated by the Board ▪ Class III / IV are selected by committee formed by CE / SE whosoever is competent
APSCL	The Positions are filled through direct recruitment or Promotion except for entry level post. Recruitment methods: ▪ All direct recruitment is made after advertising at least in two widely circulated national daily Newspapers. Promotion Methods: ▪ Promotions to the other posts shall be given by the Managing Director on the recommendation of the appropriate selection committee for recruitment.	▪ Written and oral and practical testing wherever necessary is being conducted. ▪ All candidates are assessed and evaluated separately as per the criteria set by the Appointing Authority. Candidates need to take a written test and candidates scoring 50% on the written test are generally called in for an oral test. The comprehensive marks (80% Marks for Written Test & 20% Marks for Oral Test) given by the members of the Selection Committee and where applicable the marks obtained in the examination and test determine the position of the candidates and the Selection Committee make recommendations in order of merit list. ▪ Physical Fitness Test conducted by company Medical Officer before oral test. Promotion: For Sr. Engineer/Dy. Manager to General Manager employee should meet following criteria(s) ▪ 3 years service period in Feeder post ▪ No. departmental penalty against the employee. ▪ At least average 80% score in three Annual Confidential Report. ▪ Merit of the Employees is evaluated in 100 marks scale. For Sr. Engineer/Dy. Manager and Manager: Written Test-50, Oral Test-20, Educational Qualification-20, Training-5 & Experience-5. For DGM/GM: Written Test-40, Oral Test-20, Educational Qualification-20, Training-10 & Experience-10.	▪ Candidates are selected for appointment by direct recruitment is generally appointed on probation for a period of one year, which may be extended. ▪ The successful candidates need to obtain a satisfactory report from the police about his antecedents. ▪ Employees get a maximum of five years of contract on successful completion of probationary period (inclusive of probationary period) ▪ A candidate should be minimum 18 years old to be considered for appointment	▪ In the case of post of Managing Director, Executive Director(s) and General Manager, the selection committee is comprised of Chairman of the Board of Directors as Chairman and other Board Directors as members. ▪ In the Case of Dy. General Manager, Manager, Dy. Manager, Jr. Manager concerned Director (Technical/Finance) as Chairman and other director (Technical/Finance) as member. ▪ In the case of post of lower than Jr. Engineer/ Jr. Manager, General Manager as Chairman, all Dy. General Manager(s) as member(s). *For transparency in selection process one expert member from outside of APSCL is included in all selection committee.
EGCB	▪ Recruitment begins after advertising the position(s) in at least two widely circulated national daily newspapers. ▪ Positions are filled through direct recruitment, promotion or absorption	The Selection process begins with screening out unqualified candidates and screening in those who meets the initial selection criteria. Then the candidates, for the selection of first entry post, need to go through a written test, followed by interview(s) and a medical check up. Candidates are selected based on: ▪ Candidates securing qualifying marks decided by the authority. ▪ List of successful candidates is prepared on merit basis, i.e. by adding the scores from the written test and the interview. ▪ Except first entry post, other posts are filled up either by interview or by both written & interview. ▪ The successful candidates need to obtain a satisfactory report from the police about his past experience after joining the post for service confirmation. ▪ Candidates need to clear a Physical Fitness test, conducted by a registered physician.	▪ Candidates selected for appointment by direct recruitment is generally appointed for 3 to 5 years including probation for a period of one year, which is subjected to extension. After successful completion of probation period, the service is confirmed.	▪ Chairman, EGCB, as chairman & other Directors of the Board as members for the selection of MD, Director (Tech.) & Director (Finance). ▪ Full time Director as chairman while other Officers are members for selection of other post up to the rank of GM
DESCO	▪ All appointments by direct recruitment shall be made after the same is advertised in at least two national daily newspapers. But to cater exigency, the Board of directors may waive and decide otherwise to arrange/ensure immediate recruitment. Existing employees of DESCO with required qualification may apply for an advertised post through their line managers. ▪ Positions are filled through direct recruitment and promotion expect for entry level posts.	The short listed candidates on approval by the Managing Director may be called for interview(s) and suitable testing. ▪ DESCO may undertake some or all of the following tests or may adapt any other appropriate devices in selection process: 1) written test 2) Interview 3) Practical operation / Technical test ▪ The aggregate of the marks given by each member of the selection committee in the interview and where applicable the marks obtained in the written test and viva voce shall determine the position of the candidate and the selection committee shall make recommendation in order of merit. In case of obtaining the same marks, the older candidate will be given preference/ranked higher.	▪ A Candidate should be minimum 18 years old to be considered for appointment. ▪ Candidates selected for appointment by direct recruitment is generally appointed on probation for a period of one year, which is subjected to extension. ▪ Employees get a maximum of 5 years of contract on successful completion of probationary period. ▪ Renewal of service contract of DESCO employee on the basic of performance evaluation/score points.	

<table>
<tr><th>Company</th><th>Recruiting methods</th><th>Selection process</th><th>Employment conditions</th><th>Composition of selection committee</th></tr>
<tr><td>PGCB</td><td>• Recruitment begins after advertising the position(s) by widely circulated daily newspaper.
• The positions are filled through Directed Recruitment and Promotion except for entry level posts.</td><td>Selection process begins with screening among the candidates who fulfilled the primary criteria on the basis of circulation after that the candidates need to appear for Written, Oral and Practical Examinations and tests (wherever necessary), decided by the Selection Committee. Candidates are selected based on :
• Comprehensive marks given by the Members of the Selection Committee and their marks from written, oral and practical examinations & test.
• List of successful candidates prepares on merit basis by adding the scores from the written test, the Viva Voce and other practical examinations (If necessary)
• The successful candidates need to obtain a satisfactory report from the police about his antecedents.
• Candidates also need to clean a physical fitness test conducted by a Medical Officer by any registered doctor.</td><td>• Candidates selected for appointment by direct recruitment is generally appointed on probation for a period of one year.
• A candidate should be aged between 18-30 years (32 years for son/ daughter's of Freedom Fighter) to be considered for appointment (the Board may relax the upper limit of age on the grounds of special technical qualification or experience.</td><td>• Above the post of Managers are selected by Board of Directors, PGCB and other posts are selected committee formed by Managing Director / Director (Executives) whosoever is competent.</td></tr>
<tr><td>NWPGCL</td><td>▪ Recruitment begins after advertising the position(s) in at least two widely circulated national daily newspapers.
▪ Positions are filled through direct recruitment and promotion.</td><td>The Selection process begins with screening out unqualified candidates and a short-list for the qualified candidates is prepared Then the qualified candidates need to go through a written test, followed by interview(s). Candidates are selected based on:
▪ The Candidates who get the qualified marks (set by the authority) in written test are qualified for the subsequent interview.
▪ For the purpose of transparent and fair selection marks obtained in written test out of 100 are converted to 67% and the marks obtained in interview out of 100 are converted to 33%. Then the aggregate number reflects the merit order.
▪ A merit list is prepared by compilation of the pro rata marks getting from the written test and the interview.
▪ The candidates are selected for appointment based on the top merit order from the merit list.</td><td>▪ Candidates selected for appointment by direct recruitment are generally appointed on probation for a period of one year, (subjected to extension).
▪ Employees get three to five years of contract on successful completion of probationary period (inclusive of probationary period)</td><td>As per approved and exercised Employees Service Rules- 2010 of NWPGCL
A .Appointment by direct recruitment is made by the company on the recommendations of the selection committee which shall-
1. In the case of posts of Managing Director and Executive Directors and Company Secretary, be comprised of Chairman of Board of Directors as the Chairman and other Directors as Members;
2. In the case of posts of General Managers, Deputy General Managers, Managers, Deputy Managers and Assistant Managers and other similar posts (equivalent), be comprised of concerned full time (Executive) Director as Chairman and others full time Director(s) as Members and
3. In the case of other posts, be comprised of concerned General Manager / Deputy General Manager as Chairman and other 3 (three) Members nominated by the Managing Director.
B. The Managing Director shall nominate the Committee Members.</td></tr>
</table>

(Source: Hearing from each company)

(2) Key Lessons from Previous Experience

Key Lessons from Previous Experience are shown as follows.

1) Recruiting methods

Although many companies utilized the newspaper advertisement for a job offer, the PGCB successfully utilizes its Internet homepage not only for advertising but also to disseminate a wide range of information such as scheduled-outages, resulting in the strengthening of the relationship between the local communities and the company.

2) Employment conditions

When vacant seats are available, at most companies, they are filled via direct employment from the outside, and internal employment, or transferring from BPDB. For the case of the EGCB and the Ashuganj, such vacancies have been filled by the transfer of employees on deputation ('lien') from BPDB to the company. However, the company where lien basis employees are accepted has a double standard for the salary, performance evaluation, and promotion systems. Under Bangladesh's circumstances, the intensification of labor union activities can be seen, and such a double standard system causes the ramification of the smooth transfer of the employees from their existing jobs to the new company.

3) Employment terms

At the previous corporatized companies, a trial employment period for one year in the beginning is introduced, and it will enter into an official employment agreement only when the employees' performance satisfies the expected standard. At EGCB, PGCB, and DESCO, the next contract will not be entered into if the performance for the contract terms of 3 to 5 years as a full-time employee, does not meet the criteria.

4) Selection Process

In the selection method, most of the companies carried out a Technical Test, Behavioral Test, Practical Test, and Fitness Test. In addition, some companies even carry out background checks. In the EGCB case, an applicant is burdened with a written examination as the first selection. The outline of the examination is composed of three parts; analysis ability, technical knowledge, and general educational background, and technical knowledge occupy 50% of the whole. No less than 60% of a response rate will be determined as the acceptance line, and a successful candidate will progress to an interview as the second selection. The interview estimated the adaptability to talent for making presentations, communications skills, technical knowledge, general education, and groups, etc., and no less than 60% is determined as its acceptance line. Whereas at most corporatized companies, they have introduced multilateral evaluation systems such as testing technical knowledge, technical skills, and moral tests, in particular, the EGCB is superior than other systems in terms of showing a fair and transparent numerical evaluation system by setting up a scoring system and an acceptance line.

5) Personnel relocation system (Job rotation system)

At the previous corporatized companies, whereas a training program based on OJT has been implemented, there are few companies which utilize the job rotation system to foster human capital by having a wide range of experience. This is caused by a lack of long-term manpower planning and career visions for each employee.

(3) Recommendation of the CPGCBL recruitment process and employment conditions

The following proposals are for the recruitment process and employment conditions in the new power plant under CPGCBL by referring to some of the best practices at the Bangladesh public utilities.

1) Qualification requirements

Since the new CPGCBL power plant is the newly constructed plant, all of the plant workers are to be employed under the new employment policy in principle. Therefore all the applicants should be given equal opportunity including other existing BPDB plant and IPP plant workers. The new applicant hires should be conducted in a fair manner and a high transparency in selection process.

2) Recruiting methods

Good practices at Bangladesh public utilities shall prevail. The creation of a CPGCBL internet homepage to disseminate a wide range of information from the company to strengthen relationships with the local communities and the company is recommended.
The necessary number of headquarter staff for each step is shown in the Table 12.3-3. According to the Table 12.3-3 schedule, the new applicant hires should be conducted. And the necessary number of staff in the power plant is shown in Figure 13.1-2. The new applicant hires for the power plant should be conducted at the time of a construction

start. Moreover after commercial operation, in case there has a vacancy for the staff, the new applicant hires should be conducted if needed.

3) Selection Process

From the perspective of being able to secure employees with superior capabilities, a job offer shall be advertised through the newspaper or the Internet, and a two-step selection via the written examination and interview will be conducted. In this selection process, an examination shall contain not only technical knowledge but also gauge analytical ability by checking comprehensive knowledge including general educational knowledge. Moreover, it is necessary to perform multiple evaluations and to clarify the criteria for selection points in a very transparent manner. The recruitment examination of EGCB is shown in the following table.

Table 12.3-5 Recruitment Examination (EGCB case)

1st examination: paper based writing test		
Section	Point	Time
Questions on Analytical Ability	15	15 min
Questions on Relevant Subject	25	30 min
Questions on General Knowledge	10	15 min
Sub total (A)	50	60 min
2nd examination, interview		
Communication & Presentation Skills	12	
Human Relations Skills	8	
Knowledge about Subject Matter	10	
General Knowledge	10	
Overall Impression / Appearance	5	
Ability to work in teams through the candidate’s degree of involvement in sports, cultural/social works, etc.	5	
Sub total (B)	50	
Grand total (A+B)	100	

(Source: Hearing from EGCB)

Although the detail contents and point allocation of the recruitment examination is decided by the Selection Committee of CPGCBL based on the best practices at the Bangladesh public utilities, such as EGCB, the Study Team recommends above recruitment examination of EGCB.

4) Employment system

In employment system, a trial employment period of one year, the same as APSCL shall be made for the first time, and an employment agreement for five years for full-time employees shall be concluded when the trial employment of one year has successfully been completed. After five years, an employment contract will be renewed depending on the performance evaluation results.

In order to have the company provide employees with a working place, the company has to have existed and grown continuously, and from the perspective of independence of management, and sustainable development as indicated in the management visions, the implementation of efficient management of human capital is a must. From the employee's perspective towards the work environment, a performance-based employment contract for five years shall be introduced and only the person who works for the company shall be considered for not only the company's sustainable development, but also the employee's sustainable development.

(4) Comparison of Compensation (Basic Pay) and Incentive System of Bangladesh Public Utilities

The compensation (Basic Pay) and incentive system of the Bangladesh Public Utilities are summarized in the following table for proposing CPGCBL compensation and an incentive system.

Table 12.3-6 Comparison of Compensation (Basic Pay) and Incentive System of Bangladesh Public Utilities

(Source: Hearing from each company)

<table>
<tr><th>Company</th><th>Basic Pay Structure</th><th>Incentive and Benefit</th></tr>
<tr><td>BPDB</td><td>
<table>
<tr><th>Levels/
Designations</th><th>BPDB
Pay scale</th><th>Basic Pay
(Tk.)</th></tr>
<tr><td>CE</td><td>16800-20700</td><td>16800</td></tr>
<tr><td>SE</td><td>15000-19800</td><td>15000</td></tr>
<tr><td>EE</td><td>13750-19250</td><td>13750</td></tr>
<tr><td>SDE</td><td>11000-17650</td><td>11000</td></tr>
<tr><td>AE</td><td>9000-15480</td><td>9000</td></tr>
</table>
</td><td>
▪ Incentive / Bonus: Employees are eligible for an annual incentive based on the performance of their respective departments. In addition, employees receive a festival bonus twice a year (equivalent to one month’s basic pay) to celebrate important festivals.
▪ Compensatory Allowance: Employees draw compensatory allowance attached to his post. The compensatory allowance is also admissible during the leave including leave preparatory to retirement.
▪ The house rent support may be drawn during temporary transfer for a period not exceeding four months provided the authority ordering the transfer certifies in the order that the employee is likely to return to duty to the same station on expiry of such transfer. The house rent support may also be drawn during leave preparatory to retirement.
▪ Honorarium: The competent authority may grant an honorarium to an employee for work performed which would be of exceptional character and either so laborious or of such special merit as to justify a special reward.
▪ Overtime Allowance: Overtime allowance for extra hours of work is allowed by the controlling officer at such rates as may be prescribed by the Government to the employees when required to work beyond the normal working hours in operation. The total overtime hours is not to exceed eight hours in a week. However, this limit may be relaxed in case of emergency with the consent of concerned Member of the Board.
▪ Shift Duty Allowance: The employees, when required to work regularly on rotating shift, is allowed shift duty allowance at such rates as prescribed by the Government.
▪ Annual Increment: The annual increment in the time scale of pay is drawn.
▪ Medical Allowance: Employees at BPDB receive Tk 500/- per month for medical expenses which the employee or his family members may incur.
▪ Retirement Benefits: Retirement benefits are provided.
▪ Retirement Benefits: The following retirement benefits are provided:
o Contributory Provident Fund & Gratuity: Employees can contribute towards the Contributory Provident Fund (CPF) which is set at 10% of basic pay. Gratuity is paid as two months basic pay for every year of service.
o Pension: In BPDB, employees can opt for Pension in lieu of CPF and Gratuity as per the latest pension rules. On completion of 25 years of service, the employees are entitled to full pension.
</td></tr>
<tr><td>APSCL</td><td>
<table>
<tr><th>Employee Level</th><th>Basic Pay (Tk.)</th></tr>
<tr><td>Managing Director</td><td>82,500</td></tr>
<tr><td>Director</td><td>67,500</td></tr>
<tr><td>General Manager</td><td>52,500</td></tr>
<tr><td>Deputy General Manager</td><td>45,000</td></tr>
<tr><td>Manager</td><td>39,000</td></tr>
<tr><td>Deputy Manager</td><td>33,000</td></tr>
<tr><td>Assistant Manager</td><td>27,000</td></tr>
<tr><td>Junior Manager</td><td>23,100</td></tr>
<tr><td>Staff Level I</td><td>22,600</td></tr>
<tr><td>Staff Level II</td><td>16,000</td></tr>
<tr><td>Staff Level III</td><td>14,850</td></tr>
<tr><td>Staff Level IV</td><td>11,550</td></tr>
<tr><td>Staff Level V</td><td>8,500</td></tr>
</table>
</td><td>
▪ Residence (family accommodation) is provided by company. In case of unavailability of residence, employee gets 25% of basic pay. In case of single accommodation employee gets 15% of basic pay and 10% basic pay is deducted as house rent.
▪ Overtime Allowance: This is as prescribed by GOB, and normally not to exceed 8 hours/week per employee.
▪ Traveling Allowance: Traveling allowance, fuel allowance and daily allowance are available by grade of employee.
▪ Medical Allowance: Employees at APSCL receive Tk. 1500/- per month (for Manager & below); for others (DGM to Managing Director) actual but not more than two basic pay in a year.
▪ Education Allowance: Minimum Tk. 300/-, Maximum Tk. 500/-
▪ Power House Allowance: 25% Basic Pay per month.
▪ Shift Allowance for employee working in shift: 15% of Basic Pay per month.
▪ CPF (Contributory Provident Fund): 10% of basic pay and APSCL contributes a matching amount to the fund. Before completion of 3 years service a member (employee) gets his own contribution. After completion of 3 years service a member (employee) gets both self contribution as well as company’s contribution.
▪ Gratuity: Two months basic pay for each year. For employees joined before 27 February 2010:- less than three years of service employee not gets any gratuity and after 3 years of service employee gets 100%. For employees joined after 27 February 2010:- less than three years of service employee not gets any gratuity and after 3 years but less than 5 years employee gets 60% and after 5 years or more, employee gets 100%.
</td></tr>
</table>

<table>
<tr><th>Company</th><th>Basic Pay Structure</th><th>Incentive and Benefit</th></tr>
<tr><td>EGCB</td><td>
<table>
<tr><th>Employee Level</th><th>Basic Pay (Tk.)</th></tr>
<tr><td>Managing Director</td><td>90,000</td></tr>
<tr><td>Director</td><td>75,000</td></tr>
<tr><td>General Manager</td><td>60,00</td></tr>
<tr><td>Deputy General Manager</td><td>53,000</td></tr>
<tr><td>Manager</td><td>42,000</td></tr>
<tr><td>Deputy Manager</td><td>34,000</td></tr>
<tr><td>Assistant Manager,Gr-1</td><td>29,000</td></tr>
<tr><td>Assistant Manager,Gr-2</td><td>26,000</td></tr>
<tr><td>Junior Asstt. Manager, Gr-1</td><td>21,100</td></tr>
<tr><td>Junior Asstt. Manager, Gr-2</td><td>20500</td></tr>
</table>
</td><td>
▪ House Rent Allowance: House rent allowance is not admissible wherever company accommodation is available.
▪ Festival bonus: Paying incentive bonuses is not a bar in paying festival bonus.
▪ Electricity Charge: General Managers and below level employees are reimbursed 150 units to 300 + VAT + meter rent per month. For Director level employees and above, the electricity bills are reimbursed up to 400 units
▪ Shift Allowance: This is paid @10% of basic pay provided as the incumbent is assigned to work in shift. This is not paid during the period of leave or absence from duty.
▪ Annual Increment: The minimum annual pay increases by 4% of initial basic pay.
▪ Medical Allowance: Employees are eligible for Medical Allowance, (varies from grade to grade). In addition, employees, as per Medical Rules of the Company, facing any accident resulting in temporary or permanent injury while on duty get ~~full~~ medical treatment at the cost (upto1 month’s basic pay in a year) of the company.
▪ Group Insurance: All employees are covered under a group insurance policy. The coverage is equivalent to 50 months last basic pay but not more than Tk.19 lakes.
▪ Gratuity: Employees are eligible for gratuity, which is equivalent to 2 months basic pay for every year (payable after a minimum of 3 years of service).
</td></tr>
<tr><td>DESCO</td><td>
<table>
<tr><th>Employee Level</th><th>Basic Pay (Tk.)</th></tr>
<tr><td>Managing Director</td><td>100,000</td></tr>
<tr><td>Director</td><td>85,000</td></tr>
<tr><td>General Manager</td><td>70,000</td></tr>
<tr><td>Deputy General Manager</td><td>60,000</td></tr>
<tr><td>Manager</td><td>45,000</td></tr>
<tr><td>Deputy Manager</td><td>35,000</td></tr>
<tr><td>Assistant Manager</td><td>28,000</td></tr>
<tr><td>Junior Manager I</td><td>22,500</td></tr>
<tr><td>Junior Manager II</td><td>18,500</td></tr>
<tr><td>Staff Level I</td><td>15,000</td></tr>
<tr><td>Staff Level II</td><td>13,500</td></tr>
<tr><td>Staff Level III</td><td>12,000</td></tr>
<tr><td>Staff Level IV</td><td>10,000</td></tr>
<tr><td>Staff Level V</td><td>8,500</td></tr>
<tr><td>Staff Level IVI</td><td>7,000</td></tr>
</table>
</td><td>
▪ Incentive / Bonus: All contractual employees of the company shall be entitled to two festival bonus (each equivalent to one month’s basic pay) on the occasion of Eid-ul-Fitr and Eid-ul-Azha (or Puja)
▪ House Rent Allowance: Employees under level 1 to 2 (MD and Director) receives 50% and under level 3 to 15 (GM to Peon) receives 60% of basic pay.
▪ Transport Facilities / Conveyance: MD to DGM get full time transport facilities. Duty car is assigned to Manager to carry out office duties as and when required. Deputy Manager and Assistant Manager level receive either transport facility or 10 % initial basic pay. Employees below Assistant Manager receive 10% of initial basic pay.
▪ Medical Allowance: DESCO contractual employees are entitled to, on presentation of hospital and medical bill and vouchers, reimbursement of all legitimate expenses incurred. Employees under level 1 to 6 reimburse medical expenses (equivalent to three month’s basic per year) and employees under level 7 to 9 reimburse medical expenses equivalent to two month’s basic incurred for self, spouse, dependent children and dependent parents. Employees below level 10 to 15 get Tk. 1,500 per month as medical allowance with their monthly salary.
▪ Annual Increment: On every anniversary of contractual appointment of employee, every one receives an increment of his/her pay group at the rate to be determined from time to time by board.
▪ Contributory Provident fund: All employees can contribute towards the Contributory Provident Fund which is set at 10% of initial basic pay. DESCO will contribute matching amount to the fund. At cessation of employee’s contribution and interest earned.
▪ Electricity Bill: All employees of DESCO will get allowance against electricity bill corresponding to entitled unit (up to 400 units respectively) per month payable with their monthly salary.
▪ Residential Telephone and Cell Phone Charge: For MD and directors, the phone bills (residential and cell phone) are reimbursed at actual basis. The employees under 3 to 5 (GM to Manager) entitled to reimbursement of residential telephone bill. The ceiling of entitlement is Tk. 1,000 to Tk. 2,000 per month. The ceiling of the cell phone for GM to Assistant Manager is Tk. 800 to Tk. 1,800 per month.
▪ Overtime Allowance: As daily overtime allowance, the Drivers shall receive Tk. 150 and office Peons receive Tk. 100 on account of performing duties on holidays and on all working days beyond 8:00 pm and 7:00 pm respectively and a maximum of 20 days overtime in a month shall be allowed.
▪ Group Insurance: All employees are covered by endowment policy. The coverage is equivalent to 12 months last basic pay.
▪ Gratuity: All contractual employees who have completed a minimum of three years of continuous services shall be entitled to gratuity benefit at the rate of two months’ basic salary based on the employee’s last drawn salary for every completed year of service.
▪ Accidental Benefits: If an employee sustains any bodies injury as a result of the accident while on official duty, DESCO provides, subject to the approval of the MD, or his designated, doctor’s fee, cost of medicine and other medical cost related to injury.
</td></tr>
</table>

<table>
<tr><th>Company</th><th>Basic Pay Structure</th><th>Incentive and Benefit</th></tr>
<tr><td>PGCB</td><td>
<table>
<tr><th>Employee Level</th><th>Basic Pay (Tk.)</th></tr>
<tr><td>Managing Director</td><td>100,000</td></tr>
<tr><td>Director</td><td>80,000</td></tr>
<tr><td>General Manager</td><td>65,000</td></tr>
<tr><td>Deputy General Manager/ Company Secretary</td><td>56,000</td></tr>
<tr><td>Manager</td><td>45,000</td></tr>
<tr><td>Deputy General Manager</td><td>35,000</td></tr>
<tr><td>Assistant Manager</td><td>29,000</td></tr>
<tr><td>Assistant Manager</td><td>26,000</td></tr>
<tr><td>Jr. Assistant Manager</td><td>21,000</td></tr>
<tr><td>Jr. Assistant Manager</td><td>18,000</td></tr>
<tr><td>Foreman, Office Assistant & equal level staff</td><td>15,500</td></tr>
<tr><td>Foreman, Office Assistant & equal level staff</td><td>14,400</td></tr>
<tr><td>Foreman, Office Assistant & equal level staff</td><td>13,600</td></tr>
<tr><td>Foreman, Office Assistant & equal level staff</td><td>13,000</td></tr>
<tr><td>Lineman & equal level staff</td><td>11,500</td></tr>
<tr><td>Lineman & equal level staff</td><td>10,500</td></tr>
<tr><td>Lineman & equal level staff</td><td>9,600</td></tr>
<tr><td>Lineman & equal level staff</td><td>9,000</td></tr>
<tr><td>Technical Attendant</td><td>8,500</td></tr>
<tr><td>Office Attendant & Sweeper</td><td>7,750</td></tr>
</table>
</td><td>

Incentive/Bonus: Employees are eligible for annual incentive based on the performance of their respective departments. In addition, employees receive a festival bonus twice a year (equivalent to one month’s basic pay) to celebrate important festival.
Honorarium: The competent authority may grant an honorarium to an employee for work performed which is occasional in character and either so laborious or of such special merit as to justify a special reward.
Shift Duty Allowance: The employees, when required to work regularly on rotating shift, is allowed shift duty allowance as per pay scale, 2009 of PGCB (@ 20% current basic of an employee).
House Rent Allowance: If the authority not to provide the accommodation of house then PGCB is allocated for house rent allowance for the accommodation of the employee and his family. At PGCB it is with the range of 60% to 40% on the basic salary for all depends on locations of the job.
Overtime Allowance: This is as prescribed by GOB, and not to exceed 8 hours/week per employee. Overtime allowance for extra hours of work is allowed by the controlling officer at such rates when required to work beyond the normal working hours in operation & maintenance. The overtime limit may be relaxed in case of emergency with the consent of concerned officials.
Conveyance Allowance: Company provide full time vehicle to the DGM to MD and lifting & dropping facilities ensured for Manager. Other officials get conveyance allowance as per pay scale, 2009 Traveling allowance and daily allowance are available by the grades of the employee.
Group Insurance: All employees are covered under a group insurance policy. The coverage in equivalent to 50 months last basic pay.
Gratuity: Employees are eligible for gratuity, which is equivalent to 2 months basic pay for every year (payable after a minimum of 3 years of service.)
Annual Increment: The annual pay increases by 4% over basic pay based on performance appraisal as stipulated in the service rules of PGCB.
Leave Encashment: The employees of the company have the ability to encash their earn leave (if not enjoy). They can encash/ enjoy 33 days for 01 year service @ last basic.
Electricity Allowance: Electricity allowance in with the range of 150-400 units per month as per designation, the electricity bills are allocated with the salary.
Residential Telephone and Cell Phone Charge: Company ensured Residential telephone & cell phone facilities up to the Assistant Manager (Tech) level as per service rule.
Medical Allowance: For Junior Manager Grade-1 to Assistant Manager Grade-1 the claiming of medical allowance per year is equivalent to two month basic pay and from Deputy Manager to MD claiming of Medical allowance equivalent to maximum 3 months basic pay per year. For Junior Assistant Manager-2 to staff the medical allowance is paid Tk. 1500/- per month accumulated with salary.
Contributory Provident Fund: Each employee should contribute 10 percent of his monthly basic pay to an interest of earning provident fund. Total value of the fund is paid out equally the sum of the employees and 100% contribution by the company (with interest). CPF is paid out at the time of retirement of the employees (payable after minimum 3 years of service).

</td></tr>
</table>

<table>
<tr><th>Company</th><th>Basic Pay Structure</th><th>Incentive and Benefit</th></tr>
<tr><td>NWPGCL</td><td><table>
<tr><th>Employee Level</th><th>Basic Pay (Tk.)</th></tr>
<tr><td>Managing Director</td><td>1,00,000</td></tr>
<tr><td>Director</td><td>85,000</td></tr>
<tr><td>General Manager</td><td>70,000</td></tr>
<tr><td>Deputy General Manager</td><td>60,000</td></tr>
<tr><td>Manager</td><td>48,000</td></tr>
<tr><td>Deputy Manager</td><td>37,000</td></tr>
<tr><td>Assistant Manager</td><td>30,000</td></tr>
<tr><td>Junior Assistant Manager</td><td>22,500</td></tr>
<tr><td>Staff Level-1</td><td>16,000</td></tr>
<tr><td>Staff Level-2</td><td>14,400</td></tr>
<tr><td>Staff Level-3</td><td>13,600</td></tr>
<tr><td>Staff Level-4</td><td>12,800</td></tr>
<tr><td>Staff Level-5</td><td>11,200</td></tr>
<tr><td>Staff Level-6</td><td>10,400</td></tr>
<tr><td>Staff Level-7</td><td>9,600</td></tr>
<tr><td>Staff Level-8</td><td>8,800</td></tr>
<tr><td>Staff Level-9</td><td>8,000</td></tr>
<tr><td>Staff Level-10</td><td>7,680</td></tr>
</table></td><td>▪ House Rent Allowance: 40-65% of the basic salary. House Rent Allowance varies for designation and different places.
▪ Transport Facilities / Allowance: Assistant Manager to Manager will get lifting or 10% of basic as conveyance allowance. DGM will get transport facilities. GM and above level officers are entitled for full time transport with fuel.
▪ Electricity Allowance: Director and above will get equivalent amount of money for 400 units of electricity. Manager to GM will get equivalent amount of money for 300 units of electricity and JAM to DM will get equivalent amount of money for 250 units of electricity (including Vat and other charges).
▪ Medical Allowance: The reimbursement of medical facility is equivalent to 3 months basic pay per annum JAM and above subject to placement of bills and vouchers of it. Other employees will get medical allowance of TK 1500 per month.
▪ Contributory Provident Fund: Every employee shall contribute 10 percent of his/her monthly basic pay. NWPGCL will also contribute an equal amount to CPF.
▪ Gratuity: Admissible to all regular employees who render at least three years continuous service in the Company.
▪ Festival Bonus: Two festival bonuses are allowed to all regular employees in a Gregorian calendar year at the rate of basic pay.
▪ Group Insurance: Employees will get 50 (fifty) months last basic pay coverage as group insurance.
▪ Power House Allowance: The employees, who are posted at power Station, are allowed Power House Allowance at the rate of 30% of basic.
▪ Shift Duty Allowance: The employees, when required to work regularly on rotating shift, are allowed Shift Duty Allowance at the rate of 10% of basic.
▪ Residential Telephone and Mobile Phone Allowance: For Director and above the telephone and mobile bills are reimbursed on actual basis. For Assistant Manager and above, the ceiling of the mobile bill range is from TK 1000 to1500.</td></tr>
</table>

(5) Recommendation of CPGCBL Compensation (Basic Pay) and Incentive System

The following proposals are for Compensation (Basic Pay) and the Incentive System in the new power plant under CPGCBL by referring to some of the best practices at the Bangladesh public utilities.

1) Introduction of compensation system linked to personal performance

Responsibilities must be proportional to compensation and the ratio of the base pay and that of the pay linked to the individual's performance should change depending on the individual's position. For general staff and management (middle), the ratio of base pay should be about 80% and the ratio of pay linked to the individual's performance should be about 20%. For management (upper), the ratio of the fixed portion and the performance basis should be 60% to 40%. The fixed portion of pay consists of base pay, merit pay, seniority wage and other payments.

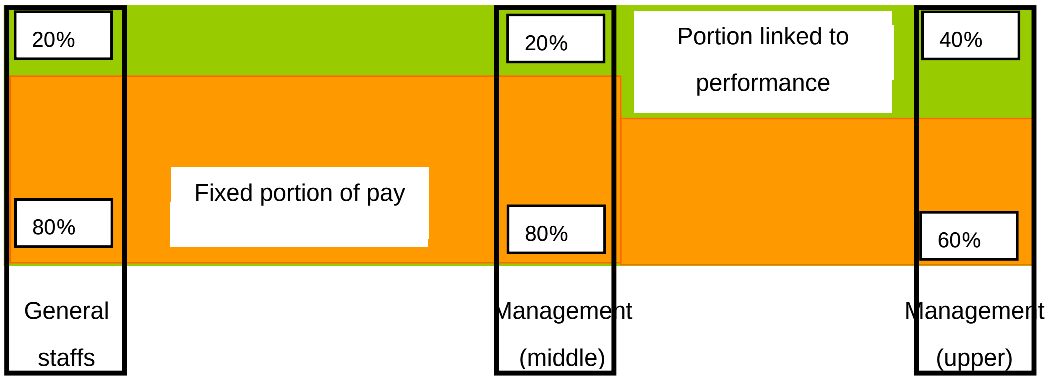


Figure 12.3-4 Compensation System Linked to Personal Performance

2) Examination of Adequacy of the Salary Standard

The table below shows the salary standards for several companies.

Table 12.3-7 Comparison Matrix of Basic Pay of Bangladesh Public Utilities

Designation	BPDB	EGCB	APSCL	DESCO	PGCB	NWPGCL
CE/GM	16,800	60,000	52,500	70,000	65,000	70,000
SE/DGM	15,000	53,000	45,000	60,000	56,000	60,000
EE/Manager	13,750	42,000	39,000	45,000	45,000	48,000
SDE/Deputy Manager	11,000	34,000	33,000	35,000	35,000	37,000
AE/Assistant Manager	9,000	29,000	27,000	28,000	29,000	30,000

As for those converted to a joint stock corporation, the salary standards for the employees in the chief engineer class is about 3 times more than the pay standard at BPDB. As described in the previous chapter, the number of personnel required at CPGCBL power plant is estimated to be about half that at BPDB power plant. In view of the high level of performance required and the heavy responsibilities, sufficient incentives should be provided. The pay standard at CPGCBL power plant therefore should be about three times more the existing pay standard at BPDB power plant. In this regard, however, and as described above, more responsibilities mean that a larger portion of the salary is linked to performance. Thus, more responsibilities do not necessarily guarantee higher pay.

In government-affiliated companies, the employees receives house rent, electricity charge, medical allowance, festival bonus, gratuity and other benefit which are not general in private sector beside basic salary shown in Table 12.3-7. The relation between the basic salary and fringe benefit referring to the example of NWPGCL is shown as follows.

Table 12.3-8 Relation between Basic Salary and Fringe Benefit

(Unit: Taka/month)

	Managing Director	General Manager	Manager	Assistant Manager	Reference
Basic salary	100,000	70,000	48,000	30,000	
House rent	50,000	38,500	26,400	18,000	
Medical	25,000	17,500	12,000	7,500	In case of maximum
Festival bonus	16,700	11,700	8,000	5,000	2 months basic pay annually
Transport	10,000	7,000	4,800	3,000	MD, GM: use company car
Electricity	2,000	1,500	1,500	1,200	Calculation by 5 Tk/kWh
Telephone, mobile	3,000	1,500	1,500	1,500	MD: all free
Total	206,700	147,700	102,200	66,200	In case of maximum
Annual salary	2,480,000	1,772,000	1,226,000	794,000	In case of maximum

(Source: JICA Study Team)

As result, the employees gain twice as much as the basic salary.
In order to secure talented personnel for management work, it is necessary to establish an attractive salary standard at the public invitation. More simple structure of the salary system which is composed of basic salary and bonus is proposed for this project. Due to correspondent with the salary level of IPP, the basic salary should include the above-mentioned fringe benefit to basic salary, and a limited value of the bonus price should be used based on the performance measurement.

3) Retirement Benefit Plan

Bangladesh public utilities have adopted three benefit plans, including a Pension Plan, Contributory Provident Fund, and a Gratuity Fund. The same Retirement Benefit Plan is recommended. The structure of each plan is described below.

a) Pension Plan

Retirement Benefit Plans are structured usually either by a defined benefit scheme or a defined contribution plan. In the case of adopting a defined contribution plan, a financial statement should report the amount of net assets deposited for the benefit plan and related contribution policies in order to satisfy the reporting requirements.

The “International Accounting Standards” and a “Bangladesh Accounting Standard,” which Bangladesh adopts stipulates that a financial statement should comply with either one of the following principles, in case a defined benefit plan is adopted.

- The amount of net assets deposited for the benefit plan, present value of total benefit and the excess or shortage of deposits resulted from the difference between the deposited amount and paid-out amount should be reported on the statement of account.
- The amount of net assets deposited for the benefit plans should be reported in the statement of account. The present value of the benefits obtained via the actuarial valuation and committed to employees should also be reported on the statement of account or an explanatory text on the actuarial valuation report should be inserted.

The present value of the committed pension benefits through the actuarial valuation is calculated in consideration of the employment period up to the end of the current period and based on the current level of salary or the projected level of salary at the time of the concerned employee’s retirement. The amount of the contribution to the retirement benefit funds will be reported in the market value. In case the retirement benefits obligation reported on the balance sheet does not present the current value of projected pension payments, the company should disclose that it does not satisfy the accounting standards. The actuarial valuation of retirement benefits is an essential step in principle.

It is important for the management to acknowledge that a retirement pension is a contingent liability which may become a management risk, and to take appropriate measures to manage pension plans. CPGCBL, a preceding model case, manages gratuity funds and provident funds but does not adopt a defined benefit plan. Similarly, IPP adopts only two lump-sum payment plans and postponed the introduction of a defined benefit plan. Also the trend in developed countries is for the companies to terminate and shift from defined benefits to defined contribution. It is advisable that corporate management should strive for ways to avoid uncontrollable risks as much as possible.

b) Contributory Provident Fund

The contributory provident fund is a lump-sum payment system. Usually, employee participation is on a voluntary basis. In case the employees participate in the system, they declare and pay the amount of contribution within a limited amount to be deducted from their salary by the employer. Whereas the employer makes a certain contribution based on the amount of employee pay and in line with a certain standard (in case of BPDB, the amount of contribution to be made by the employer is the same as the amount employee pay) and deposit the contributions in the trust account specified by the Fund. At the time of retirement, employees will receive the total of their own contribution, company contribution and any profits earned from fund management.

c) Gratuity Fund

The gratuity fund is a lump-sum payment system. The employees join the system automatically at the time of employment. They are not required to make any contributions.

When the employees who have satisfied the set period of service retire, they will be granted the gratuity fund equivalent to certain number of the months’ last salary, the amount of which is determined according to their years of service.

4) Transition of benefits to the incentive system

As the figure below shows, compensation consists of fixed pay, pay and bonus that are linked to performance, and benefits.

Like other companies that are already providing benefits excluding pension and the retirement allowance which has been discussed in the previous clause, company housing and financial aid to cover medical costs and electricity should be offered in accordance with the cultural habits of Bangladesh and to provide the same level of benefits as other companies to employees. However, an employment contract does not guarantee lifetime employment and the period of employment is, in principle, five years. In addition, some portion of the base pay is proposed to be on a performance basis. For this reason, introducing a mechanism to reduce benefits and place increased focus on incentives is considered an option.

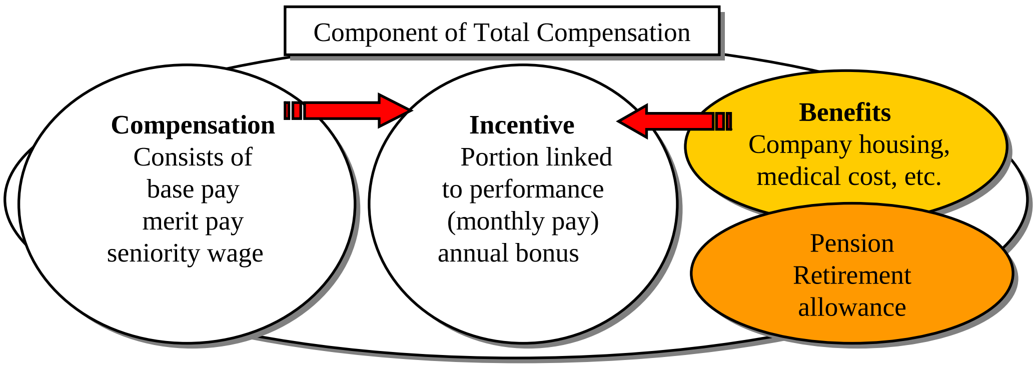


Figure 12.3-5 Component of Total Compensation

12.3.4 Career development and training system

Even if an excellent organization and management system are established, no growth of an enterprise can be expected without the right human resources. Personnel training done within a company are to provide the necessary expertise and skills training based on the corporate philosophy, business goals and business strategy, and staff must be trained and acquire knowledge and skills. Career development and a training system are shown as follows.

(1) Approach to Career Development

Career development and Training deals with the design and delivery of learning to improve performance, skills, or knowledge within organizations. Organizations to a large extent emphasize the importance of learning for the individual and the organization. Due to worldwide development of companies and altering technologies, most Organizations have realized the importance of corporate training. Training is considered as more of a withholding tool than a cost. The training system in most Industry has been changed to create a smarter workforce which can yield the best results. With an increase in competition, every company wants to optimize the utilization of its resources to yield the maximum possible results.

In addition to the traditional training required for a trade, occupation and profession, organizations recognize today the need to continue training beyond initial qualifications: to maintain, upgrade and update skills throughout their working life. Primarily training takes place as either On-the-job which is done through a normal working situation by the taking advantage of actual tools, equipment, documents or materials that trainees will use when fully trained. Off the job training is arranged away from normal work situations. Off-the-job training allows people to get away from work and concentrate more thoroughly on the training itself.

Therefore, training is the process of upgrading skills, technology and the behavioral/ managerial skill of employees in order to improve their effectiveness on the job and increase their performance levels. While training involves skill up the gradation for the current job which the incumbent is holding, development involves the same for a future job, where the incumbent is likely to get promoted.

(2) Comparison of the Training System of Bangladesh Public Utilities

The training system Bangladesh Public Utilities are summarized in the following table for proposing a CPGCBL training system.

Table 12.3-9 Comparison of Training System of Bangladesh Public Utilities

Company	Training System	Remarks
BPDB	Defined training policy	▪ BPDB has a policy of minimum training to be provided to every employee which has been defined as at least 5 training days in 2 years, non-compliance of which would lead to a summon for explanation. ▪ The Training Directorate and functional heads jointly carry out the training needs analysis once every 5 years and review it annually to develop the training calendar. However, the Training Need Identification is based purely on the subjective inputs by superiors. BPDB does not have a system of capturing training needs based on performance evaluation or job descriptions. ▪ BPDB has both in-house, external training and a system of “On the job Training” and a concept of mentoring. BPDB has a good training infrastructure. ▪ BPDB develops its own training calendar and well defined training modules. The training courses are both behavioral and technical courses. It also conducts compulsory induction courses for new joiners.
APSCL	Defined training policy	▪ At the beginning of each year APSCL prepares an annual training schedule and APSCL is continuously providing formal and on-job training of its employees at all levels for improving skill and productivity. ▪ APSCL has a full- fledged training center headed by the Manager (HRD). The training facilities are installed with support from the German Govt. in 1988 ▪ APSCL employees are provided in-house training in its own training center and are also regularly sent to the Govt. training institute like TICI, BPDB and private organizations. ▪ APSCL also arranges on-the-job training for employees under experienced employees in regular intervals according to their training needs. ▪ For newly recruited employees and apprentices, APSCL arranges intensive theoretical training in the training center and on-the-job training

Company	Training System	Remarks
		under experienced employees
EGCB	Not defined training policy	▪ EGCB does not have a sound training policy. The EGCB has a training plan for the year. Training manuals containing several modules, both technical & non-technical items, are prepared every year, and training is imparted accordingly. Besides, EGCB employees take part in different types of training at different training institutes outside of EGCB.
DESCO	Not defined training policy	▪ DESCO has its own training centre both and Uttara and Nikunja and plan to set up a new training academy in its own Head Office which is under process and now in edition to their own facility using other company / organization's training facilities such as BPDB and the oversea Training Center.
PGCB	Defined training policy	• Training program target links to the corporate target. • There will an annual short-term plan (1 year) for implementing training programs at PGCB. • All personnel and functions in PGCB will be included in the training plan. It will be the responsibility of all functional heads (GM, DGM, Manager) to ensure that all personnel under his/her control are included in the relevant plan. • A person shall undertake at least 60 man hours training in every year in his/her field of work in order to maintain competency. Functional heads will ensure that all personnel under his/her control fulfill this minimum requirement. • To fulfill the need for human resource development PGCB may utilize the training facilities of BPDB and other power sector utilities on payment. PGCB can alternately build up its own training institutions. • Training outcomes will be measured by applying suitable methodology. Corrective and preventive measures will be initiated accordingly. • PGCB develops members of its own staff as trainers in different areas to provide professional input in large number of training courses to be implemented in its training facilities. At PGC, efforts are made to develop and maintain at least 30 professional trainers from various disciplines. • Before planning of the training program for the special fiscal year Training Need Assessed from the employees will be ensured. ▪ The local training program of PGCB will be run as per the training policy of PGCB.
NWPGCL	Not defined training policy	▪ NWPGCL is providing / nominating employees in different training centers / institutes of BPDB, BIM, NAPD etc. for training purpose. Employees are also nominated for Power Sector Capacity Development Project (PSCDP) training program.

(3) Key training lessons from Previous Experience

The most newly corporatized entities have stressed the need and importance of training and development of its resources. They have paid due emphasis to a systematic training approach and are increasingly trying to move towards aligning the training objectives with the overall objectives of the organization. Most entities have an identified training budget, necessary days and infrastructure requirements as part of the Training Policies that have been adopted. Most of the corporatized entities have on-the-job training and classroom training as methods to impart training. Their calendar includes both technical and behavioural training imparted to employees. The need for a training evaluation has also been given due importance.

(4) Recommendations for Career Development and a Training System

1) Long-Term Human Capital Development Planning/ Human Capital Portfolio

CPGCBL should focus on developing operations and maintenance personnel. Therefore, the career development plan and training system should be prepared based on thoughts regarding management. Hence, for long-term human capital development planning and human capital portfolio, CPGCBL needs to prepare diversified human capital not only from a technical perspective, but from the perspective of management capability as well.

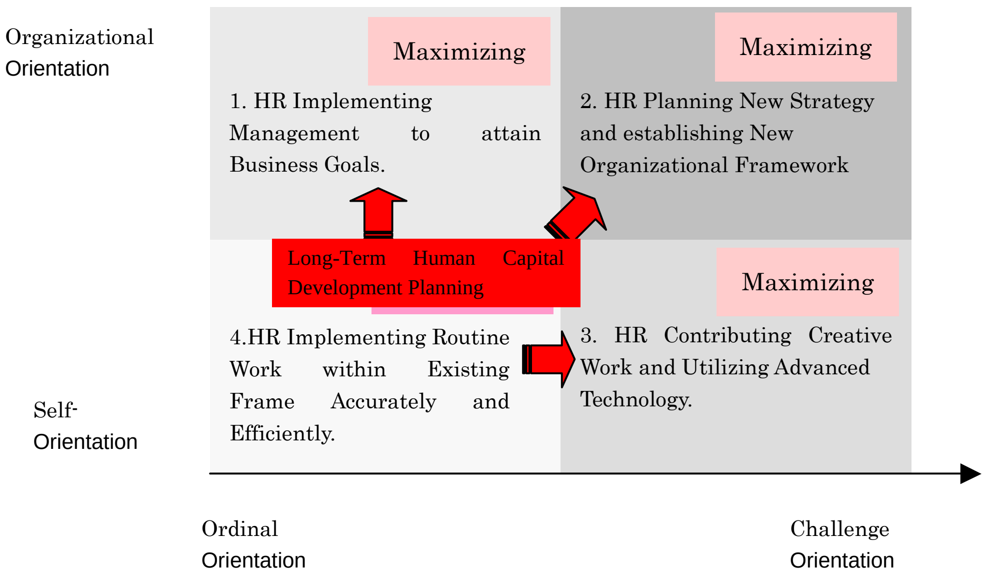


Figure 12.3-6 Human Capital Portfolio

2) Introduction of training system for TQM promotion

a) Basic Management Training

Management is generally defined as all activities utilized for managerial resources (human, operational, financial, and informational) effectively, economically, and with sustainability. For the first stage, enhancing the management capabilities of middle-class managers is a top priority. Therefore, a training program on Basic Management is recommended.

Two core principles exist for this training program, “Work Management” and “People Management”. These core elements are respectively subdivided into two aspects: “Managing Tasks” and “Improvement Tasks” under the principle of “Work Management” and “Enhancing Interpersonal Relations” and “Training and Instructing Members” for “People Management”.

b) Training in Problem-Solving Capabilities

The most important task for middle class managers is to improve daily tasks continuously in order to enhance the quality of work. Therefore, problem-solving techniques (QC Story) to enhance the ability to improve the quality of work are recommended as a key tool to develop Problem-Solving Capability at the Plant level. The following is a list of the seven major steps required for establishing a QC Story; Theme Selection, Grasping the Situation and Goal Setting, Establishment of an Activity Plan, Cause Analysis, Examination of Countermeasures and Implementation, Assessment of Effectiveness, Standardization.

(5) Long-term Human Capital Development

1) Staff Development during the Construction Period

Before launching the construction work, select the O&M leaders and cultivate them on the side during the construction. During the construction work, the structure of the equipment in P/P which can not be checked during the operations can be learned in detail. And, moreover, equipment installation skill can be verified.

2) Training System for new employees

The contents of the training are different according to the academic background and level of experience when first starting work at the company. At CPGCBL, the following training items are required.

a) Items for all new employees, mid-career workers and experienced persons

- Positioning and responsibility as a power company
- Operational principles of a power company

- System and basic knowledge of equipment of P/P (As all specifications of the plant are different, experienced persons should attend the class.)
- Safety precautions in P/P
- Basic data management knowledge in P/P

b) Concrete training for new employees and mid-career workers

- Training in operational duty (College graduates:1-3 weeks, Others:3-5 weeks, Clerical staff:1 week)
- Operational duty and business transfer during shift work, Implementation of patrol (the staff in charge of the training-chief class of operational duty who is not included in the operation duty shift the staff in charge of actual operation-OJT of staff on duty)
- Training of maintenance (College graduate: 1-3 weeks, Others:3-5 weeks)
- General maintenance (1 week)
- Training in each specialized field (3 weeks: new employees, Mid-career workers are divided according to the department from which they graduated such as machinary, electricity, instrumentation and others. In this training, OJT in the group is conducted, and the drawings of manufacturers, instruction manuals and relevant manuals are used as a text)
- During the training, OJT of patrols to check equipment, repair technology and skills in the field of repair construction, handling of measurement instruments, which are used, management of data and others is conducted.
- Safety management for operations and maintenance work
- Data management for operations and maintenance work

3) Development of Staff after commercial operation starts

For the CPGCBL headquarter staff, the main task is administrative work such as performance management for the power plant and the development of a maintenance plan after commercial operations. Specifically, the performance management for the power plant and the development of a maintenance plan. It is necessary to discern the precise needs of the power plant staff and conduct work using the TQM method mentioned in the previous section. Capital development using a combination of OJT and classroom training is recommended.

12.4 Accounting and Financial Management

12.4.1 Accounting system

(1) Accounting Policy

1) Accounting Policy

Accounting policies refer to the manner in which financial transactions are recorded in the books of account. One of the most important prerequisites to CPGCBL is to have clear and consistent accounting policies in line with the accounting standards and reporting formats as prescribed under the Bangladesh Accounting Standards and the Companies Act 1994. A complete set of financial statements are comprised of;

- a balance sheet;
- an income statement;
- a statement of changes in equity;
- a cash flow statement; and
- notes, comprising a summary of significant accounting policies and explanatory notes.

The fundamental policies have to be made official by approval at the board of directors meeting. The employees' awareness of the policies must be promoted by any means. The plans, directives as well as the handling of its business activities have to be in line with the basic policies. The company, at the same time, should be flexible in modifying the policies, so that they are consistent with the prevailing rules and regulations and with the business environment and practices. The selection of an accounting policy depends on the following criteria;

- Compliance with accounting standards
- Reliability and relevance
- Faithful presentation and completeness
- Neutrality
- Substance over form
- Prudence, and
- Materiality

For CPGCBL, lessons can be learnt from the practices at BPDB and its subsidiaries. First at BPDB, there exists no organized material in compliance with the accounting policy per se. With respect to the financial management policy, the delegation of power is documented and its copies are delivered to those concerned at BPDB. Other items announced through the circulars and recognized as the basic policy of the institution. Second, at APSCL, the accounting policy is established based on IAS, IFRS and BAS and publicized in the annual reports to such an effect[1]. For the third example, EGCB has a practice of disclosing the basic accounting policy and the basis for preparation of the financial statements in its annual reports to the effect that the specific accounting policies selected and applied for significant transactions and events that have a material effect within the framework of IAS-1, "Presentation of Financial Statements".[2] CPGCBL should consider the nature of its operations and the policies that the users of its financial statements would expect to be so done.

2) Guiding Principles of Financial Statements

The guiding principles for preparation of financial statements commonly recognized are as enumerated below.

- **Going Concern basis** – accounts are to be prepared as though the company will continue for a long period (unless the company is on the verge of bankruptcy or there is no alternative except to revoke the license or trading at insolvency).
- Statements are to be prepared on an 'accrual' basis rather than on a 'cash' basis.
  - **Accrual basis** – right to earn or liability to pay (income and expenses reflect the correct affairs of the company), and
  - **Cash basis** – only when cash is exchanged and hence may not represent the occurrence of the financial affairs.
- **Matching principle** – function matching and period matching – expenses are recognized on the basis of costs incurred and income earned within the same time period, e.g. unbilled sale of electricity and unpaid costs.
- **Consistency** – unless significant changes occur (which anyway should be separately disclosed), form of presentation and classification of expenses should be consistent from year to year.
- Form of **Balance Sheet** – as given in the Companies Act 1994.
- **Materiality and Aggregation** – material items should be disclosed separately (materiality is defined as the piece of information which can influence the user's decision).
- **Offsetting** – assets and liabilities should be shown separately without offsetting one against the other, e.g. receivables from the sale of power should not be set off against the security deposit received from consumers (unless the consumer has permanently ceased to be a consumer of the company).

[1] APSCL, "Annual Report FY 2010-11"
[2] EGCB, "Annual Report FY 2010-11"

- **Comparative information** – as per the requirements of the Company Act, the previous year's figures are required to be provided and if necessary to be re-arranged in order to be able to understand the trend.
- **Accounting measurements -** this refers to the way the accounting transactions are to be measured and reported in the financial statements. These may be based on the historical cost or inflation accounting or the replacement basis, etc. Accounting measurements are defined under the accounting standards for various situations.

3) Accounting Policy to be Adopted by CPGCBL

Based on the above and viewing the practices going on in the power sector in Bangladesh, the draft accounting policy and the accounting manual have been prepared and are included in the Appendix for recommendation to CPGCBL for adoption;

(2) Accounting Standard

1) Bangladesh Accounting Standard and International Accounting Standard.

In the world of business accounting, there exist two international standards that establish the dominant positions, i.e. the International Accounting Standards (IAS) and International Financial Reporting Standards (IFRS) both issued by the International Accounting Standards Board (IASB). In Bangladesh, the Institute of Chartered Accountants of Bangladesh (ICAB) reviews and discusses IAS and IFRS to assess whether the articles of those international standards should be adopted for Bangladesh and issues the adopted ones as the Bangladesh Accounting Standards (BAS). At present, IAS is composed of 32 articles and IFRS of 13 articles, out of which ICAB has adopted the 31 of IAS as BAS and 8 of IFRS while there remain one article of IAS and five articles of IFRS that have not been adopted by ICAB. The following table lists up all of the IAS, IFRS and Bangladesh status of adoption as of present;

Table 12.4-1 Adoption of IAS and IFRS

IAS or IFRS	BAS	Title of Article	ICAB Adoption	Particulars
IAS 1	BAS 1	Presentation of Financial Statements	2007	
IAS 2	BAS 2	Inventories	2007	
IAS 7	BAS 7	Statement of Cash Flows	1999	

IAS or IFRS	BAS	Title of Article	ICAB Adoption	Particulars
IAS 8	BAS 8	Accounting Policies, Changes in Accounting Estimates and Errors	2007	
IAS 10	BAS 10	Events after the Balance Sheet Date	2007	
IAS 11	BAS 11	Construction Contracts	1999	
IAS 12	BAS 12	Income Taxes	1999	
IAS 16	BAS 16	Property, Plant & Equipment	2007	
IAS 17	BAS 17	Leases	2007	
IAS 18	BAS 18	Revenue	2007	
IAS 19	BAS 19	Employee Benefits	2004	
IAS 20	BAS 20	Accounting of Government Grants and Disclosure of Government Assistance	1999	
IAS 21	BAS 21	The Effects of Changes in Foreign Exchange Rates	2007	
IAS 23	BAS 23	Borrowing Costs	2010	
IAS 24	BAS 24	Related Party Disclosures	2007	
IAS 26	BAS 26	Accounting and Reporting of Retirement Benefit Plans	2007	
IAS 27	BAS 27	Consolidated and Separate Financial Statements	2010	
IAS 28	BAS 28	Investment in Associates	2007	
IAS 29		Financial Reporting in Hyper inflationally Economies	Not yet adopted	Deemed by ICAB Impractical for Bangladesh
IAS 31	BAS 31	Interest in Joint Ventures	2007	
IAS 32	BAS 32	Financial Instruments Presentation	2010	
IAS 33	BAS 33	Earnings per Share	2007	
IAS 34	BAS 34	Interim Financial Reporting	1999	
IAS 36	BAS 36	Impairment of Assets	2005	
IAS 37	BAS 37	Provisions, Contingent Liabilities and Contingent Assets	2007	
IAS 38	BAS 38	Intangible Assets	2005	
IAS 39	BAS 39	Financial Instruments Recognition and Measurement	2010	
IAS 40	BAS 40	Investment Property	2007	
IFRS 1	BFRS 1	First-time Adoption of International Financial Reporting Standards	2008	
IFRS 2	BFRS 2	Share-based Payment	2006	
IFRS 3	BFRS 3	Business Combinations	2005	
IFRS 4	BRFS 4	Insurance Contracts	2008	
IFRS 5	BFRS 5	Non-current Assets Held for Sale and Discontinued Operations	2005	

IAS or IFRS	BAS	Title of Article	ICAB Adoption	Particulars
IFRS 6	BFRS 6	Exploration for and Evaluation of Mineral Resources	2006	
IFRS 7	BFRS 7	Financial Instruments Disclosures	2008	
IFRS 8	BFRS 8	Operating Segments	2008	
IFRS 9		Financial Instruments		IFRS issued in 2010
IFRS 10		Consolidated Financial Statements		IFRS issued in 2011
IFRS 11		Joint Arrangements		IFRS issued in 2011
IFRS 12		Disclosure of Interests in Other Entities		IFRS issued in 2011
IFRS 13		Fair Value Measurement		IFRS issued in 2011

(source) ICAB

The adoption and implementation of IAS and IFRS is on-going practice till present and ICAB is reported to maintain such on-going practice in future. Through the efforts paid by ICAB, Bangladesh has left one IAS article and five IFRS articles unadopted. The unadopted articles typically represent the institutional gap between Bangladesh and IFRS accounting practice. The essences of those unadopted articles are;

i) IAS 29: Financial Reporting in Hyper inflationary Economies

The objective of the article is to establish specific standards for entities reporting in the currency of a hyper inflationary economy so that the financial information provided is meaningful.

ii) IFRS 9: Financial Instruments

The article specifies how an entity should classify and measure financial assets and financial liabilities including some hybrid contracts.

iii) IFRS 10: Consolidated Financial Statements

The objective of the article is to establish principles for the presentation and preparation of consolidated financial statements when an entity controls one or more entities. Consolidated financial statements are the financial statements of a group in which the assets, liabilities, equity, income, expenses and cash flows of the parent and its subsidiaries are presented as those of a single economic entity.

iv) IFRS 11: Joint Arrangements

The objective of the article is to establish principles for financial reporting by entities that have interest in arrangements that are controlled jointly. The article requires a party to a joint arrangement to determine the type of joint arrangement in which it is involved by assessing its rights and obligations arising from the arrangement.

v) IFRS 12: Disclosure of Interests in Other Entities

The objective of the article is to require an entity to disclose information that enables users of its financial statements to evaluate; the nature of, and risks associated with its interests in other entities and the effects of those interests on its financial position, performance and cash flows.

vi) IFRS 13: Fair Value Measurement

The article defines fair value; sets out in a single framework for measuring fair value; and requires disclosures about fair value measurements.

In Bangladesh, all domestic listed companies have been required to use BFRS since 2005. Among the power sector, two companies, i.e. PGCB and DESCO are listed and are confirmed to be adopting BAS and BFRS in their financial reporting. The companies not listed are observed to be voluntarily applying BAS and BFRS in their accounting policies and financial reporting. DPDC, a company earning revenue, is adopting BAS and BFRS while EGCB, APSCL and NWPGCL, being companies still waiting for revenue earning, are reporting in their annual reports that they are adopting a certain number of BAS. For example, both APSCL and NWPGCL are observed to be adopting identically the following articles of BAS;

- ✓ BAS 1: Presentation of Financial Statements,
- ✓ BAS 2: Inventories,
- ✓ BAS 7: Cash Flow Statements,
- ✓ BAS 8: Accounting Policies, Changes in Accounting Estimates and Errors,
- ✓ BAS 10: Events after the Balance Sheet Date,
- ✓ BAS 16: Property, Plant, and Equipment,
- ✓ BAS 18: Revenue,
- ✓ BAS 19: Employee Benefits,
- ✓ BAS 21: The Effects of Changes in Foreign Exchange Rates,
- ✓ BAS 24: Related Party Disclosures, and
- ✓ BAS 37: Provisions, Contingent Liabilities and Contingent Assets.

The reason in which those two companies' adoption of BAS and BFRS is limited to the articles mentioned above is such that the other articles are rather closely related to the revenue earning and other types of transactions that are less relevant to the present stage of activities of those two companies. CPGCBL, being unlisted, shall not be mandated to apply all of the BAS and BFRS provisions from the outset but should make efforts to adopt, as a minimum, the basic provisions to the same extent with those power sector companies in Bangladesh.

2) Company Act 1994

The power sector companies are adopting the Bangladesh Accounting Standard (BAS) and/or the Company Act 1994. CPGCBL is the company established based on the Company Act 1994 (Law No. 28 of 1994) and its accounting system has to be established in meeting the requirements of the Company Act.

CPGCBL, for the time being, suffices to meet the requirements stipulated in the Companies Act 1994 whose section for the accounting and reporting prescribes to the effects that;

i) Every company shall keep proper books of account with respect to; money received and expended; sales and purchase of goods; assets and liabilities; utilization of material, labor and other items of overhead cost;
ii) The books of account shall be open to inspection by the Registrar or other Government Officer;
iii) Board of Directors shall present the annual general meeting the balance sheet, profit and loss statement and a report by the board of directors; and
iv) The balance sheet and the profit and loss statement shall be audited by the company's auditor and its report must be attached to the balance sheet and the profit and loss statement submitted to the annual general meeting.

Caution must be given to the fact that the description in the Company Act 1994 of the accounting standard is often abstract and difficult to follow in the business practices[3]. The Company Act prescribes that the balance sheet of a company shall be in the forms set out in the attached schedule of the Act or in such other form as may be approved by the government either generally or in any particular case. The Act requires the company to obtain approval of financial statements at its general shareholders meeting. The financial statements are stipulated to be comprised of the balance sheet, profit and loss statement, board of directors' report, and audit statement but are not mandated to include; the statement of change in equity, the cash flow statement and the explanatory notes.

The Securities Exchange Regulation promulgated in 1987 is mandating the listed companies to file its annual report with the Securities Exchange Commission which is to contain the balance sheet, income statement, cash flow statement, footnotes for the items appearing in the financial statements and audit report. The listed companies are

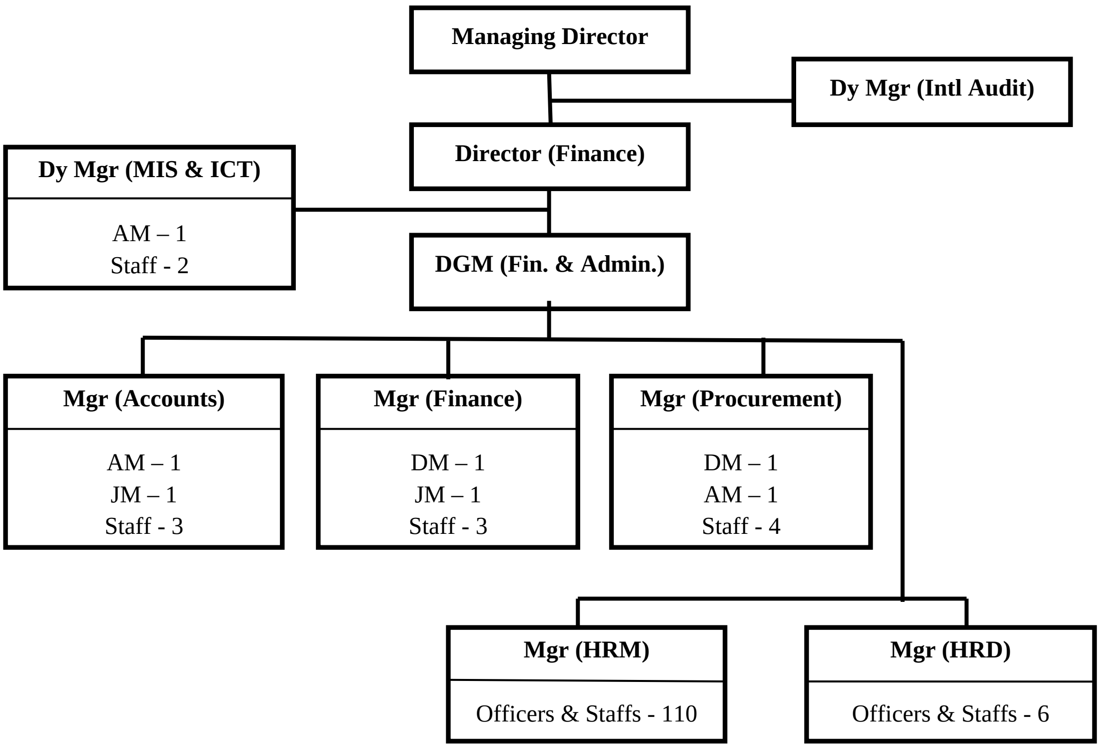
[3] World Bank, "Report on the Observance of Standards and Codes (ROSC) Bangladesh Accounting and Auditing", May 2003

also required to comply with the IAS/IFRS which ICAB officially adopted, which is nothing but the BAS and BRFS. The financial statements have to be finished within 120 days of the final date of the reported fiscal year and be filed with the Commission within 14 days of finishing the report.

CPGCBL, while a judicial person founded on the base of Company Act needs to comply with the Act. The company needs to have a clear understanding of the issue and make its own decision regarding which standards to comply and abide by.

(3) Organizational Set-up

1) Organizational Structure at Power Generation Companies
CPGCBL may not require the finance and accounts unit as large as that of BPDB, as its operations, at the initial stage, will be limited to the generation plants at the Chittagong area having no other plants or network. CPGCBL can learn from the organization of the generation entities of APSCL, EGCB or from IPPs who operate in a compact and efficient organization for the similar functions. A close look at APSCL's Finance and Administration Department, presented below may be of help to CPGCBL;



(source) APSCL, Annual Report FY 2010-11

Figure 12.4-1 Organization Chart at Finance & Admin Dept of APSCL

At APSCL, the Director (Finance) is overseeing the functions of the Accounts, Finance, Procurement, MIS/ICT as well as the large units of Human Resource Management and Development (HRM & HRD). The HRM is comprised of the sub-units of HRM, Security & Discipline, Labor & Welfare, Head Master and Medical Office, having a total number of 110 officers and staffs whereas HRD is a small unit of six officers and staff. Obviously, the Director and DGM should be spending less time for the Accounts, Finance and Procurement sections than the member of Finance is doing at BPDB. The Internal Audit Unit is seen reporting directly to the Managing Director but is considered desirable, as has been mentioned for BPDB, to report directly to the board of directors to assure its independence and autonomy.

2) Capacity Building at CPGCBL

Being a newly established enterprise, CPGCBL has no staff employed and on roster as of today. The company has to start from scratch in building up any of the functional organization including Finance and Accounts. The organizational structure of CPGCBL has been studied in 12.3.2 (3), the recruitment in 12.3.3 and the capacity development and training system in 12.3.4. At CPGCBL, Finance and Accounts Department is assumed to start with the staff of five at Step one and will gradually increase to eight at Step 5. The staff includes one Director (Finance), One GM/DGM with considerable professional experience. The qualification required for Director (Finance) can reasonably be Certified Public Accountant (CPA) or Certified Management Accountant (CMA) having professional experience for not less than 20 years in senior position in large multiunit organization. Similarly, GM/DGM should be required to have post graduate degree, holding the title of Certified Accountant, Certified Management Accountant or Master of Business Administration with the minimum of 10 years of experience in relevant field.

The entry through middle levels of staffs will be required to have acquired or to acquire the basic as well as the professional knowledge and capability sufficient to perform the duties assigned in accordance with the hierarchical levels of the positions. The following table shows the areas of the knowledge and capability required of the staffs at the Finance and Accounts Department;

Table 12.4-2 Areas of Professional Capability Required

Level		Areas of Professional Capability Required
Entry Class		(i)the company, (ii)roles and functions of the department, (iii)the company's policy, (iv)the organizational structure, (v)the chart of accounts, (vi)journal entry, (vii)the trial balance, (viii)the work sheet, (ix)the balance sheet, and (x)the profit and loss statement.
Junior Class		(i)cash accounting, (ii)cash flow, (iii)sales accounting, (iv)store and inventory accounting, (v)fixed assets accounting, and (vi)budgeting and financial closing.
Middle Class	Basic	(i)cost management, (ii)financial closing, (iii)budgeting, (iv)financial modeling, and (v)tax accounting.
	Intermediate	(i)budget control, (ii)cost management, (iii)chart of accounts control, (iv)the Company's Act and financial closing, (v)tax return, (vi)personnel expense management, (vii)cash flow management, (viii)financial modeling, (ix)performance evaluation.
	Advanced	(i)cost control, (ii)funds management, (iii)cash management, (iv)receivable management, (v)financial modeling, (v)tax management, and (vi)business management.

(source) JICA Study Team

For the staffs at Finance and Accounts Department, the opportunities should be provided in which the staffs can acquire the required knowledge and capability through their self-efforts for learning and institutional arrangements of OJT and training courses. The capacity development of the organization shall be achieved having Director (Finance) as the core leader assisted by GM/DGM trains junior staffs through continuous OJTs. In between, CPGCBL shall send them to the outside training courses that have been described in 12.3.4.

Prior to the commercial operation of the project, Finance and Accounts Department shall first be engaged in establishing, the rules and procedures, and the operational set ups including the IT based processing and management system. The involvement and participation into such stage of preparation will provide newly recruited staff good opportunities for deepening their insight into the function and responsibility of the Department. Execution of the preparation work as a group will provide the newly recruited staff to learn the company and its system through an ideally organized OJT.

After the COD, the environment will become different. The OJT will be conducted based on the routine daily operation of the Department function. A typical example of the capacity building of the financial section at such stage is found at DESCO which runs the capacity building in diversified manners of; (i) in-house training program, (ii) receiving training at outside training institutes which include BPDB Institute and Bangladesh Institute of Management (BIOM). Both BPDB Institute and BIOM run training programs for the duration of two to three months with intermittent curricula. Newly recruited staffs are sent to both of the programs in their first year. At BPDB Institute, senior level of offices including Directors, Deputy Directors, General Managers, Deputy General Managers are called in to serve as the trainers together with the outside experts enrolled.

The government shows keen interest in developing the institutional capacity at the public sector power entities. The public sector power companies are obliged to sign the Performance Target Agreement with MPEMR for each year which contains a specific target of achieving an average hours of receiving trainings for each year. At present, MPEMR is guiding the power companies to attain on an average 60 hours of training for any employee during the year. CPGCBL will be placed within the similar environment and can utilize the training systems rendered by BPDB Institute and BIOM in addition to the in-house training program that is to be exercised within the company.

(4) Chart of Accounts

BPDB has realigned and maintained the chart of accounts with periodical updating since June 1994[4]. The chart is composed of two hierarchical layers the main head and the sub-main head. The main heads are coded by three digit numerals plus one alphabetical suffix and two more digits are added to denote the sub-main heads.

The subsidiary companies of BPDB represented by EGCB are seen adopting similar charts of accounts while each company is making some adjustment to make the system to meet the actual operation of each company. The chart of accounts should be the one that enables CPGCBL to analyze, classify and summarize the data in a way that is appropriate to meet managerial, financial and statistical requirements, besides ensuring the better compliance with the statutory requirements. At the same time, the registers and forms have to be designed on the premise that they will be processed by the computer system and therefore need to be developed in close coordination with the development of the integrated financial and accounting system. The Study Team recommends that CPGCBL makes arrangements to develop its own chart of accounts to reflect the accounting, statutory and managerial requirements. The draft chart of accounts recommended to CPGCBL for adoption is exhibited below;

[4] BPDB, “Chart of Accounts”

Table 12.4-3 Draft Chart of Accounts (Balance Sheet)

Asset		Equity and Liabilities	
Main Head	**Sub-main Head**	**Main Head**	**Sub-main Head**
Utility Plant	Utility Plant in Service	Account Payable	Account Payable – Custom Duties
	Utility Plant in Process of Reclassification		Account Payable – VAT
	Utility Plant held for Future Use		Account Payable – Contractors & Suppliers
	Capital Work- in-Progress		Others
	Others	Accrued Liabilities	Accrued Interest on Loans
Investment	Investment		Accrued Salaries and Allowances
Materials and Supplies Inventory	Fuel Stock		Accrued Expenses
	Materials for Operation Supplies		Others
	Construction Stores	Bank Overdraft	Bank Overdraft
	Goods in Transit	Other Current and Accrued Liabilities	Withholding Tax
	Others		Security Deposit- Contractors & Suppliers
Account Receivable	Account Receivable- Consumers		Employee Benevolent Fund Collection
	Account Receivable- Others		Others
Advances	Advances to Contractors & Suppliers	Long Term Liabilities	Due to Government & Agencies
	Advances to Officers and Employees		Foreign Loans
	Temporary Advances		Liquid Damage Reserves
	Others		Others
Cash at Banks	Cash in Bank- Central Bank Account	Capital	Capital
	Cash in Bank – Deposit Account	Retained Earnings	Retained Earnings
	Cash in Bank- Local Collection Account		
	Cash in Bank- Pension Account		
	Others		
Cash in Hand	Petty Cash Fund		
Prepaid Expense	Prepaid Rent		
	Prepaid Insurance		
	Others		
Deferred Assets	Claims receivable from Government		

Asset		Equity and Liabilities	
Main Head	**Sub-main Head**	**Main Head**	**Sub-main Head**
	Preliminary Survey and Investigation Expenses		
	Adjustment and Suspense Account		
	Others		
Other Assets	Security Deposits		
	Others		
Accumulated Depreciation	Accumulated Depreciation – Generation Plant		
	Accumulated Depreciation – Utility Plant		
	Accumulated Depreciation – Non-utility Property		
	Others		

(source) JICA Study Team

Table 12.4-4 Draft Chart of Accounts (Income Statement)

Profit and Loss		
Main Head	**Sub-main Head**	**Tertiary Head**
Revenues	Energy Sales	
	Accrued Sales	
	Others	
Other Income	Other Operating Income	
Generation Expenses	Generation Operating Expenses	Salary
		Allowances
		Overtime Allowances
		Traveling Expense and Allowances
		Medical Expenses
		Bonus
		Stationery & Printing
		Taxes, Licenses and Fees
		Office Rent
		Water Charge
		Electricity Charge
		Post and Telegram
		Telephone, Telex and Fax
		Advertising and Promotion
		Audit Fees

Profit and Loss		
Main Head	**Sub-main Head**	**Tertiary Head**
		Legal Expenses
		Books & Periodicals
		Fuel used for Electricity Generation
		Petrol, Diesel & Lubricant used for Transport
		Transportation Expense
		Store & Spare used
		Custom Duties
		VAT
		Demurrages
	Generation Maintenance Expenses	
Financial & Other Charges	Interest Expenses on Loans (Foreign)	
	Interest Expenses on Loans (Local)	
	Losses on Foreign Exchange Fluctuations	
	Revaluation of Accumulated Depreciation	
	Others	
Development Overhead Account	Development General Overhead Account	

(source) JICA Study Team

(5) Accounting System for CPGCBL

1) Objective

CPGCBL should establish an integrated Financial & Accounting System which will:

- provide integrated IT system that will address the basic accounting and record keeping requirements;
- have correct recording and classification of financial transactions,
- have proper accountability of assets and liabilities,
- have reporting of the overall financial condition and operating results of the company,
- provide timely, accurate and up-to-date information to support the following functions;
  - budget preparation, monitoring and control,
  - cost planning, accounting and control, and
  - operational management of cash, accounts payable, accounts receivable, loans (domestic & foreign) and fixed assets,
- have general accounting functionality, and

- facilitate audit of financial transactions.

The system will have capability to generate various MIS reports aiding managerial decision making as well as operational management. It will comply with various statutory and regulatory requirements such as the Company Act 1994 and ruling regulations.

2) Module integration

The system should be able to cater to various processes related to creditors accounting, customer accounting, materials accounting, employee accounting and accounting for projects and fixed assets. It will also have capability to cater to funds/treasury management as well as budget monitoring and control. The modular break-up of financial accounting can be as follows;

- General Ledger,
- Accounts Payable,
- Accounts Receivable,
- Purchasing,
- Sales and Revenue,
- Project Accounting,
- Fixed Asset,
- Treasury and Cash,
- Store and Inventory,
- Capital and Loans,
- Human Resource Management,
- Cost Accounting,
- Management Information System,
- Consolidation, and
- Budgeting/Costing.

The integrated solution package should not only meet the existing functionality requirements but also take care of future requirements and upcoming demands/trends.

3) Approach for System Development

The principal requirement for the financial management system is the computerized and integrated accounts and MIS modules. This will enable online and real time availability of information to the top-level management. This area of work would involve ensuring compliance with various statutory requirements, adequacy review of creation of clean financial statements, development of significant accounting policies, development of improved financial management and control systems, design of budgeting system, feasibility assessments of IT enablement of accounting system, preparation of fixed assets registers, etc. The system development for CPGCBL will require the following steps;

a) Determination of financial and accounting framework within legal and statutory framework;
b) Determination of financial and accounting policy;
c) Determination of management information requirement;
d) Outline and design of management control reports;
e) Design of the chart of accounts and general ledger;
f) Adaptation of the budgeting system;
g) Preparation of procedure manual and training material; and
h) Implementation in line with the IT strategy of the company.

4) Integrated accounting package

The modular integration of the accounting package is exemplified in the figure below. In the core center lies the general ledger module which is directly interfaced with the other modules. The basic modules required for a financial and accounting system will include Cash and Bank, Purchase, Payable, Stores, Assets, Revenue, Receivables, Loan, MIS, Budget etc.

Figure 12.4-2 Integrated Accounting Package

All these modules will have interfaces among themselves through subsidiary and general ledgers. These are common for all manual or computerized system. However it is always better to go for an integrated computerized system as it provides readily available information. This helps in improving the management decision making process.

5) Standard services to be covered by the computer system

The following table describes the standard functions to be performed by Finance and Accounting Department that has to be covered by the integrated computer system in its regular business operation. The accounting packages, should it be decided to be acquired/developed should have the capability to cope with the financial and accounting transactions arising from those activities and functions.

Table 12.4-5 Standard Functions to be Covered by the Integrated Computer System

Accounting/ Financing	Subject	Standard Activities and/or Functions
Accounting	Account Receivable	(i) sales entry, (ii) invoicing, (iii) collection, (iv) account receivable management, (v) aging test, (vi) discount or rebate, (vii) revaluation of receivables, (vii) provisions, (viii) VAT.
	Account Payable	(i)suppliers master file, (ii)delivery, (iii) acceptance, (iv) due date control, (v) payment, (vi) balance control by suppliers, (vii) discount or rebate, (viii) aging of payables, (ix) VAT.
	Store & Inventory	(i)balance control, (ii) physical count, (iii) store & inventory management, (vi) aging.
	Fixed Assets	(i)ordering, (ii) inspection, (iii) book entry, (vi) payment, (v) depreciation, (vi) disposal, (vii) lease, (viii) VAT.
	Costing	(i)material cost, labor cost, (iii) expense, (iv) VAT.
	Expense Control	(i)annual budget, (ii) variation analysis, (iii) expense management, (iv) payment, personnel expense, (v) repair and maintenance, (vi) consumables, (vii) advertisement, (viii) public relations, (ix) donations, (x) VAT.
	Personnel Expense	(i)directors' remuneration, (ii) salary and wages, (iii) bonuses, (iv) fringe benefits, (v) travelling expense, (vi) allowances, (vii) VAT.
	Monthly Financial Closing	(i)monthly financial closing, (ii)monthly MIS reporting, (iii) budget variance report, (iv) reconciliation of cash and banks, (v) monthly closing of store & inventory balance.
	Annual Financial Closing	(i)finalization of sales amount, (ii) finalization of costs, (iii) allocation of overhead, (iv) cleaning up of suspense accounts, (v) calculation of tax, (vi) MIS report to Board, (vii) proposal on disposal of surpluses.
	Budget Control	(i)annual budget, (ii) progress monitoring, (iii) revised budget, (iv) variance analysis, (v) MIS report.
	VAT	(i)purchasing, (ii) sales, (iii) expenses, (iv) exempted transactions, (v) tax return.
	Tax Accounting	(i)profit and loss, (ii) exemption, (iii) tax rate, (iv) deferred tax.
Financing	Cash & Banks	(i)petty cash management,(ii) bank master file, (iii) bank transfer received, (iv) bank balance management, (v) bank account reconciliation.
	Checks & Notes	(i)checks and promissory notes received, (ii) checks and promissory notes returned unpaid, (iii) promissory note

		issued.
	Loans & Advances	(i)borrower masters, (ii) disbursement, (iii) maturity control, (iv) receipt of repayment and interest, (v) balance management, (vi) arrears, (vii) default, (viii) rescheduling and writing-off.
	Borrowings	(i)bank master file, (ii) disbursement, (iii) due date control, (iv) payment of principal and interest, (v) rescheduling.
	FOREX Management	(i)foreign exchange rate master, (ii) book entry of foreign currency amount , (iii)forward exchange contract, (iv) forex position management, (v) evaluation of forex position at fiscal year-end, (vi) foreign currency deposit.
	Funds Management	(i)funding plan for fixed investment, (ii) monthly cash flow projection, (iii) cash flow statement, (iv) MIS report.

(source) JICA Study Team

The above table is constructed to cover the modular break-up of the integrated software package and can be used as the technical specification when CPGCBL will invite the software suppliers for participating into the competitive procurement for the accounting system. Should any part of the activities and functions be not included in the readily made modules, CPGCBL should be able to request the suppliers to customize the system to cope with the request to be made by CPGCBL. But to say nothing of, the customization should be contained to the minimum or at least to the reasonable extent as the customization shall increase the total cost of the package. Being separate from the customization, CPGCBL may reasonably incorporate in the Request for Quotation the condition that the supplier is to provide the necessary assistance for training of the users and periodical updating of the system.

12.4.2 Financial management

(1) Financial Policy and Financial Planning

Financial policy is a comprehensive plan compiled in respect of financial terms with general goals, a definitive course of action chosen from among alternatives in light of given conditions that determine the present and future decisions. Financial planning involves analyzing the financial flows of the company, forecasting the consequences of various investments and financing decisions and weighing the effects of various alternatives. The investment and financing acts together, and cannot be made independently. The planning horizon can be anywhere between one to several years. The one year plan will be more detailed, whereas the three to five year will be based on more general trends. For projects having a long lead time e.g. of generation projects, the planning horizon needs to be longer. Financial planning is a process of:

- analyzing the financing and investment choices open to the company;
- projecting the future consequence of present decisions;
- deciding on the alternatives to undertake;
- preparation of a financial plan; and
- measuring subsequent performance against the goals set.

The important financial tools used are detailed cash flow statements and forecast models. Sophisticated computer models ensure that the interactions between the key parameters are captured correctly. CPGCBL should clearly define the financial policies in the form of a “Financial Policy Manual” in respect of the following areas of operation clearly designating the department responsible, procedures to be followed, approving authority, etc.

- Revenue management – receipt and remittance,
- Cash control and physical security of cash,
- Banking arrangements,
- Transfer of funds from the headquarter,
- Petty cash/interest management,
- Accounts receivables,
- Bad and doubtful debts,
- Purchase management (fuel, spare parts, supplies, etc.),
- Inventory management,
- Investment management,
- Advances to contractors, suppliers etc.,
- Accounts payable,
- Debt management,
- Leased assets and liability management,
- Payroll processing,
- Unfunded pension liability management, and
- Loans/advances to employees.

(2) Cash Flow Management

While entities (including BPDB) prepare periodic cash flow statements, the power utilities continue to be cash starved and as such, fire fight for cash management day to day. Accordingly, in addition to a cash flow statement, it may be useful if CPGCBL prepares an ‘Estimated Cash Flow Statement’ at regular intervals which can actually help it forecast its cash position in advance. In such a statement, the short term reliability of the assets would play a critical role. The flow of funds in a company is a continuous process and, thus, policy impacting one activity will have a certain impact on the cash position of the company. For example, should the number of days of sales that is sold on credit increase, the receivables shall increase, and may affect the cash available for investment in the long term. Similarly, the investment plan also has an impact on short term cash generation and may cause illiquidity in the short term. The method of funding for the investment would also impact profitability as well as repayment levels. Companies including CPGCBL should also develop contingency plans to handle unforeseen events. Hence, apart from the regular funds/cash flow analysis, companies should also draw up their liquidity funds flow statement for emergency cases in consideration of the short term reliability of the assets.

Financial policy needs to be evaluated against the actual behavior and corrections to be set. By closely monitoring the following financial indicators, management should be able to correctly evaluate the relevancy of the financial policy and corporate goals;

(a) Short term:

1) Fuel purchase payable,
2) Sales to cash cycle – number of days of credit for sale of power (i.e. meter reading and bill collection cycle), days of receivable and bad debts,
3) Inventory cycle – number of days of inventory holding, order quantity, order period, and
4) Suppliers to be paid – purchase to payment cycle.

(b) Medium to long term:

1) Investment – identification, selection criteria, prioritization, cost benefit analysis and approval for implementation, and
2) Funding mix of debt, internal resource and fresh equity, cost of funds, recovery probability.

As stated earlier, a policy has to be developed using the forecast models with alternate scenarios for evaluating the contingencies or ‘worse than now’ or ‘business as usual’ scenarios.
The modern management concept refers to the ability of an organization to have sound management and financial controls and practices to be able to focus on accountability and learning through organization-wide thinking and to establish good performance measurement processes to report on planned results. This involves creating a vision,

establishing goals to set a direction for the organization, planning the objectives, priorities, and tasks for work, setting up an effective structure and resource allocation, and reviewing work outcomes against established goals and priorities.

(3) Delegation of Power

As CPGCBL is an independent entity, it should establish its own system of delegation of financial power. With a different organizational structure and philosophy, the financial empowerment of each department as well as each rank in the organizational hierarchy will have to be re-examined and redefined in order to maximize transparency, accountability and ease of operations. The financial delegation of power can relate to three basic areas. The spending authority is the empowered authority to facilitate the incurrence of a liability. The purchasing authority is the empowered authority to procure goods or services (after ensuring that the spending authority has provided for it) and the payment authority is the empowered authority to pay the liability for the acquired goods or services.

Explicit documents exist in respect of the delegation of power at BPDB[5] and its subsidiary companies. At BPDB, the financial delegation of power is split into two, one for development expenditures and the other for recurrent expenditures. CPGCBL is to take action to start preparing its own rules and regulations concerning the delegation of power by learning lessons from the ones established under BPDB and/or its subsidiary companies. The delegation of power must be established in close coordination with the development of an effective internal control and reporting system.

Table below shows the delegation of financial power at public sector power entities to be learnt from. A significant difference lies in the delegation of financial power in between BPDB and other power entities.

[5] BPDB, “Delegation of Financial Power (Development), 2011” and “Delegation of Financial Power (Revenue, 2011”

Table 12.4-6 Delegation of Financial Power at Power Sector Entities

	Category	Description	BPDB									EGCB					APSCL					NWPGCL					PGCB					DESCO				
			Limit of Power (Lakh Taka)									Limit of Power (Lakh Taka)					Limit of Power (Lakh Taka)					Limit of Power (Lakh Taka)					Limit of Power (Lakh Taka)					Limit of Power (Lakh Taka)				
			Board	Chairman	Member	Chief Engr/ Addl Engr/ Project Director & Equivalent	Super-intending Engr/ Director & Equivalent	Executive Engr & Equivalent	Sub-Divisional Engr	Asst Engr	Sub-Asst Engr	BOD	MD	Director	GM	DGM/ Plant Mgr	BOD	MD	Director	GM	DGM/ Plant Mgr	BOD	MD	Director	GM	DGM/ Plant Mgr	BOD	MD	Director	GM	DGM/ Plant Mgr	BOD	MD	Director	GM	DGM/ Plant Mgr
A	Civil, electrical or mechanical works	(i) to accord administrative approval for procurement	2,400	800	500	300	50	10	5	5	2		800	200	50	15							1,200	300	200	100		500	100	50	20		200 (*1)	0.15	0.1	0.05
		(ii) to accept tender and approve thereof on the lowest evaluated bids after processing through Tender Committee	2,400	800	500	300	50	10	5	5	2		800	200	100	50																	200 (*1)	0.15	0.1	0.05
B	Local purchase of goods & services (*2)	(i) to accord administrative approval for procurement	2,400	400	200	100	20	5																												
		(ii) to accept tender and approve thereof on the lowest evaluated bids after processing through Tender Committee	2,400	400	200	100	20	5					800	400	100	50							1,200	500	300	300		150	75	40	25		200 (*1)	0.15	0.1	0.05
		(iii) to purchase at Govt. controlled rate or from nationalized enterprizes without calling for tender		400	200	10							400	200	50	15							1,200	300	100	50							200 (*1)	0.15	0.1	0.05
		(iv) to purchase proprietary materials or services		400	200	10							400	200	50	15							1,200	300	10	5							200 (*1)	0.15	0.1	0.05
		(v) to place order for specialized work/services without calling for tender		10	5								100	50	5	1							1,200	300	10	5		50	10	5	nil		200 (*1)	0.15	0.1	0.05
		(vi) to expend on immediate safety of employee, plant, machinery, property etc. in case of emergency	5	3	1	0.5	0.2						full	25	10	5							50	25	10	3		full	full	full	nil		20 (*1)	full	full	nil
C	Foreign purchase of goods & services	(i) to accord administrative approval for procurement	2,400	400	200	100							1,000	500	100	50							1,200	500	300	300		500	nil	nil	nil					
		(ii) to accept tender and approve thereof on the lowest evaluated bids after processing through Tender Committee	2,400	400	100	50							1,000	500	100	50							1,200	500	300	300								nil	nil	nil
		(iii) to procure the services of foreign experts through tendering procedure																					500	100	nil	nil										
		(iv) to purchase proprietary materials or services		200	100	50							1,000	500	100	50							1,200	300	10	5		100	nil	nil	nil		200(*1)	nil	nil	nil
D	General expenditure	to approve and making payments of general expenditures including the followings;																																		
		(i) taxes, VAT, duties, bills, insurance etc.		full	full	full	full	full	full	full	full		full	full	full	full							full	full	full	nil		full	full	full	full		full (*1)	full(*1)	0.1	0.05
		(ii) utility bills		full	full	full	full	full	full	full	full		full	full	full	full							full	full	full	full		full	full	full	full		full (*1)	full(*1)	0.1	0.05
		(iii) publicity & advertisement		full	30		25						full	0.5	0.2	0.1							full	2	2	0.5		full	0.2	0.1	nil		200 (*1)	0.15	0.1	0.05
		(iv) repair & maintenance of plant, machinery, etc.		800	200	100	20	2					full	100	10	5							500	200	100	0.5		full	full	20	12		200 (*1)	0.15	0.1	0.05
		(v) salary, allowances, compensation etc. to employees		full	full	full	full	full	full	full	full		full	full	full	full							full	full	full	full		full	full	full	full		full (*1)	full(*1)	nil	nil
		(vi) land acquisition					full	nil	nil	nil			full	nil	nil	nil							full	1	0.5	0.1		full	full	full	full		full (*1)	full(*1)	0.1	0.05
		(vii) professional membership, conference fees			5	1	0.1						full	nil	nil	nil												full	full	0.25	nil		full (*1)	full(*1)	0.1	0.05
E	Furniture and fixtures	(i) to accord administrative approval for purchase of furniture, fixture, office expense and other capital expenditure			20	5	1	0.6	0.4	0.2			full	nil	nil	nil							full	50	50	10		100	30	10	5		200 (*1)	0.15	0.1	0.05
		(ii) to purchase of books, journals, newspaper, etc.			10	3							full	full	full	full												full	0.1	0.05	0.03		200 (*1)	0.15	0.1	0.05
F	Sale, Lease, etc.	(i) lease of company's properties, equipment, etc.			25	10	10						full	nil	nil	nil							full	full	10	5		50 (monthly)	15 (monthly)	2 (monthly)	nil		200 (*1)		nil	nil
		(ii) scrap declaration of civil, electrical installations, vehicles and stores		100	50	20							full	nil	nil	nil							full	100	nil	nil		full	full	10	nil					
		(iii) sale of scrap by auction		50	25	10							full	20	10	nil							full	50	25	nil		full	full	full	15					
(*2) Some of the institutions have separate limits in delegation of power for procurement of services from that of goods. The limits set for the procurement of services tend to be smaller than the ones for goods.																															(*1)=To be approved jointly by combinations of; MD, Director (Fin) or Director (Tech).				

(source) JICA Study Team

Being a part of the government, BPDB has several layers of power delegation among which the Board reigns the organization empowered with large sums but is still have a definitive limitation whereas at the other power entities, the board of the directors is the ultimate organ to make decisions except those that are subject to the resolution at the shareholders' meeting. The multiple of layers structured at BPDB is partly to cope with the multiple function it performs, including the generation, transmission and distribute but partly to the bureaucratic hierarchy. The hierarchy levels should better be flattened and if achieved, can reduce the number of layers with the effect that the decision-making would become quicker.

From the table exhibited, a general tendency is recognized in which the generation entities are empowering the top management with larger limits. The larger amount of empowerment appears reasonable in the light of the fact that generation entities have to invest in the projects of gigantic amounts whereas the transmission and distribution entities make smaller investments in comparison with the generation entities. Among the generation entities, BPDB and EGCB empower Chairman and Managing Director with similar level of authority whereas NWPGCL allows larger amount to MD by approximately 50% for major categories of financial activities.

For the sake of accountability and transparency, the rule is recommendable to be simple, clear-cut and distinct in its content. BPDB's delegation of power comprised of two volumes of booklet, the development phase and the revenue phase. EGCB, PGCB, DESCO have one document of several pages integrating the development, revenue and administrative power into a single volume. NWPGCL has two volumes similar to BPDB. However, NWPGCL's rule has clear distinctions of the power category together with the underlying rules or regulations and specific instructions for utilization. The Study Team recommends CPGCBL to adopt the delegation of financial power in simplified form but with clear distinctions in its content so that the rule and actual execution of the power is transparent and can be well accounted for. The level of empowerment to the top management can be established at the similar level with NWPGCL as such is quoted to be sufficient at NWPGCL.

(4) Internal Control

Internal control is comprised of the control environment, accounting systems and financial control policies and procedures established and maintained by management to assist in achieving the orderly and efficient conduct of business at the organization. The board needs to play an active oversight role by ensuring the company has an effective control framework in place, including the assessment and management of key financial and non-financial risks and an effective monitoring and oversight process, supported by timely and accurate information and clear communication channels.

A sound internal control framework is to be composed of an effective control environment, an assessment of key risks, control activities, timely and effective information and communication processes, and an oversight monitoring process.

- **The control environment** is the foundation for the internal control system including factors such as; integrity, ethical values, and personnel competence.
- **The risk assessment process** allows management to identify and manage risks relevant to achieving the company's objectives.
- **Control activities** are policies and procedures that help ensure that management directives are carried out properly and in a timely manner. This includes segregation of duties, approval process, security of assets and controls over information system, etc.
- **Information and communication processes** allow those within the company to carry out their responsibilities. This includes preparing reports of operational, financial, and compliance related information as well as day-to-day communication processes among employees, supervisors and senior management.
- **Monitoring and oversight process** allows senior management and the board to assess the effective functioning and appropriateness of management controls. This can be accomplished through ongoing monitoring activities, separate evaluations of internal control such as self assessments and/or internal audits, etc.
- **Roles and responsibilities for internal controls.** Management delegates responsibility to each area of operation and assigns the responsibility to the designated personnel to implement the controls.

(5) Accountability and Disclosure

Accountability means the ownership of conferred responsibilities combined with an obligation to report to a higher authority on the discharge of these responsibilities and on the results obtained. Accountability includes:

- answering to the consumers/public;
- quality decision making;
- strong internal controls;
- knowledge of policies and procedures, with effective communication;

- knowledge encompassing the entire organization; and
- development and implementation of risk management practices.

The board is responsible for the oversight of financial reporting and all public disclosures. The board should examine the company's practices with regard to financials and other disclosures to ensure the company meets the requirements of the prevailing rules and regulations. It is management's responsibility to execute. The auditors need to take steps to ensure the quality, timeliness and accuracy of all disclosures and ensure they are complete, fairly represent material information and comply with all relevant rules and regulations. The management should maintain a proactive attitude towards transparent disclosure with the following in mind;

- A transparent disclosure approach indicates a commitment to good corporate governance and helps to build trust with stakeholders;
- Poor disclosure practices can adversely impact the efficiency and performance of business; and
- Companies have an ever-growing and more cost-effective means of communication with stakeholders.

12.4.3 Financing of project costs

The following describes the general principles and practices followed in Bangladesh in considering the financing method of the project costs for a development project. In structuring the financial schemes for the project, CPGCBL should take those prevailing practices into consideration and obtain effective means for identifying and engineering an appropriate financing method to cover the project costs.

(1) Procedure for Government Approval of the Project

The selection process of the individual projects for incorporation into the Project Plan is undergoing a strict screening process. For a large project like the one under our study, an executing agency is required to prepare the Development Project Proforma/Proposal (DPP) which is the basic document to be scrutinized by the government and approved by Executive Committee of the National Economic Council (ECNEC). DPP prepared by the executing agency will be submitted to MPEMR first for approval. After the approval is given by MPEMR, the document is submitted to the Planning Commission for its own scrutiny and thence to ECNEC for final government approval of the project. Any project whose investment exceeds Tk 250 million is submitted to ECNEC[6]. ECNEC is chaired by the Prime Minister for deliberation and convened normally twice a month and is ready to appraise the document at any time of the year. The DPP submitted to ECNEC is first discussed at the Project Evaluation Committee (PEC) composed of the representatives of stakeholder ministries before being submitted to the plenary session of ECNEC. DPP is composed of the following integral components[7];

- Part A: Project Summary
- Part B: Project Details
- Annexures

(2) Donor Financing

The Executing Agency has to start preparing DPP and arrange approval from a Competent Government Authority. As soon as the appraisal by the donor is completed and understanding is reached on the scope and cost of the project, the DPP should be prepared for approval by a Competent Authority.

The negotiation of a loan agreement with a donor must be preceded by inter-ministerial consultations and cleared by all concerned agencies. The Planning Commission, Finance Division, Ministry of Law, Justice and Parliamentary Affairs, National Board of Revenue and Ministry of Foreign Affairs are usually involved in inter-ministerial consultations. A loan agreement is concluded between the donor and the government of Bangladesh represented by the Economic Relations Department (ERD) of MOF. The government concludes a subsidiary loan agreement with the Executing Agency for on-lending the loan it receives from the donor. The standard terms and conditions are provided by ERD via a circular titled “Lending and Relending Terms of Local Currency/ Foreign Loans” dated March 17, 2004[8]. The standard terms of conditions by which the government provides lending its own finance and relending foreign loans to BPDB including its subsidiaries are prescribed as; (i) financing method for the foreign loans received: 100% in relending, (ii) for the government funds: 60% in equity and 40% in loans, (iii) repayment term: 20 years including a 5-year grace period, (iv) interest rate: for relending of the foreign loans at 3.0% for foreign currency and 4% for domestic currency[9], and (v) for government funded loans at 5.0% p.a.[10] The terms and conditions

[6] ERD, “GOB Project Approval Process” Aug. 2010
[7] ERD, “Project Processing Procedure (Guideline for DPD and TPP Preparation, Processing, Approval and Revision), 2005
[8] ERD Circular, “Lending and Relending Terms of Local Currency/ Foreign Loans” March 17, 2004
[9] ERD Circular, “Lending and Relending Terms of Local Currency/ Foreign Loans” March 17, 2004
[10] In on-going practice, the government loan is provided with the interest of 3.0% p.a.

are said to be flexibly adjusted by the ministerial agreement depending upon the actual project requirements. The actual cases of on-lending, however, are found frequently and significantly deviated from the standard terms subject to the ministerial consultation and comments given at ECNEC.

In determining the financing terms and conditions, donors specify in the loan agreements the objects, eligible items or ceiling limits of financing against the aggregate cost of the project. Often times, the cost components such as; acquisition of land, tax and/or administrative expense at the Executing Agency are classified as non-eligible for financing. The loan agreements to be concluded with donors, thus, leave significant gaps that are not financed under the loan agreements. The government provides budgetary funding via equity and loans for the portion left uncovered by the donors. Activities of donors in the power sector have been reviewed in the chapter 3.

(3) Financing by the Government

The DPP is required to incorporate the estimated cost of the project by components and the mode of financing with the source in its “Part-A”. The mode of financing needs to specify the amounts of financing for loan/credit; grant; equity; and others; separately calculated for each of the financing sources including the government of Bangladesh. The gap left from the loan agreement with the donors can be summed up and listed under the government financing. The cost estimate is allowed to incorporate the initial working capital into the total cost. While the initial working capital is not normally covered by the donors, it is covered by government financing so long as it is properly accounted for in the DPP. In financing the gap, the government provides the funds for 60% in the form of equity and 40% in the form of loans. The terms and conditions are agreed on among the inter-ministerial consultation and comments by ECNEC, if any.

(4) Financing by the Executing Agency’s Own Capital or Commercial Borrowing

Any project whose investment exceeds Tk 70 million but is not more than Tk 250 million has to be approved by the Planning Minister on the basis of an evaluation and recommendation from PEC[11]. For projects smaller than Tk 70 million, the Executing Agency can make an investment decision at its own board and proceed to implement. Depending upon the availability of its own capital for investment, it may invest by using its own capital or by borrowing funds from financial institutions. Under the prevailing practice, some of the public sector institutions are emerging with the capability to

[11] ERD, “GOB Project Approval Process” Aug. 2010

finance a significant amount of the capital project from its own sources. APSCL, for instance, reports that it has invested a total of US$ 41 million plus Tk 203 million for construction of a 53 MW gas engine power plant and completed it in April 2011 using its own capital. In another example, DESCO reports that it is implementing a few projects using its own funds.

(5) Suggestions to CPGCBL for structuring the financing method

The construction of a coal based power plant involves not only the erection of the plant itself but also the facilities and infrastructure related to the construction and operation of the plant for the life of the project. The related facilities and infrastructure include the transmission line, access road, transport and storage facilities for fuel coal including the unloading facility at the port. Versatile development requires a large amount of capital investment for the long term coverage of the life of the project for which the project has to secure a solid means of financing. It is logical and reasonable that the government seeks financial assistance under concessionary terms from the international donors for the objective of providing nation-wide consumers with a stable supply of electricity at a reasonable price.

In order to obtain donor assistance, it is vital to formulate the project adhering to top quality standards that is to be compiled in the DPP document for clearance and approval by the government. DPP shall be prepared in precise conformity with project specifications based on the results of the appraisal to be conducted by the donor. The cost of the project to be incorporated at DPP includes all of the costs required for implementation of the project including the related facilities and infrastructure. The executing agency is required to obey the guidelines established by the donor for use of the financial assistance including but not limited to; the procurement guidelines, the guidelines for employment of the consultants, the guidelines for social and environmental considerations, etc. CPGCBL needs to prepare a high quality of document, DPP, reflecting those conditions and the accurate cost and present it to the approval body, ECNEC, of the government for clearance. The taxes such as the custom duty, VAT, withholding taxes need to be accounted for and so is the acquisition cost of land. Some of those cost items may be classified as non-eligible items and not be financed by the donor.

12.4.4 Financing of working capital

The following describes the general principles and practices followed in Bangladesh in considering the financing method of the working capital for a development project. In structuring the financial schemes for the project, CPGCBL should take those prevailing practices into consideration and obtain an effective means to identify and engineer an appropriate financing method to cover the project costs.

(1) Financing of Pre-operational Expenses

Aside from the expenditure for plant construction, the company may incur operational expenses for overhead that are expended for the non-project specific activities of the company such as remuneration to the board of directors, personnel expense for headquarter staff, rent for the office and transportation, legal fees, etc. It may also incur expenses in exercising the trial run of the plant prior to commercial operations that may last for a brief period or a lengthy one and expenditures required for such operations may vary. In a particular practice of BPDB, the fuel cost for the trial run of the plant is covered and paid by BPDB under PPA as the Energy Payment (fuel payment). Unlike during commercial operations, the Energy Payment (fuel) does not allow the accompaniment of other expenses such as O&M, etc. The expenditures included in DPP can be financed by the government under the ADP budget whereas other expenditures will not be financed by the government or by the donor. In past experiences, those expenditures not covered by government finance were often covered by the loan extended by BPDB to its subsidiaries with no interest under the practicing of the parental care for the subsidiary companies.

(2) Working Capital for Operation

The company has to secure sufficient working capital so that it can run the operation while spending on those expenditure items and waiting until the time of collection from electricity sales. The major payment items of the company include personnel expense, fuel purchase, installment of the principal and payment of interest on the loans received. The payment schedule of those expenditure items is mostly inflexible and cannot be adjusted in accordance with the company’s cash position. The import of coal including the one for the trial run of the plant as the fuel for generation requires the company to effect payment of the purchase probably upon shipment at the seller’s port which means the payment before the coal’s arrival to Bangladesh port.

The revenue of the company comes from the sale of electricity to BPDB, single buyer, whose payment term is to be provided in PPA. The normal payment terms under PPAs concluded with the other generation entities are; 45 days after invoicing for BPDB’s subsidiary entities (30-45 days for IPPs). After payment of coal upon its shipment, CPGCBL needs to allot about one month for ocean shipping and two months for storage at the company's yard after arrival, an average of three weeks for generation/ invoicing cycle and a month and a half for the payment of the invoice. All in all, the recovery of funds used for payment on coal takes at least five months before being collected by CPGCBL from the sales of electricity. Payment for the sales of electricity is contracted under PPA which provides two categories of payment; one is capacity payment and the other is energy payment. The capacity payment covers the cost of company accruals in fixed assets and invariable O&M whereas the energy payment covers the cost of fuel and variable expenses of O&M. Fluctuations of the expenses due to inflation and foreign exchange gains/losses are basically reflected in the capacity and energy payment.

The initial working capital required by the company is to be accounted for in the DPP of which the government is to provide a budgetary appropriation. The initial working capital is assumed to include the purchasing of fuels for the trial run of the plant prior to its commissioning. After the commencement of operations, the company should make efforts to synchronize the payment schedule of major expenditures with the bill collection to minimize the working capital requirements. For the purpose of securing the working capital, the company has to secure an initial working capital for five months of coal import in addition to the standard operations and maintenance expense. If a sufficient amount of the initial working capital is provided by the government, the company can rotate such funds received for a considerable period of time without encountering a shortage of working capital so long as the operation proceeds smoothly.

Under PPA, the capacity payment is deemed constant regardless of the actual plant factors so long as the availability is maintained at the minimum percentage prescribed at PPA. The capacity payment, however, is subject to reduction at pro rata, should the availability fall below the minimum percentage prescribed. The company might come across a cash shortage situation if it fails to maintain the plant's availability. For the shortage of working capital in those instances, BPDB is quoted to have stated that the emergency loans are to be provided by BPDB to the company in need under parental care with interest, though there are no written documents available to substantiate such a statement.

(3) Working Capital for Plant Maintenance

PPA covers the payment of O&M in the capacity payment for invariable expenses and in the energy payment for variable expenses. Here again, CPGCBL needs to have working capital ready for making payment for those O&M activities including the purchasing of spare parts, contracting and paying for the O&M contractor, etc. up until the payment can be recovered through the payment under PPA. The initial purchasing of spare parts can be included in the project costs in DPP which will be financed either by the donor or by the government.

(4) Suggestions to CPGCBL for structuring the financing method

With regards to the pre-operational expenses concerning fuel for the trial run of the plant, the expenses should be counted as a part of the project costs. DPP should incorporate such expenses appropriately. The project may incur actual expenditures for commercial operations in advance of the start-up of the operation in purchasing the fuel coal for commercial operations. The expenditures for such fuel purchases are counted as the initial working capital. Besides, it needs to be assured that the financing cost of coal imports for both the trial run and commercial operations should be allowed to be accounted for under the PPA. CPGCBL needs to make sure that the DPP incorporates the requirement of the initial working capital in addition to the project costs including the fuel purchase for the trial run of the plant so that it can be adequately financed either by the donor or by the government.

12.4.5 Budget control

(1) Business Budgeting

Business budgeting essentially lays down the physical and financial operating plan/targets for the budget period, lays down the standards/yardsticks for inputs and the outputs associated with the various activities, motivates the divisional managers and staffs for to achieve the targets laid and materializes the comprehensive control of corporate business activities. It is an important tool for managerial appraisals and controls and is comprised of; budget planning and budgetary controls. It also provides an estimate of the internal generation of funds from operations, which would be available for financing the capital expenditures, meeting the loan repayment obligations, etc. With respect to its coverage, the operations budget is to cover all the stations that are in the operations phase. The expenses in respect of the developmental expenditure for improvements, additions, replacements, renewals, balancing facilities which are capital in nature are budgeted for in the capital budget.

(2) Capital Budget

The capital budget is prepared and executed in obtaining funds from the domestic source (government) and/or the foreign source (donors). At BPDB, the budget is compiled by the Director in charge of Project Development who acts as the nodal person but its fund raising is handled by the Director of Accounts and Finance Department. The procedure for the capital budget commences in December every year when the Director in charge of Project Development compiles the Project Plan comprised of the project proposals collected from the departments concerned; development, planning, and system departments. The Project Plan compiled is discussed at the board of directors meeting of BPDB. The Project Plan approved by the board of BPDB goes to MPEMR and then to the Planning Commission after being approved at MPEMR. The Project Plan is discussed and approved at the Executive Committee of National Economic Council (ECNEC) before the end of June each year.

The development budget approved is called “Annual Development Programme (ADP)” which is executed by the applicant agency. The Development Project Proforma/Proposal (DPP) approved by ECNEC is to be automatically incorporated into ADP. Should it happen that the funds available are limited to cover all the projects presented, the priority of implementation is discussed and given for inclusion to the ADP. The projects going through the above mentioned procedure are ready to be allocated with the funds for development under the ADP.

(3) Recurrent Budget

On the contrary to the capital budget, the recurrent budget is to provide the funds for the operation and maintenance of projects and its funding source is limited to domestic ones. The responsibility of budget preparation rests on the Director of Accounts and Finance Department. The major targets of budget compilation are those of the revenue accounts such as; revenue from electricity sales; other income; government subsidies and/or grants, and those on the expenditure side of accounts such as; fuel costs; electricity purchases; maintenance and repairs; personnel expenses: general administrative expenses; depreciation; interests on loans; etc. The budgeting process starts in November or December of each year. The Director of Accounts and Finance Department instructs the organizational units concerned to produce the items requiring a budget and the amount necessary to be budgeted. The information required includes the revised budget for the current fiscal year and the budget for the next fiscal year. Each budget unit is obliged to submit the actual expenses incurred during the first six months of the year together with the estimate for the remaining six months. Should the estimate for the latter half of the fiscal year and the actual expenses incurred for the first six months of the year deviate from the original budget, the budget unit is required to explain the reason behind the deviation. Upon the submission of budget data from all of the budget units, the Director of Accounts and Finance Department convenes a meeting where participants discuss the initial draft of the budget and proceed with the coordination. Once the coordination is finished, the draft budget goes up to the board of directors meeting for perusal and decision. The approved draft budget is sent to MPEMR for approval and submission to the government. The draft budget is then submitted to the Ministry of Finance to be approved by the Minister of Finance. The budget approved by the Minister of Finance becomes the official budget which is notified to each of the budget units. Strict compliance to the budget is required. When the necessity to go beyond approved budget items arises, the budget unit in charge has to obtain the approval of the Director of Finance at MOF even if the amount exceeded is small.

(4) Variance in Achievement

For the sake of reference, BPDB is controlling the strict observance of its budget and so are the other power sector entities. At BPDB, the information concerning the budget and the actual is released in its annual report every year. The following table provides the budget and achievement of BPDB for its recent fiscal year;

Table 12.4-7 Budget and Actual Performance at BPDB for FY 2010-11

	FY 2010/11			
	Budget (Tk million) *1	Increase from prev. year actual	Actual (Tk million)	Deviation (%)
Revenue				
Electricity sold	83,649	22.2%	77,304	92.4
Other revenue	3,223	17.9%	4,304	133.5
Revenue total	86,872	22.2%	81,608	93.9
Operating expense				
Fuel cost	19.153	17.0%	19,065	99.5
Depreciation	7,701 *2	3.1%	7,659	99.4
Maintenance expense	3,581 *3	75.6%	3,000	83.8
Power purchase	91,558	113.9%	83,701	91.4
Transmission expense	1,765	54.8%	1,394	79.0
Other operating expense	2,121	34.8%	1,969	92.8
Distribution expense	3,432	32.6%	2,986	87.0
Administration	1,239	9.1%	1,520	122.7*4
Operating expense total	130,551	73.8%	122,761	94.0

	FY 2010/11			
	Budget (Tk million) *1	Increase from prev. year actual	Actual (Tk million)	Deviation（%）
Operating income／loss	-43,678	1,000.9%	-41,153	94.2
Non-operating income				
Asset insurance fund	15	0.0%	15	100.0
Interest on loan	3,226	41.3%	2,896	87.1
Foreign exchange gain/loss	-145	51.0%	-2,143	1,480.7
Non-operating expense total	3,486	45.6%	5,053	145.0
Net profit／loss	-47,165	641.8%	-46,206	98.0

(note) *1: Revised budget for FY 2010-11 as per Annual Report FY 2010-2011.
*2: 2.5% of gross value of utility plant in service of pervious year end.
*3: 1.2% of gross fixed assets of pervious year end.
*4: A part of the budget established for the repair and maintenance for Tk 305 million has been transferred to the Administrative Expense causing the deviation. The performance in the Administrative Expense net of effect of such change is recorded as 98.45%.

(source) BPDB, “Annual Reports FY 2010-11”

The above table reveals that the huge deficits of operation at BPDB has been anticipated since the stage of budget preparation and the actual performance has been more or less in line with what has been budgeted despite budget control efforts. The total revenue has been short of the budget by six percent whereas total expenses have also been less than the budget by six percent. The extent of the shortfall has been balanced for both the revenue and expenses but has only helped to contain the deficit by a mere two percent. The following should be specifically noted among such performance factors; (i) depreciation was budgeted at 2.5% of the gross value of the utility plant in service at the previous year’s end; and (ii) along similar lines maintenance was budgeted at 1.2% of the gross fixed assets. BPDB has been following a policy of appropriating 3.20% of the gross value of the utility plant in service on the straight line method and a half of the normal rate on the addition made during the year for its annual depreciation[12]. The percentage that has been actually budgeted does not tally with such policy and so is the actual budget performance. Looking back at the history, BPDB is known to have budgeted 3.0% in FY 2005-06[13] and 3.1% for FY 2001-02[14]. To be similar to maintenance, BPDB used to budget 1.6% of the gross value of the utility plant in service in FY 2005-06 and 1.5% for FY 2001-02. It is apparent that BPDB is recently spending less on its depreciation and maintenance of the plants. Elsewhere, it is found that the PPAs that BPDB concludes with its subsidiary companies include an assurance of O&M expenses at a fixed percentage of the gross value of the fixed assets. For instance,

12 BPDB, “Annual Report FY 2010-11”
13 BPDB, “Annual Report FY 2005-06”
14 BPDB, “Annual Report FY 2001-02”

APSCL has been given the assurance of O&M at three percent under its PPA contract signed with BPDB in 2007[15]. Another point at issue is found in the under performance of the budget in maintenance. For FY 2010-11, only 83% of the budget has been executed while leaving 17% unused. This implies the existence of some causes that make the maintenance work impractical to be implemented. Could this possibly be due to the non-stopping operation of the plants, the non-availability of the engineers and/or the spare parts, or other causes? Efforts are invited for the correction of such incidents at BPDB. CPGCBL should learn lessons from such and make sure not to repeat the same at its own forthcoming plant.

(5) Recommendations

1) Budget Time Table

A tightly structured budget procedure along with the accompanying time table that specifies when all activities will occur, who will complete them, and when a deliverable is back at the budget section of the corporate office has to be developed for CPGCBL. By laying out the process in this manner, and following up closely on all due dates, it is possible to issue a complete budget on time. A good budget document should include the capital budget, revenue budget, stores budget, establishment budget, etc. The budget procedure and time table must be built around the budget flow in a sequential manner. It is recommended to have the budget time table with milestones so as to enable the divisions concerned to be better disciplined in terms of budget preparation and adherence. The following figure presents a typical example of the budget time table applicable under the prevailing environment;

[15] BPDB, “Power Purchase Agreement between BPDB and APSCL (draft)”, 2007

Table 12.4-8 Budget Time Table

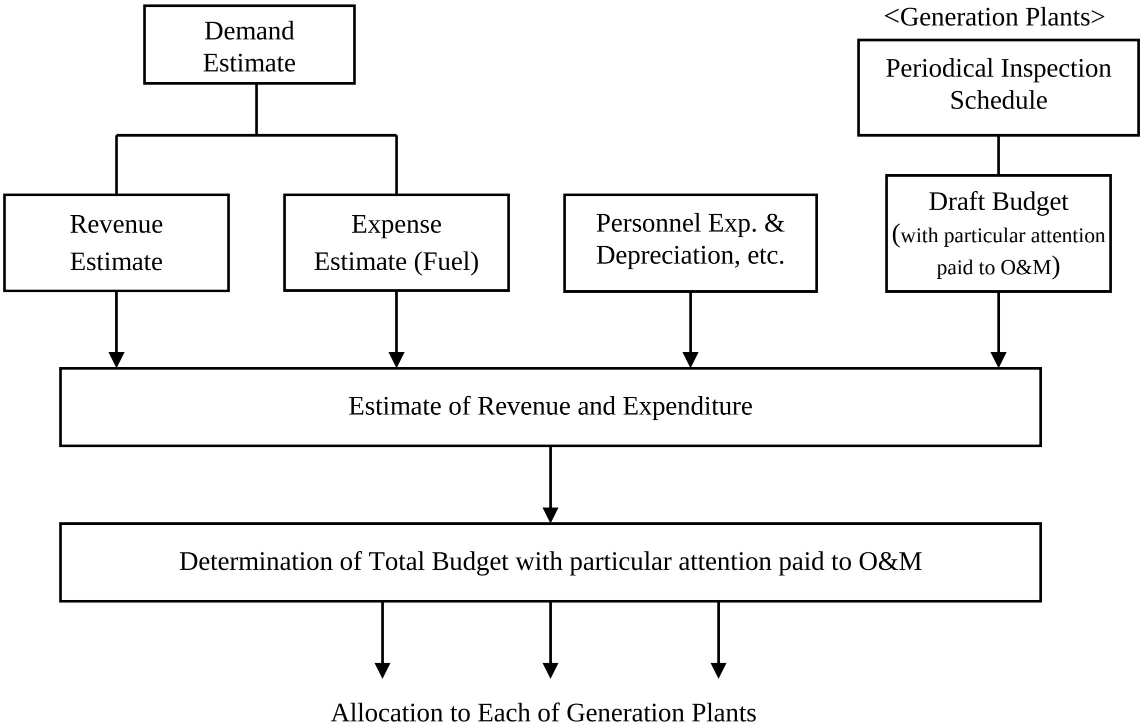
Activity	Time Frame	
	Power Station	H.O
Issue of Budget Circular		1st week of January
Commencement of the budget exercise	1st week of January	
Formulation of initial budget proposal	By 1st week of February	
Review of initial budget proposal by the Station Budget Committee and submission to Budget committee	By 10th of February	
Compilation of Station Budget		By 15th of February
Compilation of budgeted Balance sheet, Profit and Loss Account and Cash Flow Statement		By 25th of February
Circulation of initial budget proposal and budgeted Balance sheet, Profit and Loss Account and Cash Flow Statement to the various departments		By last day of February
Consolidation of comments of various departments		By 1st week of March
Review of the initial budget proposal and discussions with the stations		By 3rd week of March
Presentation of budget to Corporate Budget Committee and approval thereon		By the 25th of March
Intimation of approved budget to Power Station		By 31st March
Preparation of Final Budget and forwarding to MPEMR	By 30th April	

(source) JICA Study Team

2) Revenue and Recurrent Expense Budget

The revenue budget needs to concentrate on the estimate of revenue from electricity sales. The volume of the sale, first, needs to be estimated accurately and planned for the budget. Then comes the billing price of power which in combination with the volume estimated for the sales, can produce an estimate of the total revenue. Once the volume of generation is estimated, the expenses that will be needed for generation are to be calculated whose results will be incorporated into the expense budget. The expense budget will include items such as; fuels, personnel expenses, maintenance & repairs, depreciation, interest on loans, general administration, etc. The evaluation of the performance of budget management should not only be done at the power plant but also at the smaller units whom the responsibility budget will be allocated as much as practically possible.

It is imperative and extremely important to secure a sufficient budget for the operation and maintenance in order for the company to maintain effective and efficient operatios of the generation plants and to proceed with prudent execution of maintenance activities. For the efficient operation of the generation plants, the company undertakes to execute the scheduled maintenance and implements repairs deemed necessary as a result of the scheduled periodical checking of the plants. The budget of the company will be decided within the restriction of the total revenue and expense framework within which the company allocates the budget for each individual expense category, i.e. total budget for O&M expense of the whole company. Then, the budget determined for each category will be allocated to each generation plant in accordance with the quantified yard stick. The following figure depicts the flow of the budget preparation which envisages the revenue and expenditures with particular emphasis on maintenance and repairs, etc.



(source) JICA Study Team

Figure 12.4-3 Flow of Preparation of Recurrent Budget

In order to address the issue of the trade-off relationship that exists between the improvement of profitability and the periodical execution of the appropriate maintenance and repairs, this Study hereby recommends that the company introduce and utilize the yard stick system. Under the yard stick system, the conditional status of plants and equipment at the generation plants are checked and quantified numerically, based on which budget will be allocated to such a category of the generation plants out of the total pre-determined allocation for the category. The quantifying indicators are to consist of the following;

- Dependable capacity,
- Number of starts and stops (annual and cumulative),
- Equivalent operation hours (annual and cumulative),
- Number of forced outages, and
- Others, e.g. the extent of the seriousness of the mechanical trouble whose quantification is difficult.

The total budget allocated to each of the generation plants should be entrusted to the plant manager who would be the incumbent top of the strategic business unit (SBU) administering the plants with a certain degree of flexibility.

12.4.6 Financial simulation

The purpose of constructing the financial model is to delve into the varying situations in implementing the business plan to ascertain various factors such as; what would be the outcomes that would emerge in the financial front; whether the business plan would be viable in terms of financing and/or business promotion; what would be the tariff level that would assure the overall feasibility of the business plan, etc. In order to establish solid financial strength, a clear financial plan needs to be established. Through the process of preparing the financial plan, the management may be able to validate the commissioning date of the project, identify and become aware of the impact of the financial costs to the capital investment and the company’s competitiveness. The financial model created for the analysis has been included in the Appendix. The financial model will help the management establish a plan for obtaining and mobilizing the working capital during the operational period of the plant. Inputs to the financial model are comprised of the parameters including;

- financing structure,
- capital cost,
- operation and maintenance plan,
- revenue plan, and

Outputs of the financial model include;

- profit and loss statement,
- balance sheet,
- cash flow statement,
- financial ratios, and
- sensitivity tests.

The parameters and inputs to be reflected into the financial model need to be updated in accordance with the project's progress. For instance, a fund raising plan is to be drawn up from DPP at the initial stage of the project but will be replaced by the plan under the EPC contract as the project progresses and reaches that stage.

The user of the financial model is reminded of the fact that the outputs of the model are based on a certain assumptions and business targets to be achieved. The financial model can cope with any addition of projects as the business might expand and with a case that would involve any additional investment due to the environmental changes and/or scenarios. The model can also reflect the varying conditions of contracts such as PPA or FSA that the company will sign with outside parties. Based on such, the company will take advantage of the financial model in forecasting the financial impacts of those purchases and/or selling terms and conditions and utilize its outputs effectively during the contract negotiation.

The Chapter 14 of the Report will deal with the actual construction of the financial model and will conduct analytical work through financial simulation using the model developed.

12.5 Risk Management

12.5.1 Identification of risks

The implementation of a large scale infrastructure project involves many complex and diverse risks. The identification and allocation of those risks is critical in structuring the financing facility for such a project. The project finance which is the technology widely used by internationally established financial institutions for infrastructure projects thoroughly analyzes the risks associated and constructs appropriate measures for mitigation. Unlike the project financed under a commercial basis, the project formulated under the government sector relies upon the credibility of the government in arranging financing for implementation. For the project financed by ODA assistance, in particular, the project is implemented by the Executing Agency (Project Company) with support of the government who bears the eventual and ultimate risk for debt servicing while the provider of assistance remains keen on the debt servicing with the view to the achievement and continuation of successful operations and sustainability of the project. The concern of the provider of ODA assistance centers on the smooth implementation of the project, the efficient operation and materialization of the output, and the effect and impact is achieved as has been designed. The technology used for project finance in identifying and allocating the risks and establishing the safeguarding measures, however, remains valid and reflective in enabling the government and the Executing Agency to tightly control the project. In general, a large infrastructure project is conceived to be associated with the following materially significant risks;

- ✓ Political risk,
- ✓ Capability of the executing agency for implementation,
- ✓ Natural calamities, etc.,
- ✓ Occurrence of fatal accident,
- ✓ Project completion,
- ✓ Social and environmental risk,
- ✓ Economic and financial viability,
- ✓ Availability and stable supply of fuel,
- ✓ Related infrastructure such as the transmission lines, and
- ✓ Others

12.5.2 Analyses of risks

The risks listed above are reviewed and the mitigation measures to be taken are described in the following table for each of the risks mentioned;

Table 12.5-1 Identification of Risks by Causes (prior to COD)

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHARED			
Political risk	War or civil commotions, etc.	Suspension or destruction during the implementation phase.	X (GOB)					・Suspension, postponement of the project and/or destruction of the plant under construction.
	Seizure by government	Seizure of the Project resulting in disruption or deterioration of the efficiency	X (GOB)			・Implementation Agreement (IPP)		・same as above
	Foreign exchange control	Change in the exchange control	X (GOB)			・Implementation Agreement (IPP)		・same as above
	Law, policy or taxation change	Changes in Power Sector Policy, Coal Policy, taxation, etc.	X (GOB)			・Implementation Agreement (IPP)		・same as above
	Socio-economic instability	Riot, strikes, social unrest, etc.	X (GOB)			・Implementation Agreement (IPP)		・same as above
	Concession or operational right	Revocation of license or changes in the business rights	X (GOB)			・Implementation Agreement (IPP)		・same as above
Capability of sponsor risk	Managerial incapability	Unsophisticated management causing delay, over-run cost		X			・Recruitment of capable staff and employment of capable consultants	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHARED			
	Financial incapability	Failure to attain healthy financial conditions for, timely provision of paid-up capital and funding support for covering the cost over-run.		X			・Recruitment of capable staff	
Natural calamities, etc.	Cyclone				X	・Insurance	・Design standard (raising the ground level by 10m) and insurance	
	Tidal wave				X	・Insurance	・Design standard (raising the ground level by 10m) and insurance	
	Earthquake				X	・Insurance	・Design standard (aseismatic structure) and insurance	
	Tsunami				X	・Insurance	・Design standard (raising the ground level by 10m) and insurance	
	Others	Lightening, Storm, Tornado, Radioactive contamination, Fire, Epidemics, etc.			X	・Insurance	・Design standard (various), insurance and other appropriate measures.	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHAR ED			
Occurrence of fatal accident	Occurrence of accident	Disruption and delay in construction due to accident investigation and introduction of countermeasures				・Insurance	・Continuous training for safety management and insurance coverage	
Plant Completion (incl. access road, port and coal unloading facilities, etc.)	Insufficient capability of the consultants			X		・Consulting Contract	・Technical assessment and screening through prequalification	
	Insufficient capability of the EPC contractor			X		・Construction Contract	・Technical assessment and screening through prequalification	
	Poor Performance or defaults of sub-contractors			X		・Construction contracts	・Performance management by prime contractors and supervision by consultant	
	Delay in Govt approvals in planning, development and operation		X (MPEMR)			・Shareholder's Agreement	・Effective and timely management by CPGCBL for total project	
	Delay in progress and completion	Failure to complete the project as has been planned and designed. Along with the Project, related infrastructure required for the Project needs to be completed.		X		・Construction Contract	・Construction management by sponsor, consultant and EPC contractor	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHAR ED			
	Increase in the cost of plant and material	Insufficiency of funds due to cost increase.		X		・Construction Contract	・Contingency	
	Failure in procurement of the fuel for plant testing	Discontinuation or disruption of plant testing operation due to the shortage of fuel.		X		・Fuel Supply Contract (Coal, Gas & Oil) ・Government Guarantee for Supply of Gas (IPP)	・Mobilization of trading firms for procurement（to be funded by GOB or by JICA）	
Social and environmental risk	Non-acceptance of the Project by the local government	Failure or delay in starting construction of the plant	X (MPEMR)			・Implementation Agreement (IPP)	・Consultation	
	Failure or delay in acquisition of the land	Failure or delay in starting construction of the plant	X (MPEMR)			・Land Lease Agreement	・Consultation	
	Failure in resettlement	Failure or delay in starting construction of the plant	X (MPEMR)			・Land Lease Agreement	・Consultation	
	Resistance by local inhabitants	Failure or delay in starting construction of the plant	X (MPEMR)				・Consultation	
	Failure or delay to obtain dredging permit	Failure or delay in starting construction of the plant	X (MPEMR)			・Implementation Agreement (IPP)		
	Congestion in surface transport	Delay in construction schedule	X (MPEMR)				・Construction of access road	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHARED			
	Identification of the rare species (animals or plants)	Disruption or suspension of project implementation	X (MPEMR)				・Environmental Impact Assessment	
	Contamination/ pollution to the site environment			X			・Compliance with environmental protection guidelines	
	Deficiency financing risk	Temporary deficiency in cash flow (delay in budget execution, etc.)		X		・Borrowing Facilities from Banks ・Shareholder’s Support (Agreement)	・Financial assistance by GOB or BPDB	
	Budgeting and financing	Purchasing of fuel for plant testing and working capital required prior to COD		X		・Borrowing Facilities from Banks ・Shareholder’s Support (Agreement)	・Preparation of budget and fund raising for budget implementation	
	Fluctuation of exchange rate	Unexpected cost increase in construction cost, etc. and insufficiency of funds due to exchange loss.		X		・Borrowing Facilities from Banks ・Shareholder’s Support (Agreement)	・Contingency	
	Increase in inflation	Unexpected cost increase in construction cost, etc. and insufficiency of funds due to cost increase.		X			・Contingency	
	Insurance risk	Availability of specific coverage and/or fluctuation of insurance premium		X		・Insurance contract	・Consultation with insurance broker or company	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHARED			
	Non-compliant bids	Delay in project implementation		X		・Invitation for Bidding, Conditions for Pre-qualification and Specifications	・Quality enhancement of cost estimation	
Transmission lines	Failure in acquisition of the right of way	Delay in construction of the transmission lines	X (MPEMR)			・Implementation Agreement (IPP)	・Consultation	
	Delay in completion of the inter- linked transmission lines	Non-readiness for trial run	X (MPEMR, PGCB)			・Implementation Agreement (IPP)	・Formulation of the Project without relying on the other transmission lines	

(source) JICA Study Team

Similarly, the risks listed for the phase after the commissioning date are reviewed and the measures to be taken for mitigation are described in the following table for each of the risks mentioned;

Table 12.5-2 Identification of Risks by Causes (post COD)

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
Political risk	War or civil commotions, etc.	Suspension or destruction during the implementation phase.	X (GOB)			・Implementation Agreement (IPP) ・Power Purchase Agreement		・Suspension, postponement of the project and/or destruction of the plant under operation
	Seizure by government	Seizure of the Project resulting in disruption or deterioration of the efficiency	X (GOB)			・Implementation Agreement (IPP) ・Power Purchase Agreement		・same as above
	Foreign exchange control	Change in the exchange control	X (GOB)			・Implementation Agreement (IPP) ・Power Purchase Agreement		・same as above
	Law, policy or taxation change	Changes in Power Sector Policy, Coal Policy, taxation, etc.	X (GOB)			・Implementation Agreement (IPP) ・Power Purchase Agreement		・same as above
	Socio-economic instability	Riot, strikes, social unrest, etc.	X (GOB)			・Implementation Agreement (IPP) ・Power Purchase Agreement ・Insurance		・same as above

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Concession or operational right	Revocation of license or changes in the business rights	X (GOB)			・Implementation Agreement (IPP) ・Power Purchase Agreement		・same as above
Capability of sponsor risk	Managerial incapability	Unsophisticated management causing operational inefficiency		X			Recruitment of capable staff and Incentive system	
	Financial incapability	Failure to attain healthy financial conditions for, timely provision of working capital.		X				
	Operational and maintenance incapability	Increase in accidents, maintenance cost, and inefficiency in operation		X			Training system for operational staffs and incentive system	
	Incapability of the outsourced company	Failure to achieve the targeted level of performance under contract		X		・Outsourcing Contract	Enhancement of training system and employment of foreign engineers	
Natural calamities, etc.	Cyclone	Continuous non-accessibility period for berthing by the coal carriers			X	・Insurance	Design standard (coal storage for 60 days) and insurance	
	Tidal wave				X	・Insurance	Design standard (raising the ground level by 10m) and insurance	
	Earthquake				X	・Insurance	Design standard (a seismically strong structure) and insurance	

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Tsunami				X	・Insurance	Design standard (raising the ground level by 10m) and insurance	
	Others	Lightening, Storm, Tornado, Radioactive contamination, Fire, Epidemics, etc.			X	・Insurance	Design standard (various), insurance and other appropriate measures.	
Occurrence of fatal accident	Occurrence of a major scale of accident	Long term disruption in plant operation		X		・Insurance	Preventing maintenance and insurance	
Plant Completion (incl. access road, port and coal unloading facilities, etc.)	Failure to achieve the designed capacity performance	Less revenue due to reduction of output		X		・Construction Contract	Extension of warranty period	
	Unexpected deterioration in operational performance	Increased consumption of fuel due to inefficiency or less revenue due to reduction of output		X		・Construction Contract	Periodical maintenance	
Social and environmental risk	Negative impact on fishery	Suspension in plant operation or reduction in operating ratio			X	・Insurance	Reconsideration on warm water discharge	
	Traffic congestion on surface transport				X		Construction of access road	
	Contamination/pollution to the site environment			X			・Compliance with environmental protection guidelines	

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Malfunctioning and/or deterioration of environmental devices	Suspension in plant operation or reduction in operating ratio		X		・Manufacturer's Warranty ・Insurance	Periodical maintenance and insurance	
Economic and financial viability risk	Sales and collection risk	Sales price in short of cost recovery and/or slow collection		X		・Power Purchase Agreement		
	Delay and/or insufficiency in tariff adjustment				X	・PPA	Good operational performance, close monitoring and adjustment of tariff	
	Deficiency financing risk	Unexpected shortfall of funds for expenditure and/or debt servicing		X		・Borrowing Facilities from Banks ・Escrow Account ・Shareholder's Support (Agreement)	Parental funding support by BPDB	
	Budgeting and financing	Failure in financial management for O&M, in particular, the fund shortage for periodical maintenance		X		・Borrowing Facilities from Banks ・Shareholder's Support (Agreement)	Incorporation of sufficient budget for periodical maintenance）	

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Fluctuation of foreign exchange	Unexpected cost increase in fuel cost and O&M and insufficiency of funds due to exchange loss.		X		・Power Purchase Agreement ・Borrowing Facilities from Banks ・Shareholder's Support (Agreement)		
	Insurance risk	Availability of specific coverage and/or fluctuation of insurance premium		X		・Insurance contract	・Consultation with insurance broker or company	
	Aggravation of inflation	Unexpected cost increase in fuel cost and O&M and insufficiency of funds due to cost increase.		X		・Power Purchase Agreement ・Borrowing Facilities from Banks ・Shareholder's Support (Agreement)		
Availability and stable supply risk of fuel	Non-availability of Fuel and other materials	Occurrence of shortfall in fuel coal and/or other materials		X		・Coal Supply Contract	・Diversification of supply sources ・Sufficient stocks maintained	
	Non-availability of coal-carrying vessel	Occurrence of shortfall in fuel coal		X		・Charter-hire contract	・Medium term charter contract of spot hire contract diversified ・Sufficient stocks maintained	

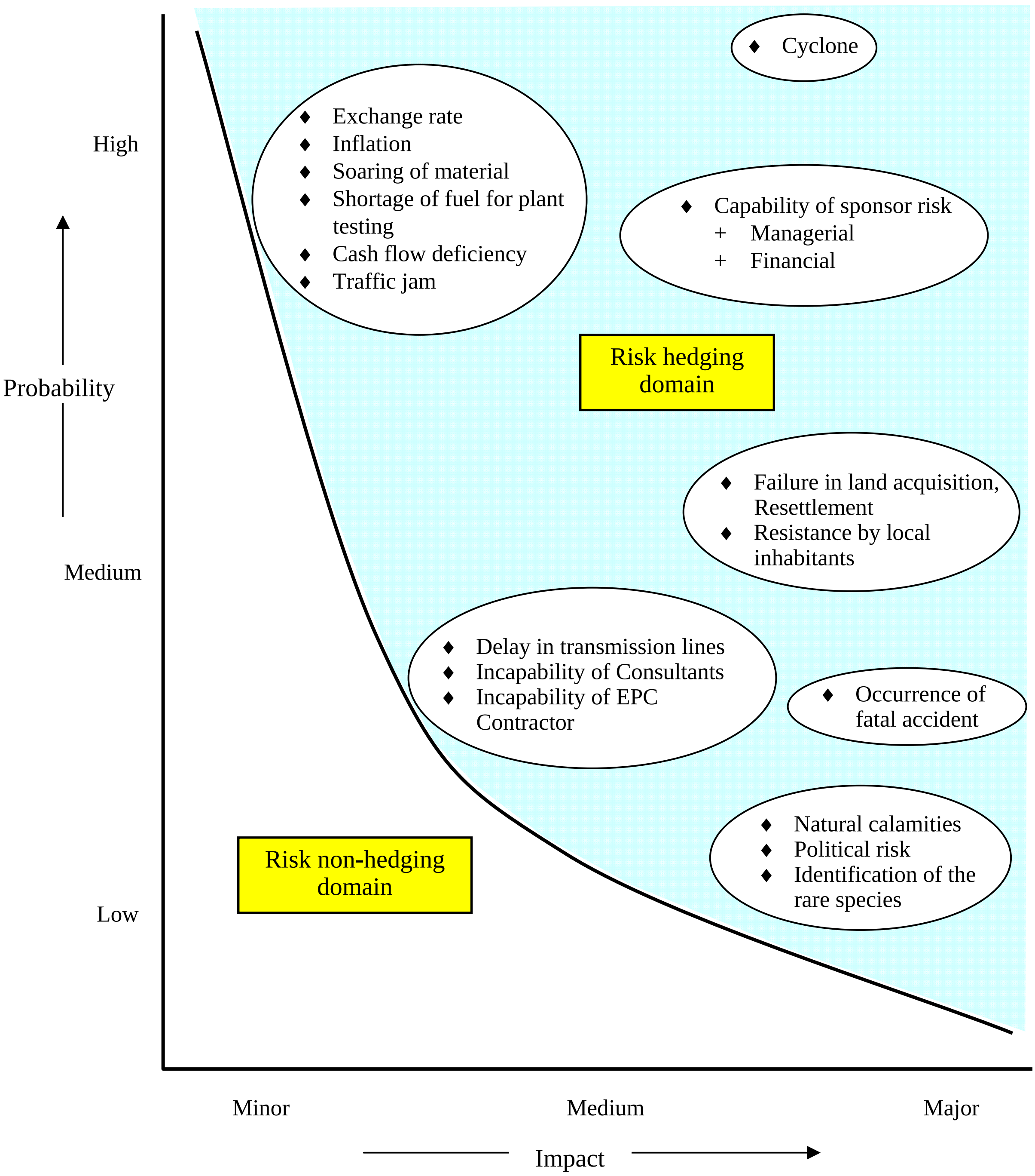
Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Long term contract risk	Discontinuation or disruption of stable operation due to the shortage of fuel while Binding obligation for purchase for the contract term and/or take-or-pay obligation		X		・Coal Supply Contract	Diversification of contract terms	
	Volatile market price	Instability in the import cost of fuel resulting in the loss of economic/financial viability		X		・Power Purchase Agreement		
	Unbalanced qualities of fuel coal	Inharmonious quality for mixing		X		・Coal Supply Contract	Construction of a reserve mills for coal of low calorific value	
	Non-availability of start-up fuel	Inability to start-up the plant		X		・Fuel Supply Contract ・Government Guarantee for Fuel (Gas or Oil) Supply (IPP)	Sufficient storage of fuel	
Transmission lines	Troubles at transmission lines	Inability to transmit the power causing the suspension of plant operation	X (PGCB)			・Power Purchase Agreement ・Implementation Agreement (IPP)		

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
Others	Sluggish increase in power demand	No dispatch instruction to the plant	X (MPEMR)			・Power Purchase Agreement ・Implementation Agreement (IPP)		
	Development of low cost gas field and/or procurement of LNG (provision of lower price gas)	Dispatch instruction to the coal fired plant becomes subordinate to other fuel and the coal fired plant to be operated as the middle-load system	X (MPEMR)			・Power Purchase Agreement ・Implementation Agreement (IPP)		

(source) JICA Study Team

It should be noted that in the two tables given above, it shows that the risk categories as well as the sub-categories appear similar in many of the risk items but the profiles are described distinctively different as the risks surrounding the Project may appear in a different manner between the two phases of the Project.

The risks are then analyzed in terms of their probability of occurrence and the impacts associated. In order to distinguish the risks that should be safeguarded or mitigated from the ones that should be left unattended, an attempt is herein made to draw a curve and plot each of the risks in a figure above or below the mitigation curve. The mitigation curve distinguishes the sphere for mitigation from the one for non-mitigation. For the risks plotted above the mitigation curve, appropriate measures for mitigation should be deliberated and introduced as their products of the probability multiplied by the impact becomes substantial. Meanwhile, the risks below the mitigation curve will be left without mitigation as the products of the probability multiplied by the impact will be less substantial. The following figure is one that describes the analysis for the phase prior to the commissioning date;



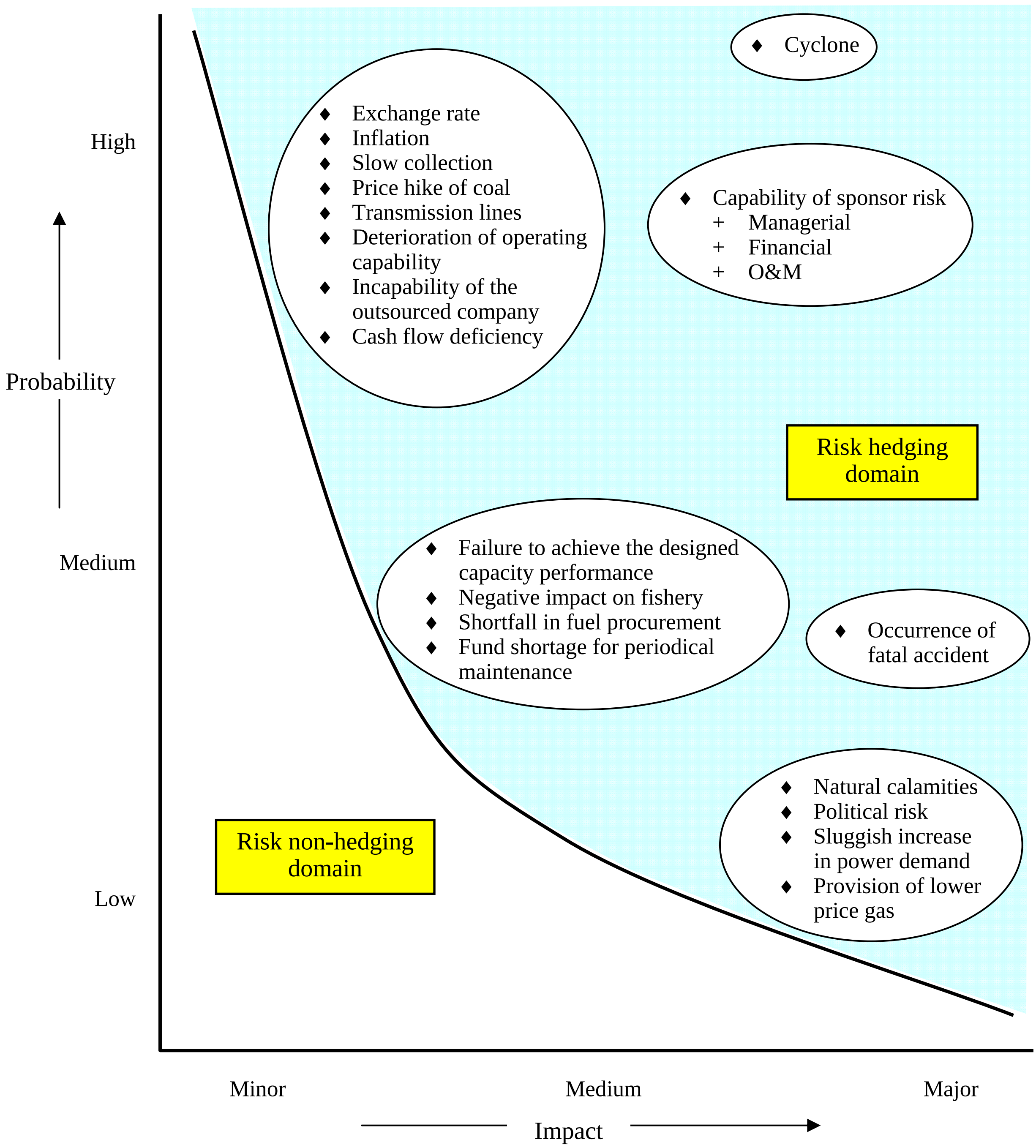
Probability
High: 1 time per 3 years or less
Medium: 1 time per 5 to 10 years
Low: 1 time per 20 years or longer

Impact
Minor: several months of delay in construction or about 10% increase in construction cost
Medium: approximately 2 years of delay in construction or about 50% increase in construction cost
Major: cancellation of the Project or more than 100% increase of construction cost

(source) JICA Study Team

Figure 12.5-1 Identification of Risks by Causes（prior to COD）

Similarly, the following figure depicts the risks analyzed for the period after the commissioning date;



Probability	Impact
High: 1 time per 3 years or less	Minor: about 10% of annual turnover
Medium: 1 time per 5 to 10 years	Medium: about 50% of annual turnover
Low: 1 time per 20 years or longer	Major: exceeding 100% of annual turnover

(source) JICA Study Team

Figure 12.5-2 Identification of Risks by Causes (post COD)

12.5.3 Contractual safeguards and prevailing practices in Bangladesh

In Bangladesh, actual cases of project finance and contractual agreements thereof are observed in the formations of IPPs. A typical case of the security package of IPP financing is comprised of the following contracts[16];

a) Implementation Agreement,
b) Power Purchase Agreement,
c) Gas Supply Agreement,
d) Oil Supply Agreement,
e) O&M Agreement,
f) Construction Contract,
g) Shareholders' Agreement, if any,
h) Financing Documents,
i) Escrow Agent,
j) Insurance Policies,
k) Guarantee,
l) Land Lease Agreement,
m) Consents to and acknowledgements of assignments and direct agreements in favor of Lenders in respect of the documents assigned as security to the Lenders under the Financing Documents.

For the public sector project, similar agreements are brought in and practiced among the parties concerned with the exception of; implementation agreement, shareholders' agreement, escrow agent, a part of the guarantee package, and assigning of documents. Following table lists up important contracts normally signed for power development projects to be implemented by the public sector and by the private sector together with some of their relevant specifics;

[16] Power Cell, MPEMR, "Sirajganj Power Project", (website) as of June 12, 2012

Table 12.5-3 List of Important Contracts to be Involved for Power Development Projects

Name of Contract	Parties to the Contract	Content	Time Limit for Signing		Particulars (Reason of Difference between Public & IPP Projects)
			Public Sector Projects	IPP Projects	
Implementation Agreement	Government – IPP	The government commits its involvement and commitment to IPP for development and generation of electricity for delivery to national grid.	Not customarily practiced	Project Effective Date (PED) *1	To enable Lenders assess the financial viability and security package so that the Lenders can make commitment for extending long term loan based on the financial structure and the security package
Land Lease Agreement	Land Owner – Executing Agency (E/A)	Lease of land by land owner (BPDB) to E/A for the location of the Facility	Sufficiently prior to Construction Start	PED	
Power Purchase Agreement	E/A – BPDB	Off-take agreement between the single buyer, BPDB, and the generation company, E/A for the sale of the electricity generated	Sufficiently prior to Commercial Operations Date (COD)	PED	
Gas Supply Agreement	E/A - Gas Supplier	Agreement between the Gas Supplier and E/A for the Supply of Gas for generation of power	Plant Testing Date	PED	
Coal Supply Agreement	E/A - Coal Supplier	Agreement between the Coal Supplier and E/A for the Supply of Gas for generation of power	Sufficiently prior to Plant Testing	PED	
Oil Supply Agreement	E/A - Oil Supplier	Agreement between the Oil Supplier and E/A for the Supply of Gas for generation of power	Sufficiently prior to Plant Testing	PED	
Consulting Service Contract	E/A - Consultant	Agreement between the consultant and E/A for the advisory and assistances for E/A's work in designing, engineering, procurement, construction, completion, start-up, testing and commissioning of the Facility	Upon Execution of Loan Agreement		IPP is not mandated to employ the consultant.
Construction Contract	E/A - Contractor	Agreement between the construction contractor and E/A for the design, engineering, procurement, construction, completion, start-up, testing and commissioning of the Facility	Upon Execution of Loan Agreement	Construction Start Date	IPP retains option for signing of the construction contract so long as it meets the key

O&M Service Agreement	E/A – O&M Service Provider	Agreement between E/A and O&M contractor for assisting E/A in the operation and maintenance activities	COD	Upon execution but not later than 120 days prior to COD	milestone dates established up till the eventual COD
Shareholder's Agreement	Shareholder – E/A	Agreement between the shareholder and E/A for assisting E/A with provision of equity capital, subordinated capital, if and when required	Not customarily practiced	PED	To enable Lenders assess the financial viability and security package so that the Lenders can make commitment for extending non-recourse long term loan based on the financial structure and the security package
Share Purchase Agreement	BPDB - IPP	Agreement between BPDB and IPP committing BPDB and/or IPP to make equity investment		PED	
Budget Financing Agreement	Government – E/A	Agreement between the government and E/A for provision of equity and loan from the national budget	Not customarily practiced		
Loan Agreement (for Donor Lending)	Government - Donor	Agreement between the donor and the government for provision of financial assistance for long term	Upon appraisal of the Donor and approval of ECNEC		
Subsidiary Loan Agreement	Government – E/A	Agreement between the government and E/A for on-lending the donor loan received by the government	Upon appraisal of the Donor and approval of ECNEC		
Loan Agreement (for IPP)	E/A – Lender Institutions	Agreement between the lender institutions and E/A for provision of long term loans		Financial Closing Date (FCD) *2	Lenders sign and commit extension of non-recourse long term loan based on the financial structure and the security package.
Escrow Agreement (for IPP)	E/A – Lender Institutions	Agreement between E/A and the lender institutions to establish an account under control of escrow agent for pooling funds for debt servicing		FCD	
Government Guarantee	Government - IPP	Guarantee to be issued by the government for the payment obligations of; BPDB under PPA; the Gas Supplier under Gas Supply Agreement; BPDB under the Land Lease Agreement; BPDB under Share Purchase Agreement; PGCB for wheeling responsibility under Implementation	Not customarily practiced	FCD	

		Agreement			
Assignment of Securities	E/A – Lender Institutions	Agreement between E/A and the lender institutions for assigning to the lenders the security packages of; Implementation Agreement, PPA, Gas Supply Agreement; Oil Supply Agreement; O&M Agreement; Construction Contract; Consulting Contract; Shareholder's Agreement; Budget Financing Agreement; Escrow Agreement; Insurance Policies; Guarantee; Land Lease Agreement; and Consents to the assignment in favor of the lenders in respect of documents assigned as security to the lenders.	Not customarily practiced	FCD	Lenders sign and commit extension of non-recourse long term loan based on the financial structure and the security package.
Letters of Credit	E/A's Bank - Supplier		Prior to Shipment of Supplies	Prior to Shipment of Supplies	
Insurance Policies	Insurance Company – E/A		Construction Start Date for Construction Insurance and COD for Operations Insurance	Construction Start Date for Construction Insurance and COD for Operations Insurance	

(note) *1: Project Effective Date is defined as the date on which the last of the Project Agreements, i.e. the Implementation Agreement, the Land Lease Agreement, the Fuel Supply Agreement, the Power Purchase Agreement and the Share Purchase Agreement, is executed and delivered by each of the parties thereto.
*2 Financial Closing Date is defined as the date on which the Financial Closing occurs. Financial Closing is achieved through the execution of the Financial Documents, i.e. the Loan Agreement, Notes, Indentures, the Security Agreement, Guarantees, and other documents relating to the construction and permanent financing of the Facility between the company and the Lenders.

(source: JICA Study Team)

By and large in the power sector development projects, the types of contracts involved can be classified into two; one is the project documents and the other is financing documents. The former includes the Implementation Agreement, the Land Lease Agreement, the Fuel Supply Agreement, the Power Purchase Agreement and the Share Purchase Agreement and are to be signed among the Government, the Sponsor, the Sponsor's Parent Companies, the Fuel Suppliers, the Off-taker, etc. The latter includes the Loan Agreement, Notes, Indentures, the Security Agreement, Guarantees, and other documents relating to the construction and permanent financing of the Facility and are to be signed by the Sponsor and the Lenders. It is customary that for the IPP projects the signing of the projects agreement precedes the signing of the financing documents with the time interval of approximately nine months. The time interval is introduced so that the potential lenders can conduct due diligence of their own based on the financial structure established by the project agreements and assess the financial viability of the project for extending the non-recourse long term loan. For the public sector project on the other hand, there is no such distinctive time gap between the type of documents and rather it tends to be such that the agreements are signed at the last minutes before their implementation.

The contents, terms, and conditions contracted in those agreements, however, are not significantly different between the public sector project and the private sector one. But what is recognized is that there is a marked difference in the ways those agreements are enforced. In the private sector, those agreements contracted are rigidly observed and complied with during execution whereas the ones in the public sector are less rigidly observed and complied with, whereas the public sector entities have been less rigid in observing the agreement signed and commitments made in the laissez faire atmosphere. An atmosphere of inertia has been taken as the reasons causing inefficiency and irrationalities of the power sector in the country. There is an acute need of drastically changing such prevailing practices. While this Project is not of the private sector, but the enforcement of the agreements have to be made in the manner which is prevailing in the private sector.

The important agreements have been drafted and are attached into the Appendix.

12.5.4 Power Purchase Agreement (PPA)

BPDB is to purchase all the generated electricity from BPDB's subsidiaries and the IPPs. The Power Purchase Agreement (PPA) is made between BPDB and BPDB's subsidiaries and IPPs to determine the purchase price. The IPP Cell of BPDB is responsible for PPA matters not only with private IPP but also with BPDB's subsidiaries. Payment for electricity is paid based on the PPA from BPDB to BPDB's subsidiaries and IPPs. Therefore, PPA is of considerable significance for the BPDB's subsidiaries and IPPs' management system.

A key position of a typical PPA between BPDB and BPDB's subsidiaries and IPP's is shown below;

(1) Payment conditions

- Payment consists of two portions, Capacity payment and Energy payment
- BPDB's subsidiary-IPP sends the bill for the previous month to BPDB by the 7th of every month, and BPDB pays the charge within 30 or 45 days after receiving the bill.

(2) Capacity payment

- Capacity payment is determined by dependable capacity.
- Dependable capacity is determined based on the dependable capacity test, which is carried out within one month after annual periodical maintenance. However, when the results of the dependable test are different from the actual value, the company has the right to claim a re-test.
- Dependable Capacity Test measures 12 Net Energy Output continuously every 30 minutes in a power transmission end (delivery point). Dependable capacity is taken as the average value.
- Capacity payment consists of 2 parts, namely escalable part and non-escalable part. For the escalable part, the predetermined escalation rate (consumer price index) is to be taken into account.

(3) Energy payment

- Energy payment is proportional to the generated electric energy (Net Energy Output).
- When the gas price fluctuates, the unit price of energy payment also changes according to the amount of such changes.

(4) The penalty for outage in operation

- As stopped operations, forced outages, maintenance outages, and scheduled outages are specified.
- In the sum total of the three outages specified above, the annual total of 876 hours (36.5 days) is allowed. In addition, every 3 years an annual total of 1376 hours (57.3 days) or 1440 hours (60 days) is permitted.
- When the number of outage hours exceeds the permitted period, BPDB's subsidiary-IPP needs to pay a penalty according to the number of hours which exceeded the allowable hours. The unit price of a penalty is the same as those of the capacity payment.

(5) Risks related to PPA

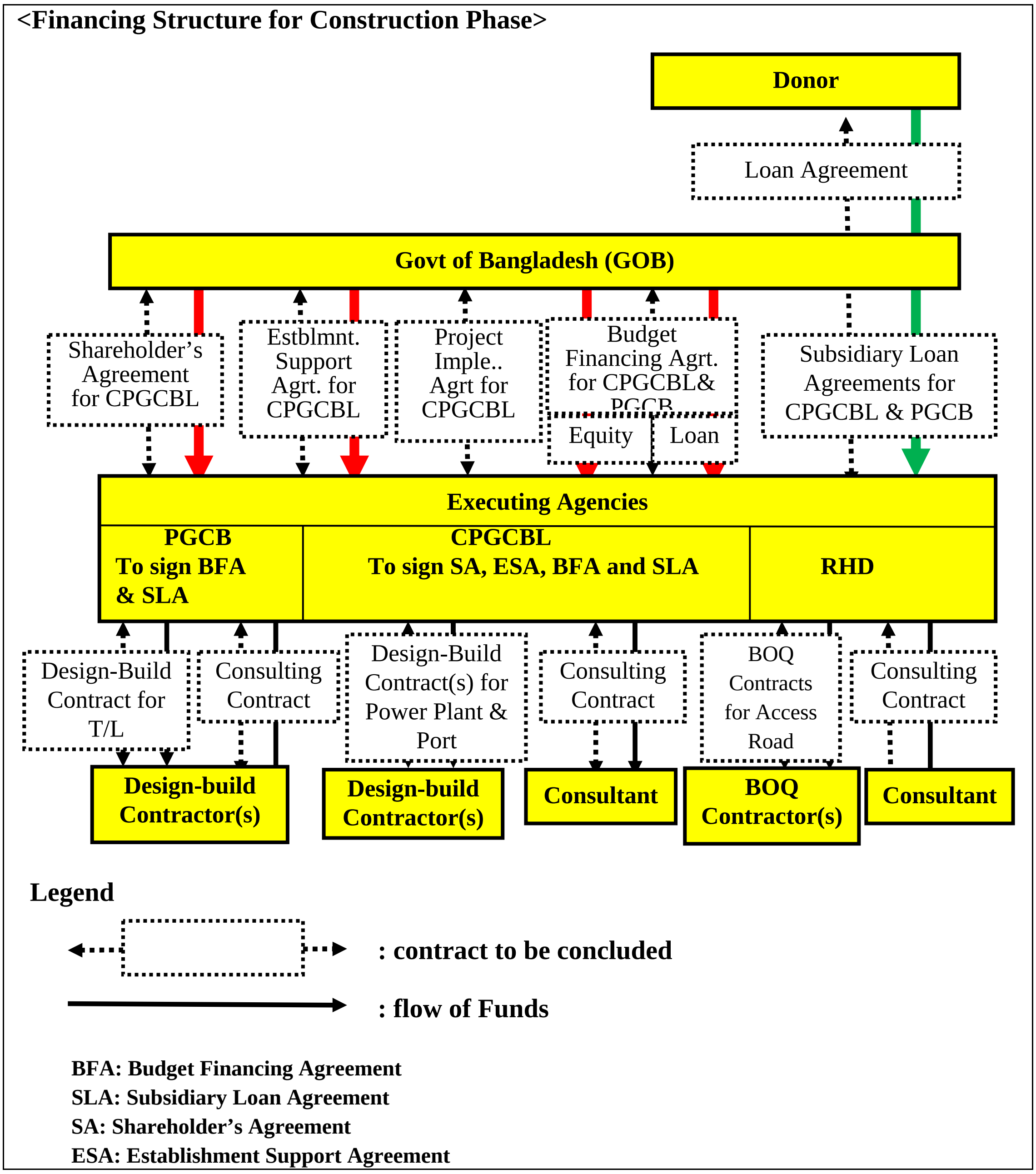
- Procurement of coal would be the possible major risk for CPGCBL. Different from the PPAs for the existing BPDB Subsidiaries, whose power plants are fueled by domestic gas procured by BPDB, CPGCBL might not be able to receive an even capacity charge in case the company fails to generate enough power for the agreed dependable capacity level due to a shortage of imported coal. Although the current draft PPA with private IPPs whose power plant will be also fueled by imported coal does not mention the payment conditions of the capacity charge in case of a fuel shortage, it might add the conditions because the power generation companies will be solely responsible for the procurement of imported coal.
- Besides the above, there seem to be no significant financial risks related to PPA for CPGCBL because, like other BPDB subsidiaries, the company may be able to expect financial assistance from BPDB finally.

(6) Measures for protection from fluctuation risks

- In the PPA, BPDB's subsidiaries and IPPs are exempted from risks related to currency exchange fluctuation, inflation, and fuel expense fluctuation.

12.5.5 Measures for minimization of risks

The financing structure places the major parties to be involved in the Project and the contractual relationship to be established. The following two figures illustrates the contractual agreements and the flow of funds among the parties concerned with the project during the phases of construction and commercial operation separately, the first being the financial structure during the construction phase where the funds raised by the executing agency through the equity and loans provided by the government and the donor are dispended for the construction of the project as the payments under the EPC contract as well as the consulting contract ;



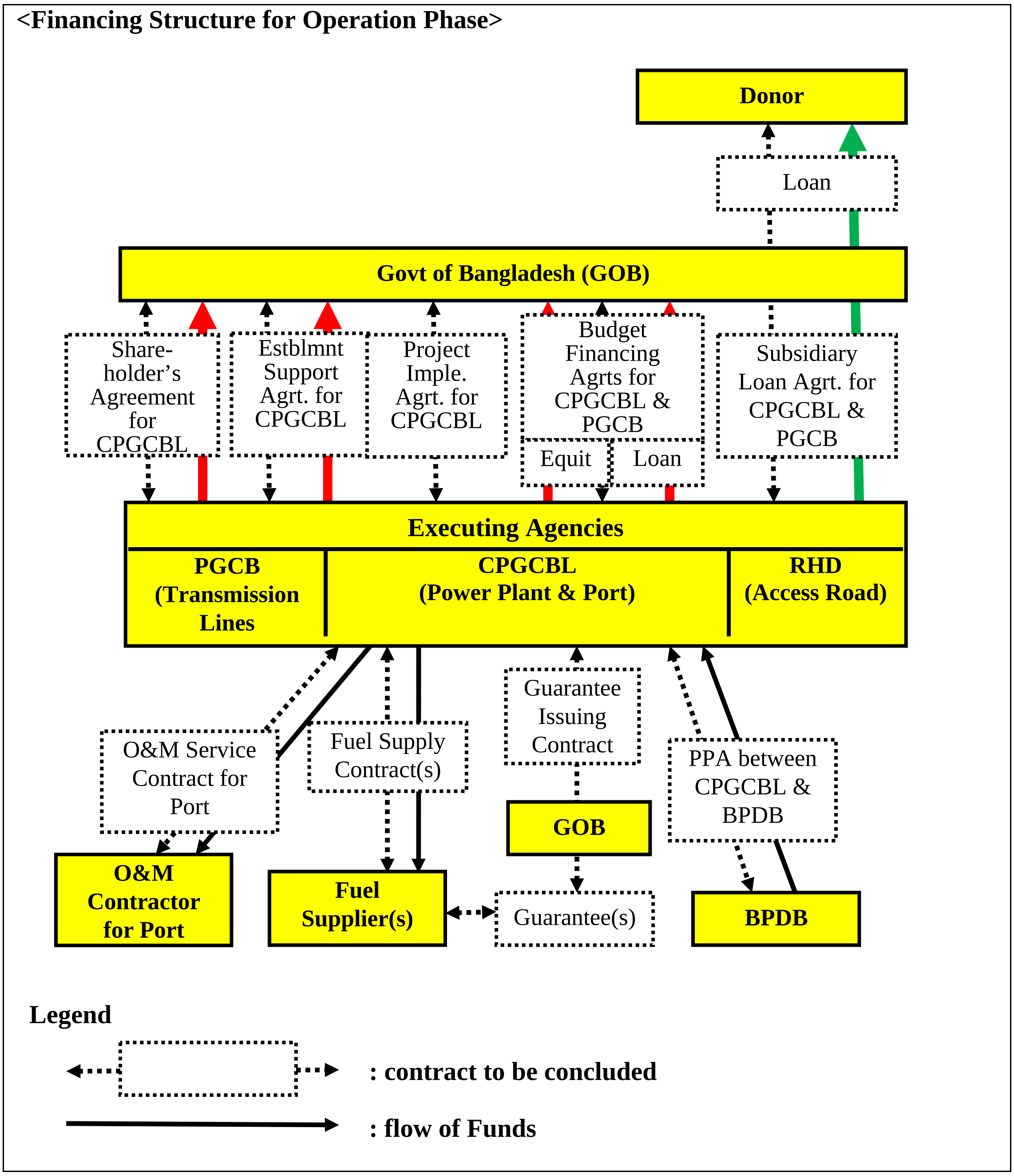
(source) JICA Study Team

Figure 12.5-3 Financing Structure during Construction Phase of ODA Funded Project

The financing method as well as the terms and conditions of the ODA funded projects have been described in 12.4.3 (2) above. In essence, the standard terms of conditions by which the government provides lending its own finance and relending foreign loans to BPDB including its subsidiaries are; (i) the foreign loans received is relent 100%, (ii) the government provides the rest of the funds required of which 60% in equity and 40% in loans, (iii) repayment term: 20 years including a 5-year grace period. By relending the foreign loans, the government is transferring the responsibility of repaying the foreign loans to the Executing Agency together with the foreign exchange risk, although the ultimate responsibility for repayment and debt servicing is assumed by the government.

With respect to the budget financing agreement between the government and CPGCBL, the prevailing practice is that no specific agreement is signed between the government and the power entities for provision of budget funds. It deems to be imperative that the government and the generating company should have a clear document stipulating the terms and conditions of the funds provided as well as the obligation and responsibility to be obeyed for such funding. The budget financing agreement may be replaced by separate agreements one of which will be signed for equity investment and the other for government lending between the both parties.

What follows next is the financial structure during the commercial operation phase in which the executing agency produces and sells the electricity to BPDB as the single buyer from whom the executing agency collects payment for the sale and then to pay for the import of fuel and other expenses while making land lease payments; principal and interest on loans borrowed.



(source) JICA Study Team

Figure 12.5-4 Financing Structure during Commercial Operation of ODA Funded Project

In respect of the major risks stipulated earlier and the financing structure constructed, there remains some vulnerability to be addressed for reinforcement and mitigation. The vulnerability is admitted within the realm of the following risk categories and it is hereby recommended that strong and effective measures be taken to safeguard and minimize the risks;

(1) Capability of the Executing Agency for implementation

The Executing Agency of the Project is designated to be the CPGCBL who has been established of very late in September, 2011 under the Company Act 1994. All of the company's capital comes from the government. BPDB has been authorized by the government to hold shares in the company. The company appointed two top positions of Managing Director and Company Secretary from the incumbent staff of BPDB on a deputation basis. Aside from those positions, no one else has been appointed nor hired for the company. On the other hand, BPDB has been working through a unit established for the development of three coal based mega power projects[17] in different locations of the country which includes the Project. The company remains a nominal vehicle with no full time personnel. Any of the preparatory work has to rely on BPDB's unit for the mega projects. The preparation of the Project includes a feasibility study for which the project owner has to actively engage, acquire and accumulate the complete knowledge and full ownership of the Project. It is of vital importance that the company is reinforced with an appropriate organizational set-up including the structuring of the board, human resource policies and mobilization entailing the employment of skilled staff and financial resources to make itself a full-fledged institution for carrying out the Project's preparation, execution and implementation. At an early stage of project implementation and commercial operation, the company may take advantage of the assistance to be provided by international consultants and/or experts. In addition, there must be a firm commitment by BPDB to provide CPGCBL with sufficient financing support including a capital injection.

(2) Availability and stable supply of fuel/raw materials

The supply of fuel is of vital importance to the stable and continuous operation of the power generation plant. A certain volume of coal meeting a prescribed quality standard has to be fed into the Project continuously. There should be no break of time in the feeding of coal to the generation plant. It is desired that the coal fuel becomes available to the Project on a long term contract basis. Project finance normally requires the conclusion of a long term supply contract of fuel to minimize the risk of operational disruption due to the deficiency of fuel. The Project is confronted with the same risk of the non-availability or instable supply of fuel. Should it happen that the supply of fuel

[17] The three projects are; 1,320 MW Coal Based Thermal Power Plant each at Khulna, Chittagong and 5,320 MW Coal Based Thermal Power Plant at Maheshkhali. (CEGIS, "Consulting Services on Coal Sourcing, Transportation and Handling of 2X660 MW Coal Based Thermal Power Plants Each at Chittagong and Khulna, and 8,320 MW LNG and Coal Based at Maheskhali", June 2012)

coal shall be arranged with the mixture of multiple contracts in the shorter and/or medium term, it is imperative to make sure that the mixture of those contracts enables the Project to utilize fuel continuously without a break with the exception being the period of time when the plant is shut down while clearing the quality standard designed for the plant. The Project may find it difficult to enter into a long term contract with the suppliers without having the payment guarantee by the government to cover the buying obligation. The government is urged to provide support by issuing the guarantee for such purchase contracts if required.

(3) Project completion

The completion of the Project requires not only the physical completion of the plant but also the achievement of the designed capacity and efficiency of operation. In addition, the large infrastructure project also requires the completion of related infrastructures such as the port, access road and transmission lines, etc. A delay in the construction of any part of the plant and related infrastructure results in the inability or inefficient operation of the Project. The causes for the failure or delay in completion can vary. The Executing Agency, CPGCBL, together with its parent, BPDB and the government (collectively “Sponsor”) have to ensure that the whole of the Project including the related infrastructure is completed within the planned schedule and budget. The measures introduced by the project finance to safeguard the project completion include; (i) selection and employment of the EPC contractor with a good track record and adequate capability; (ii) monitoring of the implementation of EPC contract through monthly reporting and inspection, (iii) giving proper consideration and providing measures for social and environmental protection with appropriate assistance from the consultants and/or by NGOs; (iv) construction supervision through the consultant, (v) commitment and provision of the additional finances by the Sponsor for cost over-run, (vi) commitment to a financial agreement that establishes certain financial ratios to be achieved immediately prior to the completion.

(4) Stable operations

The Executing Agency has little experience in operating the coal-based power generation plant of advanced technology. The operation and maintenance of the Project requires assistance to be provided under the O&M service contract with experienced contractor(s). The project finance may even adopt the outsourcing of the management of the plant under the management contract or the introduction of a technical assistance agreement with the Sponsor or the third party. The sponsor may reasonably consider outsourcing of O&M to an experienced contractor under a service contract. Needless to say, a sufficient budget is secured for O&M irrespective of the adoption of the outsourcing or not.

(5) Sales and collection risk

The project finance relies solely upon the revenue from the sales proceeds of the Project for repayment of the loans provided. The disruption of cash flow due to unstable sales endangers the debt servicing by the borrower. The financers require the Project to secure the stable and long term contract for sale of the products. The conclusion of the PPA covering the entire project period is a must requirement for the commercial project financing. Even if the sales contract covers the long term, there remains the risk of a price fluctuation. The project can be protected from the risk of price fluctuation by making sure that PPA accommodates the payment in full reflection of both the inflation and fluctuation in the exchange rate. For additional protection, the risk of collection and price fluctuation can be minimized through the opening of an escrow account to which any excess portion of funds derived when the sales proceeds exceeding the operational expense and debt servicing is credited and pooled for future debt servicing purpose. Alternatively, the Sponsor commits paying the deficiency amount to the Executing Agency when the sales proceeds are short of covering the operational expenses and debt servicing. Such a case of deficiency payments can be resorted to when the government commits to paying a subsidy to bridge the gap in electricity prices.

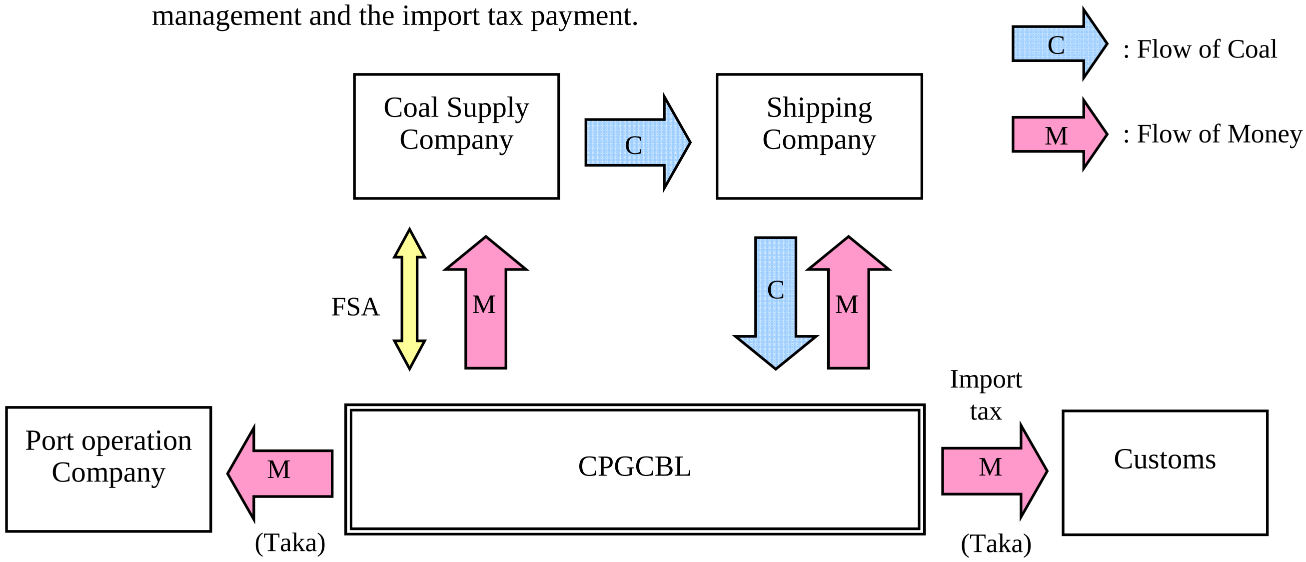
12.6 Coal Procurement

The JICA Study Team carries out a comparative study of the following three options for the method of coal procurement and proposes optimal ones.

- Option 1: CPGCBL procures Coal
- Option 2: Government of Bangladesh (GOB) procures Coal
- Option 3: Private Trading Company (PTC) procures Coal

(1) Option 1: CPGCBL procures Coal

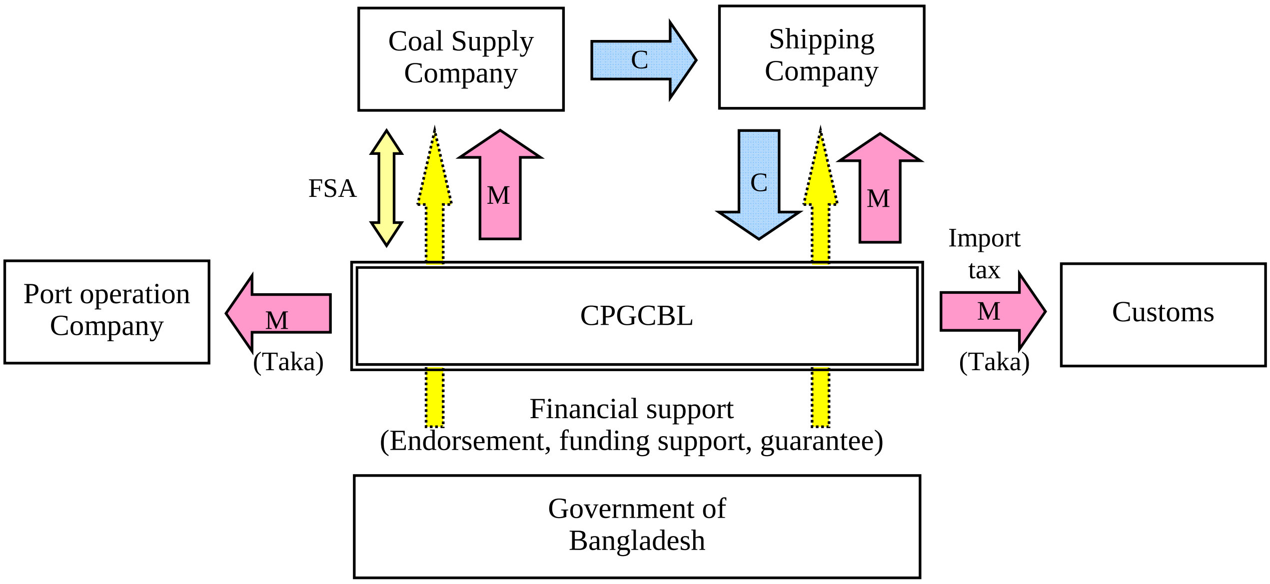
The CPGCBL procures coal, and carries out the related business of port operation management and the import tax payment.



(Source: JICA Study Team)

Figure 12.6-1 Flow of Coal (Option 1)

In the initial stage, the CPGCBL does not have enough experience in coal procurement and it is very difficult to obtain trust from the coal supply company. Therefore, the JICA Study Team modified Option 1 a little, and set the following option (Option 1') which GOB completely supports.

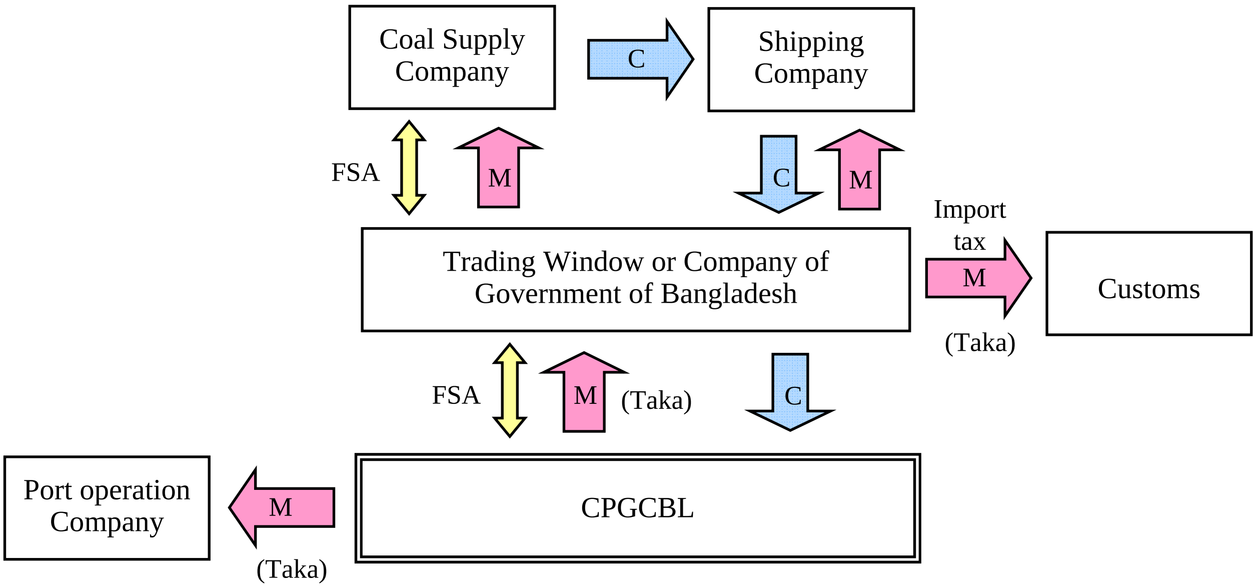


(Source: JICA Study Team)

Figure 12.6-2 Flow of Coal (Option 1')

(2) Option 2: Government of Bangladesh (GOB) procures the Coal

GOB establishes a Trading Window or a Company of GOB, this organization procures coal, and it supplies coal to the coal users such as the CPGCBL.

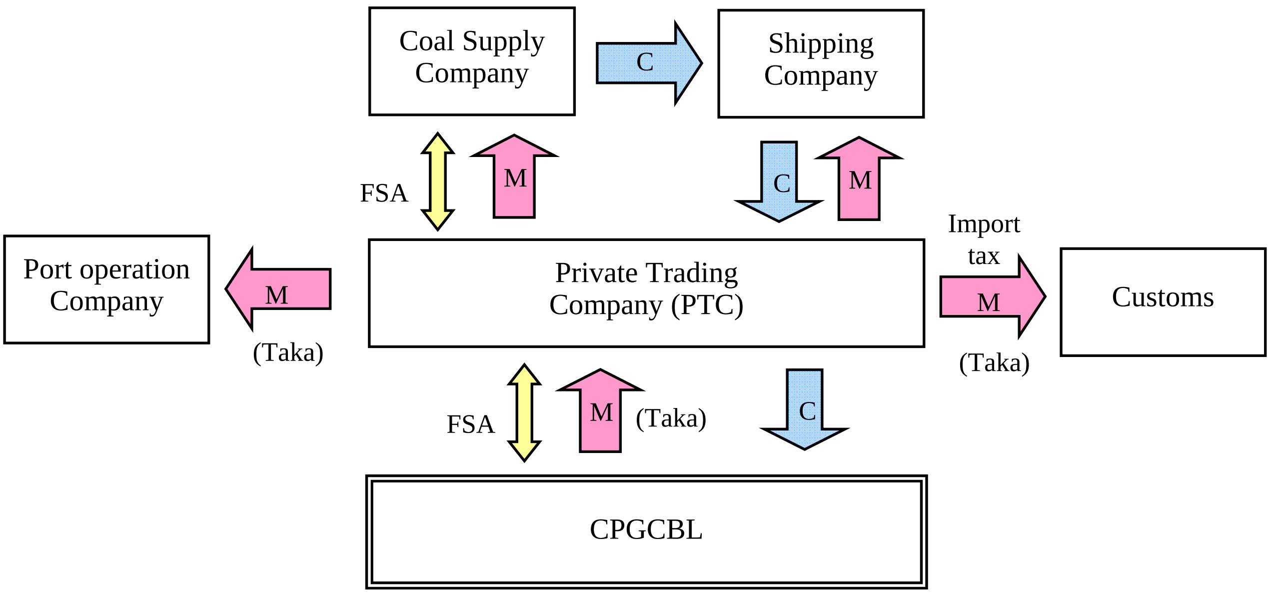


(Source: JICA Study Team)

Figure 12.6-3 Flow of Coal (Option 2)

(3) Option 3: Private Trading Company (PTC) procures the Coal

The CPGCBL procures coal through PTC. PTC also executes the related business of port operation management and the import tax payment.



(Source: JICA Study Team)

Figure 12.6-4 Flow of Coal (Option 3)

When PTC is an enterprise in a foreign country, payments will be made in dollars.

(4) Comparative Analysis for each Option

The result of a Comparative Analysis for each Option is as follows.

Table 12.6-1 Comparative Analysis for Each Option

	Option 1’	Option 2	Option 3
Procurement by/through	Directly by CPGCBL	Through GOB’s window	Trough PTC
Total cost of Fuel	Less costlier	Medium	Costlier
Procurement risk	Coal may not be procured if appropriate support from GOB is not obtained.	Procurement is possible if it never sticks to the import country and the quality.	None
Staffs required at CPGCBL	Because the business that CPGCBL should execute increases, a large number of employees are needed.	Medium	Because a considerable part of the business is outsourced, the number of employees is less than others.
Experience and capability accumulation	The experience and networks are accumulated in the CPGCBL.	The experience and networks are accumulated in Bangladesh.	The experience and networks are not accumulated.
Foreign currency (FC) for payment	CPGCBL should prepare the foreign currency.	CPGCBL should not prepare the foreign currency. But GOB should prepare the foreign currency.	CPGCBL should prepare the foreign currency when PTC is an enterprise in the foreign country.
Selling of imported coal	CPGCBL can enjoy advantage in reselling business.	The newly established organization executes the import coal sales in Bangladesh.	PTC executes the import coal sales to the other companies.
Others		It is necessary to establish the governmental enterprise besides CPGCBL.	There is a possibility that PTC requests GOB's support without supplying the coal only by the credibility of the CPGCBL.

(Source: JICA Study Team)

Option 1' is the most excellent plan from the cost, experience, and the resale point of view. However, procurement risk is high, and the support from GOB is indispensable. On the other hand, Option 3 is effective as a plan that avoids procurement risk.

In Japan, power utilities basically purchase coal from coal suppliers through Japanese trading companies (Option 3). Recently, Japanese power utilities have started a self-procurement system of coal with the rights of coal mines due to cost reduction (Option 1). There is not any developing country to import coal for power plants. (except for IPP projects)

(5) Coal Procurement Method

The coal procurement in this Project is for the first import coal in Bangladesh. Dealings with the country where Bangladesh does not have enough experience as an import country will begin. Therefore, it is necessary to consider the following points.

- To secure a stable supply for the long term
- To procure good quality coal at as low a price as possible
- To secure procurement transparency
- To accumulate knowledge of the coal procurement in Bangladesh in the future

Based on these points, the Study Team recommends the following coal procurement plan. (Refer to Figure 12.6-5)

In consideration of the above terms and conditions, the procurement of coal is executed via an international tender. However, because CPGCBL does not have knowledge concerning the execution of an international tender, an experienced consultant is employed. This consultant creates tender documents and decides the evaluation criterion for selecting the successful bidder. The price, the quality, and the stability of supply, etc. are considered to be the evaluation criterion.
After selecting a successful bidder, the Supporting Agency comprised of the CPGCBL staff and the above mentioned consultant is established. The organization chart of Supporting Agency is as follows.

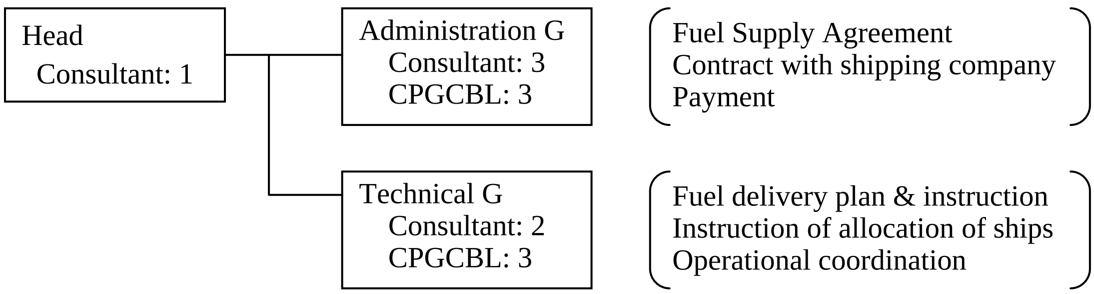


Figure 12.6-5 Organization Chart of Supporting Agency

The Supporting Agency executes the following service.

- To support CPGCBL related to a fuel supply agreement (including annual price negotiation and contract extension, etc.)
- Instruction of fuel delivery (amount and time)
- Contract with shipping company

- Instruction of allocation of ships
- Payment procedures based on the contract
- Operational coordination with port operation company and CPGCBL (or coal yard operation company)
- On the Job Training (OJT) for coal procurement etc.

The trading company has been accumulating a lot of knowledge in the area of coal procurement. However, there is the strong concern that a conflict of interest will arise when becoming a constituent member of the Supporting Agency because it will become a contracting party. In consideration of this point, the consultant who is a third party becomes a constituent member in the Supporting Agency.

1) Time schedule

The consultant who has sufficient experience in coal procurement is hired for about five years before the first shipment. Furthermore, the consultant executes a tender concerning the coal procurement. In order to have CPGCBL staff accumulate knowledge, CPGCBL will establish a Supporting Agency with the consultant. At the stage where knowledge is accumulated in the future, CPGCBL will execute the procurement of coal.

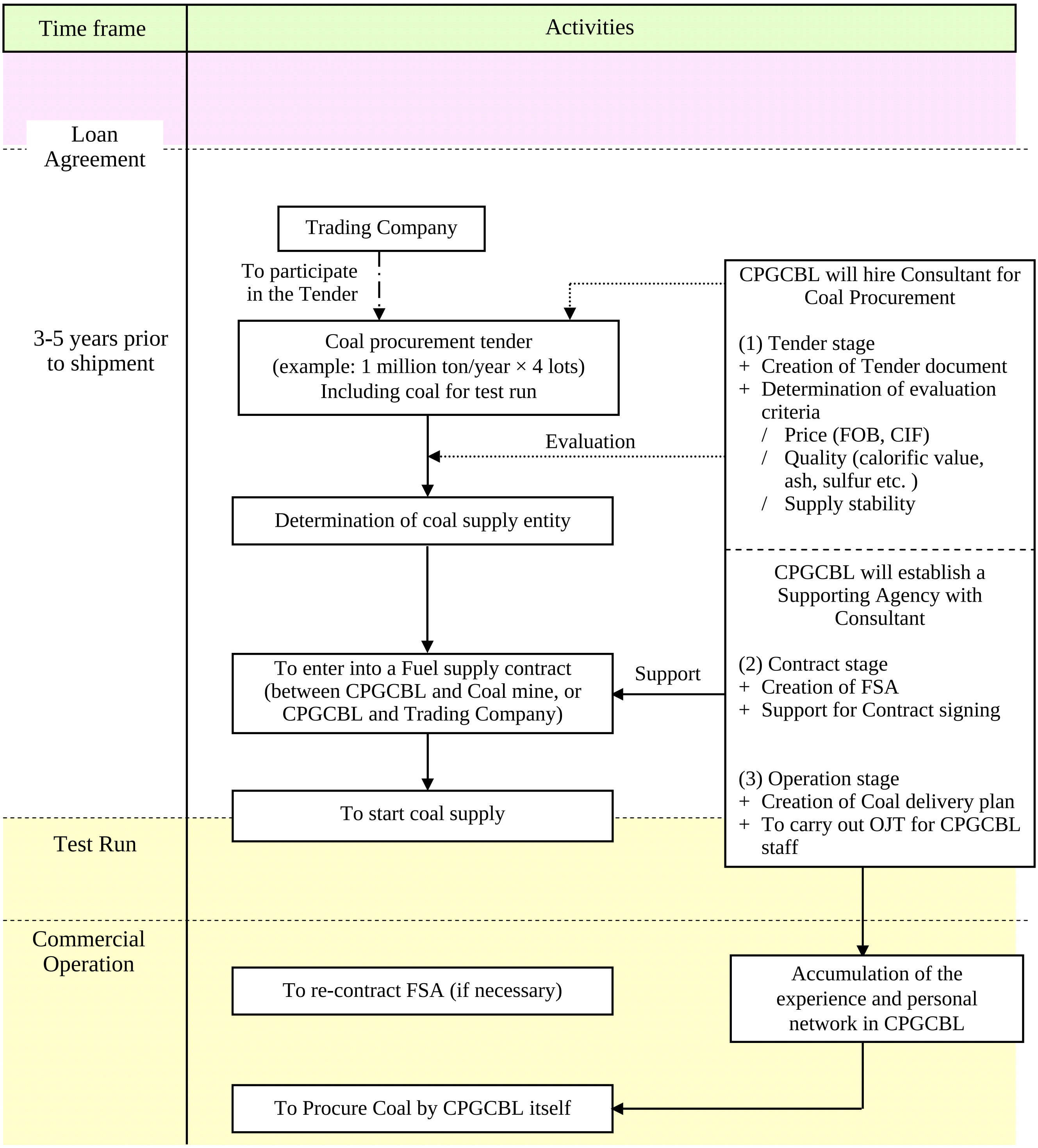
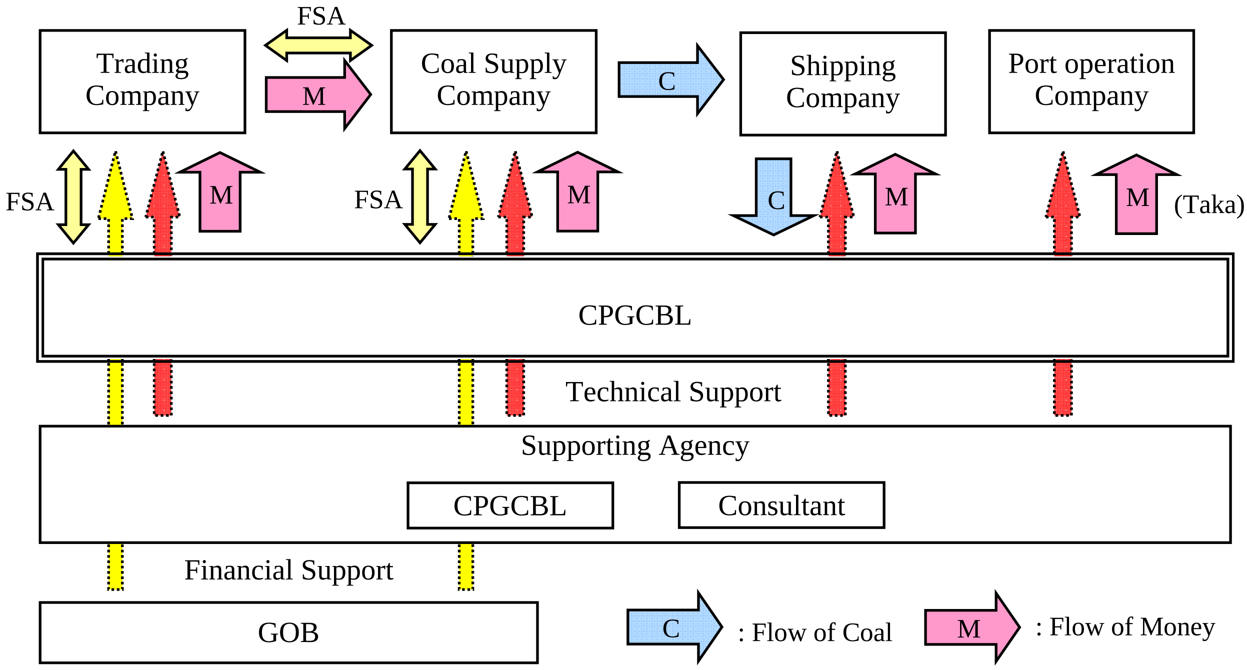


Figure 12.6-6 Recommendation Flow of Coal procurement

2) Operation system for several years after commercial operation

Supporting Agency supports CPGCBL technically concerning the coal procurement for several years after the commencement of commercial operations.

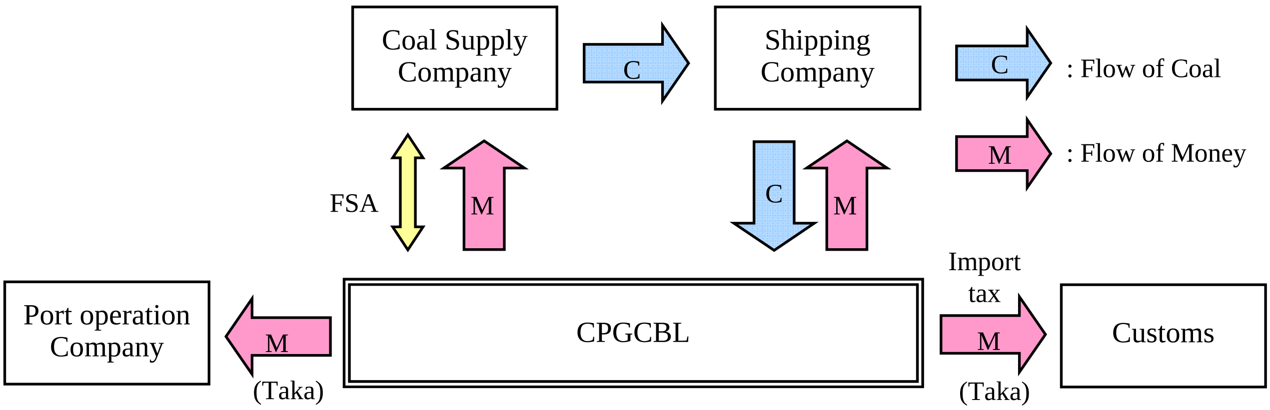


(Source: JICA Study Team)

Figure 12.6-7 Operation System for Several Years After Commercial Operation

3) Future operation system

The CPGCBL staff belongs to the Supporting Agency, and accumulates the experience in coal procurement. The CPGCBL staff belongs to Supporting Agency, and accumulates the experience in coal procurement. Afterwards, CPGCBL gradually reduces the input and assistance that had been provided by the Consultant until finally CPGCBL is able to procure coal independently, and carries out the related business of port operation management in the future.



(Source: JICA Study Team)

Figure 12.6-8 Future Operation System

12.7 Information Management

This section describes the management of information relevant to the daily operations of the power plant. The structure of this section is as follows: First, the section describes the matter of dispatching information including telecommunication architecture; Second, the section proposes the feedback of such information to the power company's O&M activities utilizing a database-type IT system; finally the section discusses the use of the information for public communications, e.g. on environmental matters.

12.7.1 Dispatching information

According to the "Electricity Grid Code 2012," authorized by the Bangladesh Energy Regulatory Commission (BERC), generation power companies shall install a system which provides their power plants' realtime information required by PGCB's National Load Dispatch Center (NLDC) to monitor and control. Such information includes i) bus voltage, ii) frequency, iii) MW, iv) MWh, v) MVAR, vi) Power factor, and vii) the status of circuit breakers. The dedicated communication network for this purpose has been developed by PGCB and the power generation companies. The telecommunication media varies from the power line communications, microwaves, to the optical fiber. The major transmission system is a synchronous digital hierarchy (SDH) system. For SDH, STM-1 (150Mb/s) is adopted for branch sections, while STM-4 (600Mb/s) is composed of the trunk ring network around Dhaka city. To satisfy N-1 criteria, redundancy is required in its design philosophy, usually achieved using two optical fiber routes. The main route is composed of SDH, while the alternative route is composed of PDH, the analogue communication system.

In the PGCB network, its telecommunication network for power supply use is physically separated from the network for non-power-supply related data, such as e-mail and the telephones for back-office staff. While they use the public telephone network for the latter purpose, they use their own dedicated telecommunication network for the former purpose.

In the case of CPGCBL, the company is responsible for developing the communication link between its power plant and the PGCB network, while this infrastructure will belong to PGCB once the link is completed. Currently, there are plans to lay the OPGW (optical ground wire) along the 400kV transmission line from the Matarbari Power plant to Anowara 400 kV Substation, leading to NLDC through the also planned Anowara Substation – Megnaghat Substation 400 kV transmission line.

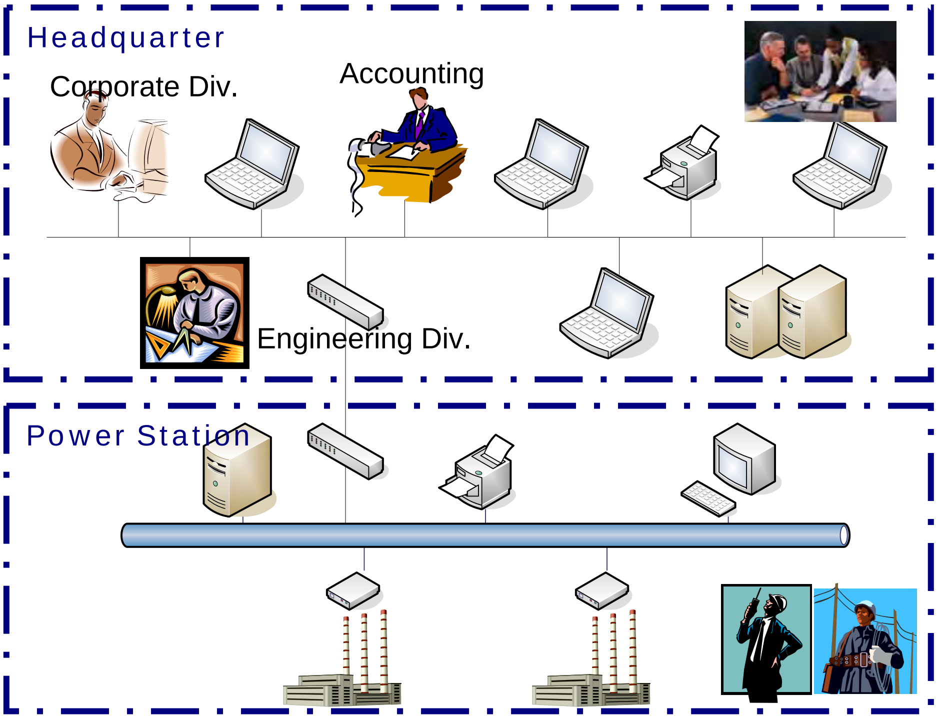
As seen above, the CPGCBL's power plant's dispatching information will be transferred to PGCB's NLDC through the PGCB's SCADA network. On the other hand, the CPGCBL's office will not receive the information because the company's office will not be connected with the SCADA network. Similar to the existing BPDB's subsidiaries, the company's office will only receive limited information like the day-ahead availability of the power plant from NLDC through the public telecommunication network, e.g. fax or email.

12.7.2 Feedback to O&M activities: Introduction of the performance management system

Here, the JICA Study Team proposes maximizing the use of information monitored at the power plant utilizing the database-type IT system and developing the company’s own internal network.

Besides the issue of the network, CPGCBL could face a challenge similar to the one that the other BPDB subsidiaries have faced: there has been a tendency for information data like the plant’s drawing and facilities’ manual to only be available to certain select company staff, usually management because the data is stored as a hard copy or even their electronic copies are stored in the managers’ stand-alone personal computer. The key issue here is that such information is not easily accessed by those who really need it, e.g. planning engineers and accounting management staff. Their tasks include the preparation of annual operations and a maintenance plan and/or financial statements.

Figure 12.7-1 shows the image of the system architecture necessary for this purpose. CPGCBL could develop the system by itself or could procure the system with similar function from the market.



(Source: JICA Study Team)

Figure 12.7-1 The Image of Information Integration in Power Plants

The system would consist of operations data processing computers with functions such as the following:

- ✧ Fuel efficiency management
- ✧ Utilization of generation record to the power production plan
- ✧ Development of reports to be submitted to the government, e.g. monthly generation report.
- ✧ Development of PR material, e.g. IR information such as annual reports.
- ✧ Development of statistical data utilized for the periodical inspection schedule.

Utilizing the system composed of the network and database that would enable the company to develop these outcomes easily and in a timely manner.

Table 12.7-1 Type of Information Data

<table>
<tr><th colspan="2">Item to be monitored 24 hours</th><th colspan="2">Item to be recorded during installed capacity output level [14:00 1,000 MW]</th></tr>
<tr><th>Item</th><th>Sample figure</th><th>Item</th><th>Sample figure</th></tr>
<tr><td>Electricity Generated</td><td>16,660 MWh</td><td>Output at generator</td><td>1,000 MW</td></tr>
<tr><td>Power for station operation consumed</td><td>636 MWh</td><td>Main steam pressure</td><td>246 atg</td></tr>
<tr><td>Availability</td><td>69.1%</td><td>Main steam temperature</td><td>538 ℃</td></tr>
<tr><td>Ratio of power for station operation</td><td>3.8%</td><td>Reheated steam temperature</td><td>567 ℃</td></tr>
<tr><td>Efficiency at power plant</td><td>39.6 %</td><td>Temperature of supplied water</td><td>279 ℃</td></tr>
<tr><td>Fuel consumed</td><td>3,354 kNm^3</td><td>O_2 at ECO exit</td><td>1.4 %</td></tr>
<tr><td>Fuel calorific value</td><td>10,740 kcal</td><td>Temperature of emission gas</td><td>110 ℃</td></tr>
<tr><td>Amount of water supply</td><td>2 t</td><td>Efficiency at Power Station</td><td>40.3%</td></tr>
<tr><td>Gap of water temperature between intake and discharge</td><td>3.9 ℃</td><th colspan="2">Condenser</th></tr>
<tr><th colspan="2">Status of Jelly fish</th><th>Item</th><th>Sample figure</th></tr>
<tr><th>Item</th><th>Sample figure</th><td>Seawater temperature at intake</td><td>21.1 ℃</td></tr>
<tr><td>Time at peak inflow</td><td></td><td>Gap of water temperature between intake and discharge</td><td>7.0 ℃</td></tr>
<tr><td>Peak amount</td><td>t/h</td><td>Degree of vacuum</td><td>719.7 mmHg</td></tr>
<tr><td>Amount now as of 8 am</td><td>t/h</td><td>Deviation of vacuum</td><td>-1 mmHg</td></tr>
<tr><th colspan="4">Gas emission</th></tr>
<tr><th>Item</th><th>Sample figure</th><th>Item</th><th>Sample figure</th></tr>
<tr><td>Concentration of NOx</td><td>ppm</td><td>Concentration of particulate matter</td><td>mg/Nm^3</td></tr>
<tr><td>Concentration of SOx</td><td>ppm</td><td></td><td></td></tr>
</table>

(Source: JICA Study Team)

For its communication network, because CPGCBL cannot use PGCB's SCADA network for its own use, the company needs to build its own internal network. Considering the characteristics of the transmitted data, it is preferable to adopt a higher level of network security. For this purpose, it would be appropriate to purchase PGCB's fiber leasing (dark fiber) service which utilizes PGCB's OPGW. The use of the commercial VPN service provided by public telecommunication providers would be also the second-best choice.

12.7.3 Public relationships

While the aforementioned subsection focuses on the use of data for internal usage, this subsection proposes the use of data for external use, i.e. public relationship. Given their large size, power plants tend to attract attention from their local community. Therefore, building mutual trust is essential to maintaining a good relationship. Information disclosure of the plants would be one such approach. The type of information for this objective would include the following:

1) Gas emissions: Major gases emitted from power plants include particulate matter, NOx, and SOx. Because the Ministry of Environment and Forest (MoEF), the government body responsible for environmental matters, does not require power generation companies to report their emissions regularly, existing power companies rarely disclose

their emissions online, such as through their website. Instead, they report their emissions via a paper-based report to the government if requested to do so. The companies should install monitoring posts for the emissions if there is a request from their local community such as from the residents.

2) Water temperature of condenser (heated water discharge): The change of sea water temperature around the power plant might affect the eco-system there, which could impact the fishing industry. For this purpose, regular monitoring, e.g. water temperature measurement at fixed points would be appropriate to maintain amicable relationships with local fishery groups.

12.8 Management Plan

The company that belongs to the power sector sets the target value of the Key Performance Indicator (KPI) that evaluates the achievement of the company every year. And the company is exchanging the contract with the Secretary of Power Division. The performance of the company is evaluated according to the level of achievement in light of the target value, and a bonus is paid (or a penalty is imposed) according to the achievement level. The KPIs that the generation companies adopt are as follows, though the KPIs are different depending on the business contents. (The target value is an example of the APSCL)

Table 12.8-1 Example of KPIs at Generation Company (APSCL)

	Key Performance Index (KPI)	Unit	Target
1	Plant factor	%	82
2	Availability factor	%	86
3	Auxiliary consumption	%	5.0
4	Power factor at HT side of step-up transformer	%	85
5	Average training hour per employee	hours	60
6	Average No. of responsive bids	Simple ave.	3.25
7	Percentage of tenders re-tendered	%	6.0
8	Average time to procure-foreign spare parts	months	3.70
9	Current ratio	ratio	2 : 1
10	Quick ratio	ratio	1.5 : 1
11	Debt service coverage ratio	ratio	3.5 : 1
12	Implementation of annual development program	%	100

(Source: APSCL)

These KPIs are target values as the company, and all employees make an effort to achieve these target values. Therefore, it is necessary to set more specific KPIs to evaluate the performance of the power plant in order to improve the numerical value of the above-mentioned KPIs.

(JICA Study Team will propose the KPIs in the power plant based on this idea in the future.)

Chapter 13

Operation and Maintenance Management

Chapter 13 Operation and Maintenance Management

13.1 Organizational Management System

13.1.1 Basic policy

The operation & maintenance management of the power plant should basically be executed by the employee. However it is inefficient to have an employee responsible for all operations and maintenance work of the power plant. Given that the amount of this work which is of a specialized nature and requires a specific skill set is not fixed, outsourcing to a construction company is more efficient than to employ one skilled person in each power plant. Moreover, a routine work and a not typical work to the power plant does not require any special technical skills. Therefore, from the point of the personnel cost reduction view, outsourcing these works to other companies is more beneficial than turning it over to employees. Assigning such work to outside entities whenever possible will contribute to the revitalization of the regional economy.

However, at the commencement of commercial operations it is believed that there are no companies who are able to handle such O&M of the equipment introduced for the first time in Bangladesh. Therefore, for a while, employees will be responsible for these works, and after the necessary technological knowledge is absorbed, skilled engineers will come together to establish a new consignment company. (Establishing a subsidiary company is one option.)

The basic idea of work allocation is shown as follows.

Table 13.1-1 O&M Work Allocation

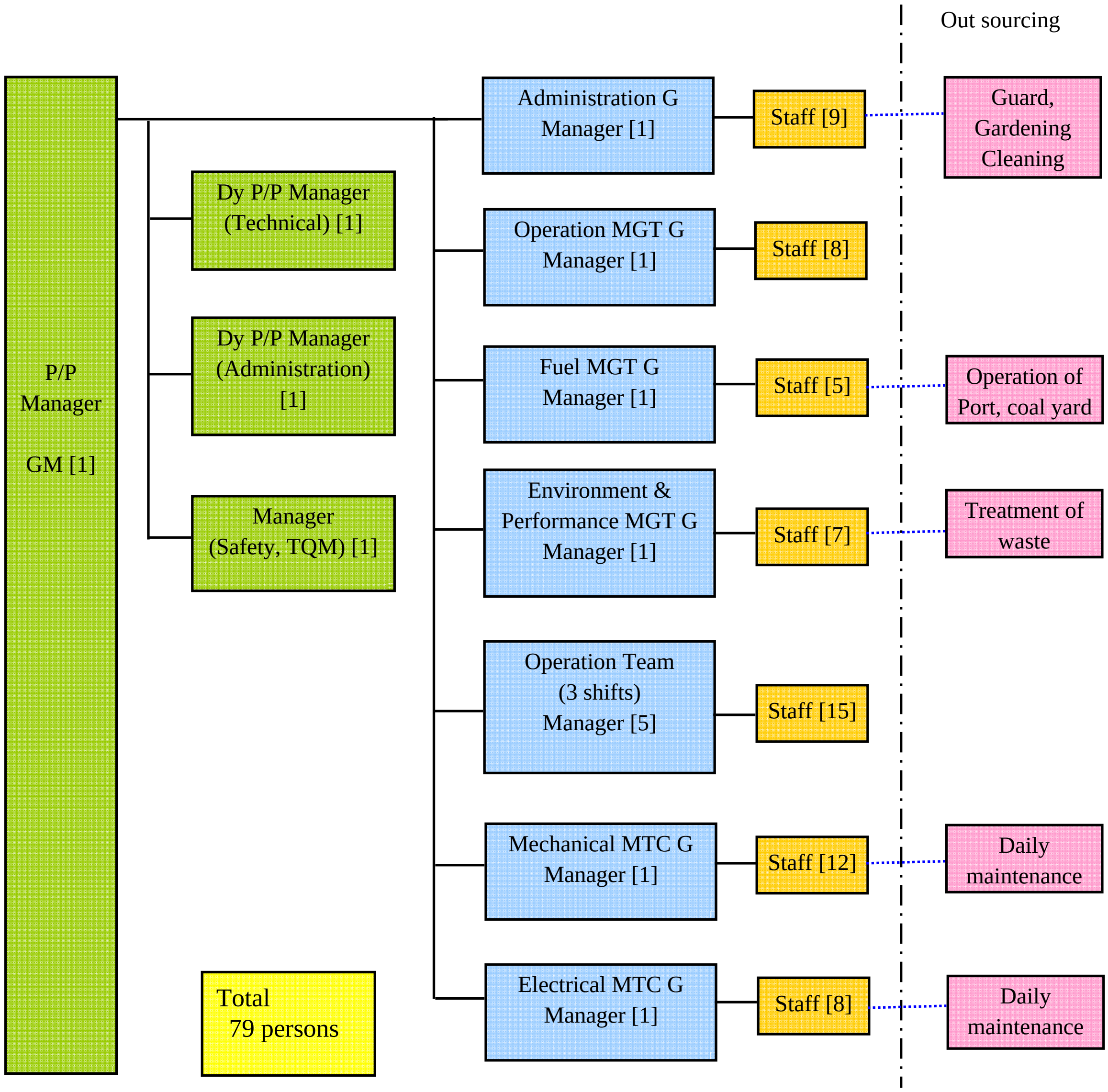
Item	Contents of work
Work that employees execute	■ Operation of main plant (shift duty) ■ Maintenance management of main plant (boiler, turbine, control system, mill) ■ Initial check at forced outage ■ Urgent repairs in an emergency (Workshop staff) ■ Planning (operations, maintenance, and procurement) ■ Supervising maintenance work ■ Management of consignment work etc.
Work that employee executes for a while, to be outsourced as earlier as possible	■ Operations of coal yard (including coal mixture) ■ Maintenance management of coal related facilities (harbor, coal yard, conveyor) ■ Waste water treatment and processing of ash, etc. ■ Maintenance management of environmental facilities (electrostatic precipitator, desulfurization facility, ash pond, etc.) ■ Daily repair work and the simple checks of the main plant and auxiliary machine
Work outsourced to the other companies	■ Guards ■ Cleaning ■ Gardening

Item	Contents of work
	■ Management of incidental equipment such as a company cafeteria ■ Major overhauls

13.1.2 Organizational chart and job description

(1) Examples in Japan

As a reference, the organization chart (as of June, 2012) of a coal-fired thermal power plant (1,000MW 1 unit) in Japan is shown below.



(Source: JICA Study Team)

Figure 13.1-1 Organizational Chart of a Coal Fired TPP in Japan

The number of employees of power plants is 79. However, many jobs are outsourced, and about 320 persons (including 79 employees) do the operation and maintenance work under normal conditions.

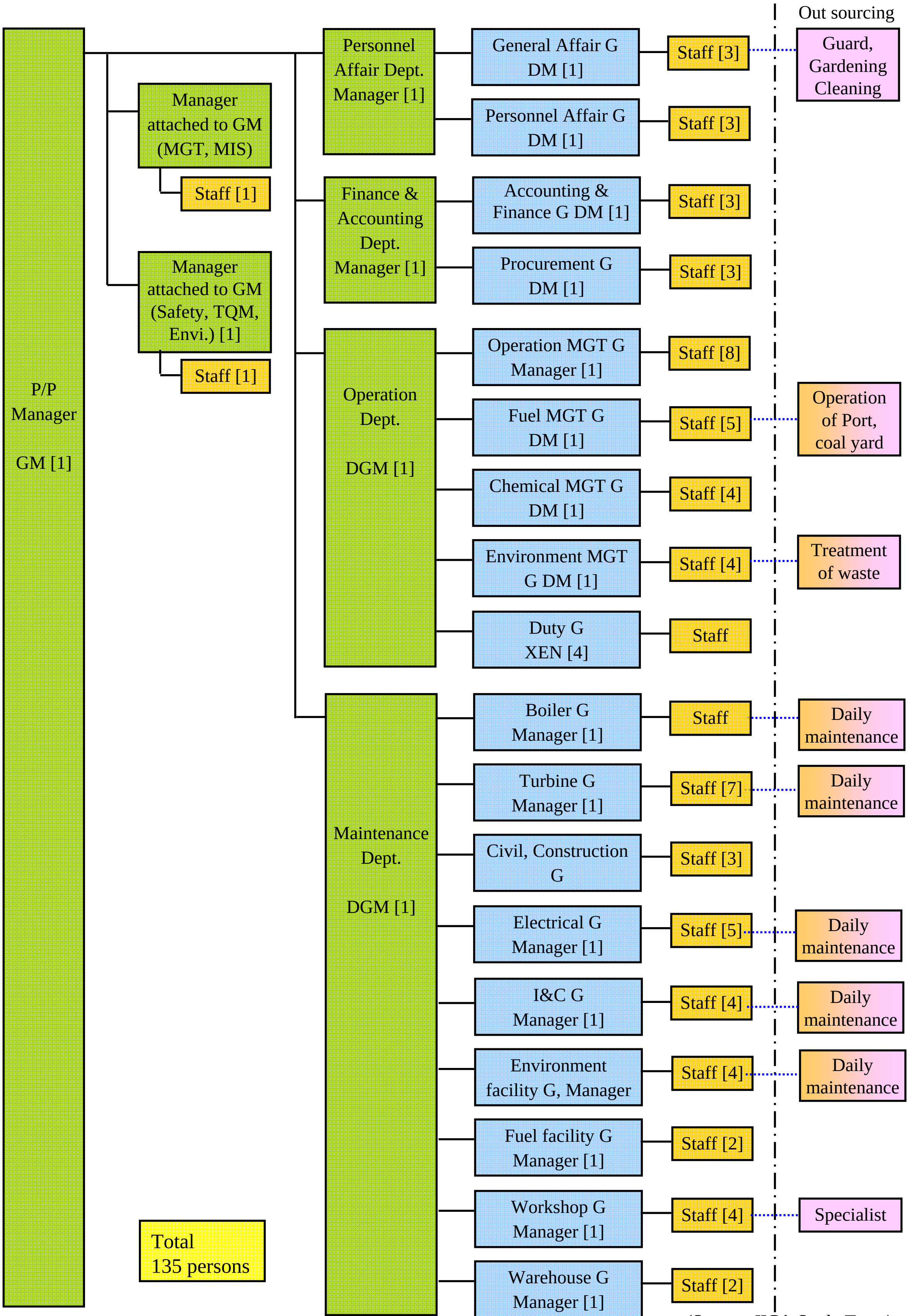
Table 13.1-2 Job Description of a Coal Fired Thermal Power Plant in Japan

Group name	Job description
P/P Manager	■ Overall management in Power Plant (P/P)
Dy P/P Manager (Technical)	■ Assist P/P manager for technical matter
Dy P/P Manager (Administration)	■ Assist P/P manager for administration matters
Manager (Safety, TQM)	■ Assist P/P manager for safety and total quality management
Administration Group	■ General affairs ■ Public relations ■ Estate management ■ Employee relations ■ Human resource ■ Accounting & procurement ■ Security guard
Operation Management Group	■ Generation plan in P/P ■ Operation management ■ Disaster prevention ■ Safety management
Fuel Management Group	■ Receipt, store, inventory of fuel ■ O&M for fuel facilities (stacker, belt conveyer, etc.) ■ Fuel loading work management
Environment & Performance Management Group	■ Facility performance & generating cost management ■ Chemical analysis for fuel, water, etc. ■ Environmental management ■ O&M for environmental facilities ■ Business plan in P/P ■ Office automation
Operation Team	■ Operation & Observation (5 teams x 4 persons/team, 3 shifts)
Mechanical Maintenance Group	■ Maintenance for mechanical facilities (boiler turbine, etc.) + Daily maintenance + Design and cost calculation of periodical maintenance + Safety, Quality, process control of whole work + Equipment diagnosis
Electrical Maintenance Group	■ Maintenance for electrical facilities (generator, control, etc.) + Daily maintenance + Design and cost calculation of periodical maintenance + Safety, Quality, process control of whole work + Equipment diagnosis

(Source: JICA Study Team)

(2) Recommendations

Referring to an example in the coal-fired power plant in Japan, the Study Team proposes the following organization chart and number of staff in the power plant:



(Source: JICA Study Team)

Figure 13.1-2 Organizational Chart of Matarbari CTPP

Job description of each section is as follows.

Table 13.1-3 Job Description of the Coal Fired Thermal Power Plant

Group name	No. of employees		Job description
	Manager	Staff	
P/P Manager	1		Overall management in Power plant
Manager attached to GM (MGT, MIS)	1	1	Assist P/P manager for business plan in P/P, facility performance & generating cost management, office automation and information system matter
Manager attached to GM (Safety, TQM, Envi.)	1	1	Assist P/P manager for safety, total quality management and environment matter
Personnel Affair Dept.	1		Assist P/P manager for General affairs and Personnel affairs
General Affair Group	1	3	General affairs Public relations Estate management Security guard
Personnel Affair Group	1	3	Employee relations Human resource
Finance & Accounting Dept.	1		Assist P/P manager for Finance & Accounting
Accounting & Finance Group	1	3	Accounting
Procurement Group	1	3	Procurement
Operation Dept.	1		Assist P/P manager for Operation
Operation Management Group	1	8	Generation plan in P/P Operation management Disaster prevention Safety management
Fuel Management Group	1	5	Receipt, store, inventory of fuel O&M for fuel facilities (stacker, belt conveyer, etc.) Fuel loading work management
Chemical Management Group	1	4	Chemical analysis for fuel, water, etc.
Environment Management Group	1	4	Environmental management O&M for environmental facilities
Operation Team	4	28	Operation & Observation (4 teams x 8 persons/team, 3 shifts)
Maintenance Dept.	1		Assist P/P manager for Maintenance
Boiler Group	1	13	Maintenance for boiler
Turbine Group	1	7	Maintenance for turbine
Civil, Construction Group	1	3	Maintenance for civil facilities
Electrical Group	1	5	Maintenance for generator
I&C Group	1	4	Maintenance for control equipment
Environment facility Group	1	4	Maintenance for environmental facilities
Fuel facility Group	1	2	Maintenance for mills
Workshop Group	1	4	Workshop
Warehouse Group	1	2	Warehouse
Total (135)	28	107	

(Source: JICA Study Team)

This organizational chart and number of staff is after outsourced work is completed. Therefore, it is necessary to increase the number of staff at the commencement of commercial operations in the Fuel Management Group, Environment Management Group, Boiler Group, Turbine Group, Electrical Group, I&C Group, and Environmental facility Group. Furthermore, they will eventually be transferred to the outsourcing company.

13.2 Operations and Maintenance Management

13.2.1 Basic Policy

The proposed coal-fired power plant includes many technologies which are introduced for the first time in Bangladesh. The following mechanism should be established for the operations and maintenance of the power plant. This mechanism urges Bangladesh to expand the number of Bangladesh workers who will be in charge of the power plant, and it is important to encourage Bangladesh workers so that in near future they can independently manage the construction stage and O&M stage of the same type of power plant with domestic workers.

(1) Implementation of on-site training during the construction stage

The contract conditions of the EPC contractor (or manufacturer of power plants) should include the following three terms; 1) proactive efforts are made to select engineering companies and engineers from Bangladesh, 2) workers should absorb the technical knowledge through OJT, and 3) workers of CPGCBL, construction companies and experts can enhance their skills during the construction stage.

(2) Technical cooperation by trainers of manufacturers

From the start of commercial operations until the initial failure settles and the operation level is in the stable operation zone, it is supposed to need technical assistance. In order to prevent major accidents due to the late implementation of countermeasures for the initial failure, the on-site supporting system and mechanism that technical cooperation by trainers of manufacturers should be stationed at the power plant in terms of boilers and turbines for a few years is proposed. On the other hand, it is necessary to be independent from the trainers, so it is proposed to introduce the on-site system where trainees can investigate and go over troubles with the trainers.

(3) Employment of O&M consultants

Among the O&M work, there is particular work for the coal-fired power plant such as the combustion control of boilers, cleaning of boilers, disposal of fly ashes, water management of boilers, and operations of an environmental treatment system. In addition, there is fuel management work as well as the scheduling of coal import vessels and coal imports/coal discharges (coal blending). It is necessary to implement various works with no experience. Therefore, the on-site supporting system/mechanism with O&M consultants where workers can be trained by responding to on-site trouble will be established for a few years before the trial operation. Regarding O&M consultants, the above-mentioned Supporting Agency in Chapter 12.6 who works for coal procurement can be responsible for the O&M consultants.

13.2.2 Characteristics of a coal-fired power plant

The generating system which is introduced to this project is supposed to be the first large-scale thermal generation system in Bangladesh. Bangladesh has much experience in the O&M of gas-fired boilers, however, they have zero experience in coal-fired boilers. These are the following differences between coal-fired boilers and gas-fired boilers. In terms of O&M, coal-fired boilers require higher technical skills than gas-fired boilers.

Table 13.2-1 Comparison between Coal-fired Boiler and Gas-fired Boiler

	Coal-fired Boiler	Gas-fired Boiler
Draft system	In order to prevent leaking of combustion ash out of the boiler, the balanced draft system (The furnace internal pressure is kept at approximately -10mmAq by forced draft fan for combustion air and induced draft fan for combustion gas) is introduced to maintain the negative pressure environment in the furnace.	The forced draft fan for combustion air maintains the pressure environment in the furnace.
Burner structure	Complicated structure that requires adjustment of flame angle and flame length with primary air (For pulverized coal transportation: pulverized coal + primary air), secondary air and tertiary air	Simple structure with ring burner nozzles injecting constant pressured gas
Quantity of combustion ash	Ash content depends on kinds of coal. Bituminous coal and sub-bituminous coal contain around 10-20% of ash. Therefore, it is necessary to conduct fly ash disposal for clinkers on the bottom of the furnace and the bottom of electrostatic precipitator (In the case of ash reclamation, it needs to acquire huge land and ash dispersion measure.)	Almost no dust is generated.
Ash stain in boiler	Ash stain such as slagging and fouling caused from combustion ash and melting is unavoidable	Almost no stain is generated.
Structure of auxiliary equipment	Environmental management system with coal mill, primary draft fan, ash disposal facility, electrostatic precipitator and desulfurization equipment	Only by gas pipe
Fuel property	Coal property depends on the coal field. Calorific value has the range of ±500～700kcal/kg less than that of the design coal. Component ratio is changed due to ash content, moisture content, and sulfur content.	All the same
Difficulty of combustion control	The difference of coal property affects the combustion. In spite of coal blending, melting, stick, accumulation of ash occurs. The stains of the heat transfer surface influence the operation of the boiler.	Once adjusted, it is not necessary to fix it again. No ash and no stains of heat transfer surface are expected.

(Source: JICA Study Team)

In terms of turbines, the maximum temperature and pressure of the steam are higher than the existing unit and materials for turbines are upgraded. However, there is no basic difference.

In terms of turbines, the temperature and the pressure are higher than the existing unit.

All additional issues for operation of coal-fired boilers that arises due to the difference from gas-fired boilers are O&M for combustion, ash disposal and the cleaning of boilers.

13.2.3 Technical capacity in Bangladesh

(1) Active units

1) Designed steam condition

- Gas-fired power plant 150～210MW level (Ghorasal, Ashuganj)
  Inlet steam condition 12.4MPa Main steam 538℃/ Reheat steam 538℃
- Coal-fired power plant 125MW level (Barapukuria)
  Inlet steam condition 12.4MPa Main steam 538℃/ Reheat steam 538℃

For this project, it is proposed that the inlet steam condition of the turbines is 24.5MPs, main steam is 600℃/ Reheat steam is 600℃ level. Compared with active units in Bangladesh the pressure and the temperature of the turbines for this project are on the high end. That requires high developed techniques.

2) Investigation of current operations

The current operation status of Ghorasal Power Plant and Ashuganj Power Plant that the Study Team visited is described as below.

Table 13.2-2 Current Operation Status of Ghorasal and Ashuganj Power Plant

Unit.	Commissioning	Installed Cap(MW)	De-rated Cap(MW)	Running hours	Turbine Major O/H	Remarks
Ghorasal P/P (BPDB)						
3	14-09-1986	210	180		2	HP Heater By-Pass
4	18-03-1989	210	180		1	HP Heater By-Pass
5	15-09-1994	210	190		0	HP Heater By-Pass
6	31-01-1999	210	190		0	Shutdown from 2010 due to accident
Ashuganj P/P (APSCL)						
3	14-12-1986	150	150	193,075		
4	04-05-1998	150	150	188,006	1	
5	21-03-1988	150	150	172,851	1	

(Source: BPDB, APSCL, modified by JICA Study Team)

The boiler type of Ghorasal Power Plant (made in Russia) and Ashuganj Power Plant (made by IHI) is the box type gas-fired boiler, whose horizontal super heater and re-heater element are located in the upper part of the furnace. The operation status is stated as below.

- The blast furnace bottom is flat. It takes about four days to set up the scaffolding to the top of the furnace. The furnace steam generating tube which deteriorated over time and the superheater tube are replaced block by block.
- As for turbines, the overhaul is conducted less than normal or desirable as the

above table shows. It seems that overhaul is not conducted if the power plants are capable of continual operations. Therefore, operations were continued minus any consideration of turbine-room efficiency.

- At Ghorasal Power Plant, because the power output declined by approximately 10%, it applies a high pressure feed water heater by-pass operation.[1]
- It takes approximately six months to conduct a major overhaul for turbines. It takes much time for alignment and field balancing.
- The power plants do not have vibration analyzers to measure the vibration phase and amplitude.
- Unit 6 of the Ghorasal Power Plant has been shutdown since the fuel oil of the turbine room caught fire in July 2010. It has not been repaired for two years, and now it will take time to tender.

3) Investigation of the maintenance status

The soot blower is not installed for the gas-fired boiler because the ash deposition never occurred for the gas-fired boiler. It is not recognized in Bangladesh that stains of heat transfer surface due to the combustion ash breaks the heat storing balance and the unbalance affects the operation of the boiler. It is considered that there is no experience of leakage/spout due to local overheating of the metal tubes.

However, a domestic maintenance work system has already been established. In Bangladesh, the emergent repair work of leakage on time-related deteriorated tubes and the planned replacement of tube elements are conducted by in-house engineers or by outsourcing.

For example, the tube is repaired with TIG welding by in-house welders. On the other hand, the non-destructive inspection among the weld testing is outsourced.

Centrifugal-type fans and pumps whose structures are simple are repaired in the in-house workshop based on the extent of the damage.

According to the interview with both power plants, there is no measure to shorten the construction period during the major overhaul which needs a power shutdown for a long period. They will continue to work the usual operation day-time shift. If there is any incentive for workers by if the shortening of the construction period and increasing power generation will serve as an incentive to the workers, the active revision of the construction schedules can be recommended.

[1] In general, the bleeding a part of the steam from high pressure turbine to utilize feed water heating makes efficient. By-pass operation can increase the power output if utilizing all the steam for feed water heat is used for generation. However, that causes the decrease of efficiency.

(2) Capacity of subcontractors

The Study Team investigated if the domestic construction companies can be engaged in the maintenance work in the event of an unexpected shutdown and the inspection/ measurement/maintenance during an overhaul.

1) Investigation of the construction companies specializing in repair work of the power plant

The Study Team conducted interviews with Bengal Electric Limited and Levant Industries Limited.

Bengal Electric Limited was established in 1965, which was in charge of the construction work of the boiler made by IHI at the Ashuganj Power Plant. Materials and machineries for construction are lined up by themselves and can be one of subcontractors for this project. (They have no experience in some of the constructional elements with this project. However, they are possibly capable of applying their basic skills to the necessities.)

Levant Industries Limited was established in 1986, which specializes in electricity work, instrumentation work, construction / maintenance of outside auxiliary equipment. They have subcontractor experience.

Both companies have subcontractor experience under EPC contractors for power plants. However, the generating facility for this project is the first one for Bangladesh, different from that of the existing power plants.

- ♦ Difference of tube caliber (For instance, a wall tube of the existing natural circulation boiler furnace is 63.5 mm φ, a wall tube of a once-through boiler furnace is 22.2 mm φ)
- ♦ Difference of the boiler/turbine structure between the 210MW level and 600MW level (product weight by facility)
- ♦ Main stream pipes and reheat stream pipes require a larger diameter and one that is thicker than the existing ones.
- ♦ Difference of boiler/turbine elements due to higher temperature / higher pressure in terms of steam conditions
- ♦ Increase in size of coal mills
- ♦ Introduction of axial fans
- ♦ Installment of desulfurization equipment and so on.

Regarding the technology of the proposed generation facility, both companies have the potential to be responsible as a subcontractor of the EPC contractor under the trainers of manufacturers. Additionally, it is possible for the workers to improve their skills when they work as a subcontractor during the construction stage, and it is assumed that in the future they might be capable of overhaul work and maintenance work.

With regards to welding, it is presumed that they have no dissimilar joint of Cr-Mo-SUS materials, or the joint of SUS-SUS materials.

With the advice from the welding trainers of manufacturers combined with OJT experience, welders who have experience in the on-site welding of the small-caliber boiler tubes, dissimilar joint of Cr-Mo material and SUS material, on-site welding of SUS-SUS materials are supposed to improve their skills that will be applied to the maintenance work after the commencement of commercial operations.

2) Investigation of the testing companies specialized in non-destructive testing

The Study Team conducted interviews with the NDT Division of the Bangladesh Atomic Energy Commission and the Bangladesh Industrial X-Ray.

Bangladesh Atomic Energy Commission was established as a research center on the utilization of nuclear energy and nuclear power generation technology, and the NDT Division established in 1986, in charge of non-destructive inspection.

Regarding non-destructive testing, they have machinery for radiographic tests (X-Ray, γ-Ray), ultrasonic flaw detection test (UT), magnetic particle flaw detection test (MT), penetrant flow detection test (PT), and electromagnetic testing (Eddy Current). Also, they have containment vessels to transfer the radioactive source.

In addition, BAEC acquired ISO-9712 “Qualification and Certification of NDT personnel”[2], and BAEC conducts lectures for NDT personnel.

Bangladesh Industrial X-Ray is a private company established in 1995. As for the contents of the inspection, there is no difference between the NDT Division and Bangladesh Industrial X-Ray. They are well-experienced in the Mymensingh Power Plant-1 (subcontractor of MHI), Mymensingh Power Plant-3 (subcontractor of Siemens), and the Ghorasal Power Plant (subcontractor of Russian companies).

They also have PWHT (Post Weld Heat Test) technologies and heat treatment technology after the thick-section weld such as the main steam pipes.

As far as the investigation of both organizations, there is no problem in being able to conduct non-destructive testing. There is no difficulty in the quality management of non-destructive testing if they work under the control of trainers of manufacturers as a

[2] JIS Z 2305 corresponds to ISO-9712.

subcontractor.

In Bangladesh, they have no experience in the non-destructive testing of the thick-section weld such as main steam pipes and high temperature reheat pipes. It means that there is the potential to input the new technologies to improve their skills in many cases through the construction of this coal-fired power plant.

The remaining life assessment for high temperature materials which deteriorated over time such as SUMP and the Replica method which are disseminated as types of metallographic testing in Japan has never been done in Bangladesh.

Also, TOFD (Time of Flight Diffraction Technique) which is disseminated as internal defect testing of the welded heat affected zone in the large caliber of tubes such as tge main steam pipes and the high temperature reheat pipes have never been done in Bangladesh.

If SUMP and TOFD is necessary, it is possible to request the manufacturers to do the testing. On the other hand, it is necessary to have an awareness of the issues on the deterioration of high temperature/high pressure materials in the case related to the O&M of USC plant.

13.2.4 Countermeasures for individual issues

(1) Issues on the upgrading of the steam condition and materials

The inlet steam condition of the turbine in the active power plants in Bangladesh is the Pressure 12.4MPa, Main steam temperature 538℃/ Reheat steam temperature 538℃ level. The materials of the boiler final superheater, the final reheater and the headers of the heaters are assumed to be ferritic low alloy steels (Cr content: 1-2%) of ASME-T22 (JIS-STBA24) or ASME-T11 (STBA-23).

The USC plant which has the inlet steam condition 24.5MPa, Main steam temperature 600℃/Reheat steam temperature 600℃ requires more upgraded materials than the existing ones.

Specifically, the quality of materials should be effective for the strength of the high temperature and high pressure, high temperature corrosion of the outside of the tubes, steam-grown oxide scale of the inside of the tubes, and sulfidation corrosion due to atmospheric reduction. For example, high-temperature, high-pressure materials for boilers are made by combining ferritic alloy steel of 9Cr.12Cr (Cr content: 9%, 12%) and austenitic stainless steel of 18Cr-8Ni. Therefore, many dissimilar joints of alloy steel and stainless steel can be produced. (At the dissimilar material joint, it is expected that the difference of the thermal expansion coefficient of the materials causes cracks, carbon transfer causes decarburization, and creep strength and thermal fatigue of ferritic materials become weak.)

It is said that the reliability of those heat-resistance steel materials depends on the welding process. Especially, the more the Cr content of the ferritic alloy steel increases, the more important is it to conduct heat treatment (normalizing and tempering).

The standard of the materials is based on the ASME (American Society of Mechanical Engineer) which is applied to many countries to acquire the ASME certification for the production of boiler tubes. It is necessary to conduct a comparative evaluation of the published chemical composition of the materials in introducing heat-resistant steel, not only ASME certified chemical composition, but also the total life of the heat-resistant steel.

Box. Japanese cases

- ♦ According to the Electric Utility Industry Law in Japan, it is stated that an inconel welding rod should be utilized to prevent the crack on the dissimilar joint.
- ♦ In Japan, additional materials to prevent the creep strength and steam oxidation are supplied to the published chemical composition of ASME certified materials. Additional materials are described as the certified material of “Fire STBA-28” (There are no same materials in the ASME certified materials) in the Technical Standard of Thermal Power Facilities.

The power plant starts commercial operation, settles the troubles from the structure, the materials and the installation, and falls in the zone stable operation. After that, it matters if the various values on the operation stay within the range of the standard. The values affect the change of the high-temperature, high-pressure materials with a cumulative operation period and the number of starts, and also the process of the creep strength and thermal fatigue.

Especially, the deterioration of the metallographic structure is expedited by the disorder of the combustion control of the burners, the unbalance of combustion gas flow, and the unbalance of the steam flow in the tubes.

It is difficult to prevent a tube leak in the coal-fired boilers. However, continuous standard operations could reduce the number of boiler tube leaks.

(2) Ash stain of coal-fired boilers

The biggest issue for the O&M of coal-fired power plants is how to continue the safe operation of the large-scale coal fired boiler at the planned operation schedule.

Compared with gas-fired boilers of the same level of evaporation, all the size of height, width and length are enlarged. It is proposed to introduce a hopper-bottom boiler whose figure of the furnace bottom is the hopper type. The ash hopper is easy to collect the combustion ash in order to eject them out of the furnace safely.

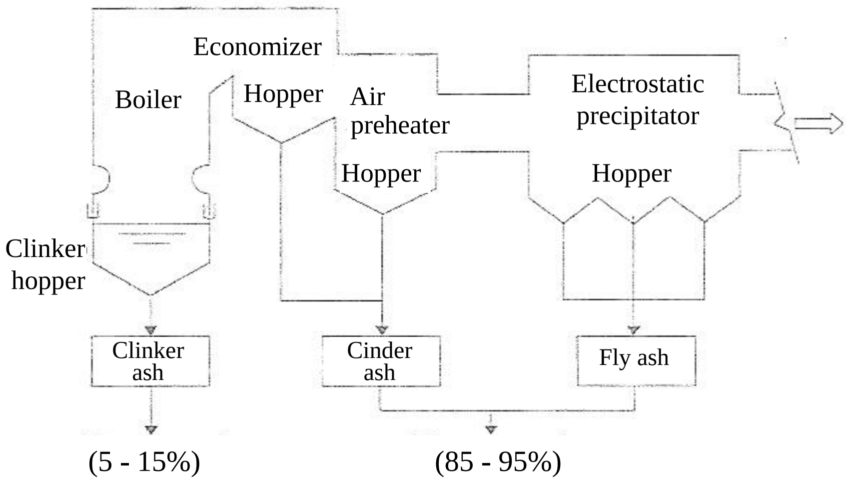


Figure 13.2-1 Distribution of Ash in Pulverize-coal-fired Boiler

Ash stain such as slugging and fouling caused from combustion ash and melting is unavoidable though it depends on the ash constituent of the fuel coal and the softening level of ash.

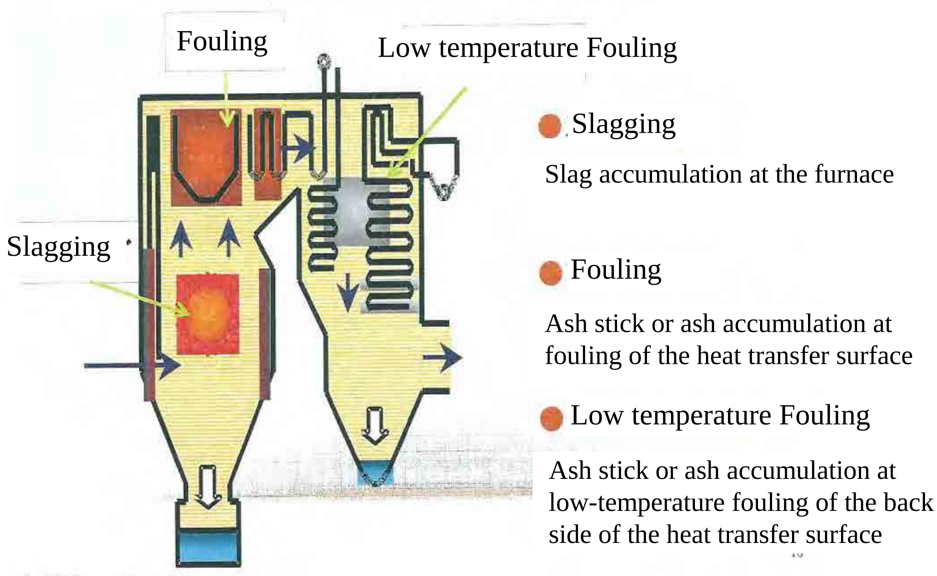


Figure 13.2-2 Ash Stain of Pulverize-coal-fired Boiler

General failures caused from the ash of the low grade coal such as subbituminous coal are described below:

- Sulfidation corrosion at the slugging of the furnace,
- High temperature corrosion of ash at the fouling of the heat transfer surface in the upper part of the furnace,
- Ash stick or ash accumulation at the low-temperature fouling of the back side of the heat transfer surface,
- Steam explosion inside the clinker hopper due to peeling and falling of slag from the surface of furnace,
- Temperature decrease of the heat stored due to ash accumulation on the finned coal economizer.

On the other hand, failures never occur in the gas-fired boilers. The failures affect the exhaust gas temperature. As result, this causes a decrease in the thermal efficiency.

Ash erosion is also a peculiar case only for the coal-fired boiler, which causes thinning of the outside of the tubes.

Measures for ash stains are conducted as follows;

- The steam-soot blower which is not used for the gas-fired boiler is installed to operate for sequential ash stain removal several times a day. For the difficult stains, this operation is intensified,
- When the power demand is low, the generated output is decreased at 50% of the capacity. In this case, the difference in temperature between the outside of the tubes and the clinker with the ash stain affects the removal of the ash stains;
- Forcible separation for boilers with low-level coal, low-softening-temperature coal is conducted. Large blocks of ash stains at clinkers are shut by a water gun (high-pressure hydrant),
- Also, the addition is blown into the boiler to soften clinker adhesion.

(3) Disadvantages in the maintenance schedule due to the change of size and the figure of the hopper bottom of the coal-fired boilers

Removing the stains on the heat transfer surface, coal-fired boilers requires a shutdown of operations once a year for cleaning. The following table shows the work schedule.

Table 13.2-3 Work Period (the shortest case)

days	1-5	6-10	11-15	16-20	21-25	26-30
Clinker removal of the upper part of the furnace						
Setting of the temporary floor						
Setting of the temporary scaffold						
Practical operation						
Dismantlement of the temporary scaffold						

(Source: JICA Study Team)

In the case of coal-fired boilers, it is impossible to enter the furnace just after a shutdown. There is the danger that the lumps of clinkers of the furnace wall tubes and pendant-type superheater tubes could fall off, and it is necessary to remove the clinkers from the upper manholes without the machinery until safety is ensured. This work needs 5-7 days for the 600MW subbituminous coal-fired boilers.

The blast furnace bottom of the gas-fired boilers is flat, while the bottom of the coal-fired boilers is the dipping structure. A measure to prevent workers from falling to the clinker hopper of the blast furnace bottom is to construct a temporary floor at the opening to cover the open area. It would take several days for this work.

Next, in order to work inside the furnace, a temporary scaffold is set up at the top of the burner. This work would require approximately 10 24-hour shifts. (Without instituting a 24-hour shift, it would take 7 more days.) Regarding the temporary scaffold, there are two types. One is a draw-up from the blast furnace bottom. The other is a pendant from the roof. There is no difference in the work period. After the practical operation, it takes approximately 4 days for to dismantle the temporary scaffold.

Before and after the practical operation, it requires 20-25 days. In the case of a simple overhaul, it takes 30 days. The key to shorten the work period is the clinker removal, the scaffolding and the dismantlement of the temporary scaffold.

To shorten the work period for the clinker removal, it is actually usual that the de-lamination-effective addition agent is shut or a water gun (water injection blower) is operated. Preventing the clinker, it is expected that the coal blending ratio should be the baseline of the design coal, and the combustion control should be implemented to maintain so that the temperature of the furnace exit gas is below the ash softening temperature.

It is also important to purchase the furnace scaffold which is used for the construction period and for the filming the video of the scaffolding and dismantlement to be referred to when working inside the furnace.

This is how at minimum a 30-day shutdown is required every year. The cleaning of the boilers during the periodical inspection and securing simple overhaul leads to stable power plant operations.

(4) Acquiring technical skill for the operation staffs of large-scale coal-fired power plants

Among candidates for the operation staff, the candidates for upper-level leaders (leader or sub-leader of shift workers) improve their skills from the on-site integrated training (unit training including boilers and turbines) for around 6 months at the same type/capacity plants of the same manufacturer. The number of trainees for the integrated training is planned to be around 8-10 composed of more than 2 members from the 4 groups, considering the decrease in the number of candidates due to a career change or moving overseas.

The trainees for the integrated training should work as the main operators for the trial operation. During the trial operation, the trainees undergo OJT by the trainers of manufacturers on a case-by-case basis. The operation status value changes, according to the slagging at the furnace wall tubes due to the coal characteristic and combustion situation and the fouling on the heat transfer surface of the superheaters and reheaters. During the operation, it is necessary to grasp the change of the boiler performance (NOx characteristic, unburned combustible loss characteristic) from the combustion of the coal blend based on the boiler design coal, and to acquire the measure for the emergent operation of the safety system. That is why it takes approximately 6 months for the trial operation.

In addition, young candidates should join to acquire various technical skills including surveillance.

(5) Acquiring technical skill for water quality management of USC boilers

In order to prevent scaling or erosion in the boiler/turbine caused due to the level of water quality or steam quality, water quality management is to be conducted. Additionally, both systems are installed; AVT (All Volatile Treatment, injection of ammonia and hydrazine) system which is installed in the existing natural circulation system boiler, and CWT(Combined Water Treatment, injection of ammonia as pH control and injection of oxygen instead of hydrazine) system for scale control in the furnace wall tubes. At the starting and shutdown, volatile matter treatment is conducted, and oxygen treatment is implemented during the continuous operations. Candidates for the chemical group of generation work during the day-time shift needs to acquire the technical skills on the water quality management from the trainers of manufactures.

(6) Acquiring technical skills of the maintenance staff for large-scale coal-fired power plants

Among the maintenance division, the upper level candidates as well as the operation staff (the total number is 8, 2 members each from the boiler, turbine, electricity, generation control groups and are managers who can grasp the practical work, can instruct the needs to sub-contractors, and provide leadership on safety management) should undergo 6 months of training at the same type of plants. Concretely, aiming at the major overhaul period, it is expected that the training should be conducted to acquire the technical skills in all stages of the major overhaul; shutdown of plants, setting the scaffolding, inspection, measurement, water pressure of boilers, boiler ignition, maintenance checks and ventilation. During the on-site training, the trainees acquire technical skills on the simple overhaul, which is for the clean-up of the coal-fired boiler for 30 days every year, the emergent maintenance work for the boiler tube leakage and daily maintenance work.

Especially, in the case of a coal-fired boiler, it is important to acquire the skills needed for the quality management of the boiler tubes. The measures are as follows; temporary scaffolding, removal of ash and scale on the outside of the tubes, visual inspection of erosion or thinning, trend management of UT wall thickness measuring instrument, and acquiring the construction techniques of the temporary scaffold and operational management of the elevation scaffolding.

After the start of construction, it is best that the photo or video data of the boiler construction or welding be used for the textbook materials for the young staff. The photos/videos can show the access to the tube leak or scaffolding. With regard to turbines, visual training materials should be made, focusing on carrying the turbines to the turbine cylinder, setting up the rotors, installing the upper half of the turbine to the cylinder, and controlling the stacking bolts.

It is also important to manage the first value at the turbine alignment and the field balancing, and to establish a mechanism to take over the trend control.

On the other hand, the textbooks rich with photos of the dismantling are necessary for handling the equipment which is carried in a perfect-state, such as pumps, draft fans, large valves, and opening the safety valves of the boiler.

It is best that the candidates in charge of the coal mills join the overhaul judged by the manufacturers during the trial operation to learn about the operation of the coal mills, which requires inspection and maintenance based on the operation period.

13.3 Career Development and Training in Power Plant

As CPGCBL, in the future implementation of O&M of the large-sized coal-fired thermal power plant of which there has been zero implementation in Bangladesh up until now, we propose the incentive-based career development and training system inside CPGCBL.

13.3.1 Basic Policy

The recruitment of power plant personnel started about two years before commencement of plant commercial operations. All required personnel are put in position at the time when the test run starts.

The core personnel, such as the manager and foreman, who have work experience in other thermal power plants in Bangladesh should be employed a little early and cultivated during the period of construction work. Practical training in an overseas similar plant is planned for those who would become core staff. These core staff will become the key men of the operations and maintenance section of the plant and after the commencement of commercial operations serve as instructors and provide OJT to subordinates.

On the other hand, as general staff, not only experienced persons but also young persons with no power plant experience will be recruited. In addition, a training menu will be prepared so that even an inexperienced young person may rise to become one of the core staff in the future.

13.3.2 The training method of power plant staff

(1) Cultivation of O&M staff during the period of construction work

As described in the previous chapter, the training of O&M staff during the period of construction work can be established by deploying the candidates of leaders who will become the key men of the operation department and maintenance department of the power plant after starting the operations of the power plant to learn the required specialized technology.

(2) Training of O&M staff via overseas job assignments

The coal-fired thermal power plant which has the same function of the proposed plant does not exist in Bangladesh. Therefore, one proposal is that it is necessary to train by dispatching candidates to overseas coal-fired thermal power plants prior to commercial operations of the plant, specifically to overseas countries, such as India and Indonesia, for about one year, and be actually engaged in operations and maintenance work, and exposed to the method of accumulating technology, know-how and O&M experience.

(3) Training in Coal Operation Management and Environmental Management staff

It is necessary to train the personnel in not only plant operations and maintenance but also provide training in the area of coal operations and environmental management after commercial operations. Although there are plans to outsource the management of coal operations and environmental management, personnel who will superintend and deal with the outsourcing companies will be needed. The necessary skills need to be acquired by dispatching a candidate to other coal-fired power plants prior to plant commercial operations.

(4) New employee training

In the future implementation of power plant O&M, new employee training is an important factor to achieve stable operations. The necessary ability of having new employees acquire the necessary technological skills is so that they can handle basic power plant operations. The targets are shown as follows.

- ♦ Having a sense of responsibility and understanding the disciplinary rules as a company member
- ♦ Understanding the related laws and manuals for power plant operations and maintenance, and carrying out the actual operations according to the laws and manuals
- ♦ Understanding the safety rules and safety operations of the power plant

The one year new employee training schedule is proposed in the following table.

Table 13.3-1 New Employee Training Schedule

month	1	2	3	4	5	6	7	8	9	10	11	12
Class room training												
Day shift training												
Night shift training												
Comprehensive training												
Operating simulator training												

(Source: JICA Study Team)

Basically, the staffs who have experience working in overseas plants for a long period of time will serve as instructors. A resident technical instructor from a manufacturer will also be hired if needed.

(5) Adoption of a Recognition System

Measures in which a certain level is set according to the level of acquired technology that is linked to a wage scale is desirable. It is also required to implement measures to avoid the loss of the staff who have acquired the required skills to IPPs whose wage standard is higher by establishing a system where a staff who has acquired the same level of skill as a technical instructor from a manufacturer are given a title like Meister in Germany and an appropriate wage.

Table 13.3-2 Operator Training Pattern

Qualification	New employee	Class I	Class II	Class III	Class IV	Class V	Class VI
Business experience	1 year	1-2 years	1-2 years	2-3 years	2-3 years	2-3 years	
Skill level	Worker			Engineer Vice Chief Engineer		Chief Engineer	Master
Curriculum	Induction training (two months) OJT (ten months) Promotion examination (once every year)	An examination is taken once during the 1-2 years business experience mentioned, and if passed, the candidate will be promoted to the 2nd class. Those with excellent results will be directly promoted to 3rd class A skill level contest will also be held once a year, and those who obtain excellent results will get a rise in their salary				✓ They are responsible for the junior staff training. ✓ They should arrange to have the trainers receive training.	
Penalty	If the examination is failed 3 times in succession, the candidate will be retired from the course.	✓ Staff demonstrating remarkably inferior skills will be demoted.					

(Source: JICA Study Team)

13.3.3 Operator training

(1) New employee operator training

The schedule of new employees' operator training is described in the previous section. Furthermore, the contents of new employees operator training are shown in the following table.

Table 13.3-3 Contents of New Employees Operator Training

Training	Term	content
Class room training	2 months	✓ Company Policy ✓ Related laws and manuals for operation ✓ Safety education ✓ Basic electrical and mechanical knowledge ✓ Mechanism of the coal-fired power plant
Day shift training	4 months +2 month	✓ Safety training ✓ Feature of coal-fired power plant operation ✓ Work contents of coal-fired power plant ✓ Main system mechanism and layout ✓ Point of drawing and measurement equipment ✓ Point of patrol and manipulation method ✓ Checking point and method of main equipment
Night shift training	3 months	✓ Emergency contact and evacuate system ✓ Method used for tool and measuring instrument ✓ Method of starting and stopping for auxiliary machine ✓ Method of periodical inspection ✓ Emergency operation in case of minor trouble ✓ Security system in power plant
Comprehensive training	1 month	✓ Theme selection of priority issue solving activities ✓ Accident case examination ✓ Basic knowledge of environmental measure
Operating simulator training	2 month	✓ Basic operation training ✓ Emergency operation in case of minor trouble ✓ Priority issue solving activities

(Source: JICA Study Team)

(2) Turbine operator training

The trainee first joins a duty team; desk training on the following items is mainly performed as the training for a turbine operator. The trainee is made a sub operator in the power plant operation, and is then promoted to operator within a fixed period.

- Circulation water equipment
- District hot water supply equipment
- Deaerator
- Feed water pump

(3) Boiler operator training

While a boiler operator is undergoing training, the trainee joins a duty team similar to that of the turbine operator training and undergoes primarily desk training of the following items. The trainee is made a sub operator in the power plant operation and in particular, undergoes boiler-related valve training, then is promoted to operator within a fixed period.

- Ash handling equipment
- Mill equipment
- Air pre-heater equipment
- Soot blower equipment
- Coal feeder and others

(4) Senior operator

Through five year's work experience as an operator, the operator then conducts the technical generalization of the work of newcomer subordinates as a senior operator, in addition to determining technical matters, judgment, etc. and labor safety as the leader of an operation shift group.

Table 13.3-4 Operator Training Pattern

Training candidate	Training items and course	Training period
Sub operator（New employee）	The new employee basic training Basic operator training	1 year
Sub turbine operator	Sub turbine operator training Sub turbine operator work (OJT)	1-2 years
Sub boiler operator	Sub boiler operator training Sub boiler operator work (OJT)	1-2 years
Turbine operator	Turbine simulator application training Turbine operator work (OJT)	2-3 years
Boiler operator	Boiler simulator application training Boiler operator work (OJT)	2-3 years
Senior operator	Accident operation and instruction training Turbine/Boiler operator work (OJT)	2-3 years

(Source: JICA Study Team)

(5) Accident restoration training

Training to enhance judgment capacity in an emergency and operation skill in the event of an emergency is an essential factor in stable power plant operations not only for new employees but also for senior staff. During these days, a few manual restoration operations took place at the latest power plant due to the automation of the power plant system. Because of that, it is difficult to conduct accident restoration training using an actual system.

Therefore, it is necessary to train with a team using a simulator to make up for emergency operations using the actual system. The following table shows some examples of simulator training and the concept of simulator design is described in the following section.

Table 13.3-5 Examples of Simulator Training for Accident Restoration Training

System	Accident
Boiler System	✓ Tube leak ✓ Pulverized Coal leak ✓ Lowering of vapor pressure ✓ Lowering of vapor temperature
Turbine System	✓ Vibration enhancement ✓ Lowering of oil pressure at bearing part ✓ steam condensate tank leak
Electric System	✓ AVR accident ✓ Generator stator armature short circuit ✓ Generator rotator short circuit
Control System	✓ Transmitter accident ✓ Controller accident
Other	✓ Earthquake ✓ Lowering of air pressure

(Source: JICA Study Team)

13.3.4 Improvement of operation management capability by introducing the operating simulator

(1) Objective and expected effects

It is expected that the introduction of a simulator for operator training or the analysis of thermal power plants helps improve the operator’s capability and contributes to safety and stable operations at the power plant. The simulator works on PCs, making it inexpensive and compact, allowing for installation at power plants. The simulator is expected to be a highly effective form of training, since it is created exclusively for the target thermal power plant and is therefore capable of describing the characteristics specific to the plant.

(2) Reinforcements

1) Baseline examination for customization of the simulator

a) Establishment of a plant model

A plant model shall numerically formulate the mechanical behavior of the boiler, turbine, heat exchange, pipe work and valves, and precisely simulate behavior such as the temperature, discharge, and pressure by thermal and fluid dynamics based on design drawings and test run data.

b) Establishment of the C&I system model

Boiler and turbine works in line with C&I system commands, which are programmed to properly work for the expected behavior. Therefore, the precise simulation of the C&I system program on a simulator is necessary to realize a high quality simulator.

c) Establishment of a control panel

A control panel on a simulator's PC is a duplication of the control panel at a real power plant. Trainees are able to simulate a manipulation of the "pushing button", and "twisting lever" at the power plant's control room by clicking, touching on a control panel on a simulator's PC for the pushing button. The whole control panel and magnified view of a selected part is displayed on the multiple displays of the PC. This function provides trainees with the opportunity to learn the fundamental operating training of the manipulation by carefully monitoring the indicators.

2) Delivery, installment, and the test run of the simulator

In one example, a whole system of the PC-based simulator is shown in the figure below. The system is composed of a trainer's PC which incorporates the plant and C&I model systems, and Trainee PCs having control panels. These three systems (plant, C&I, and control panel models) are mutually controlled on customized software.

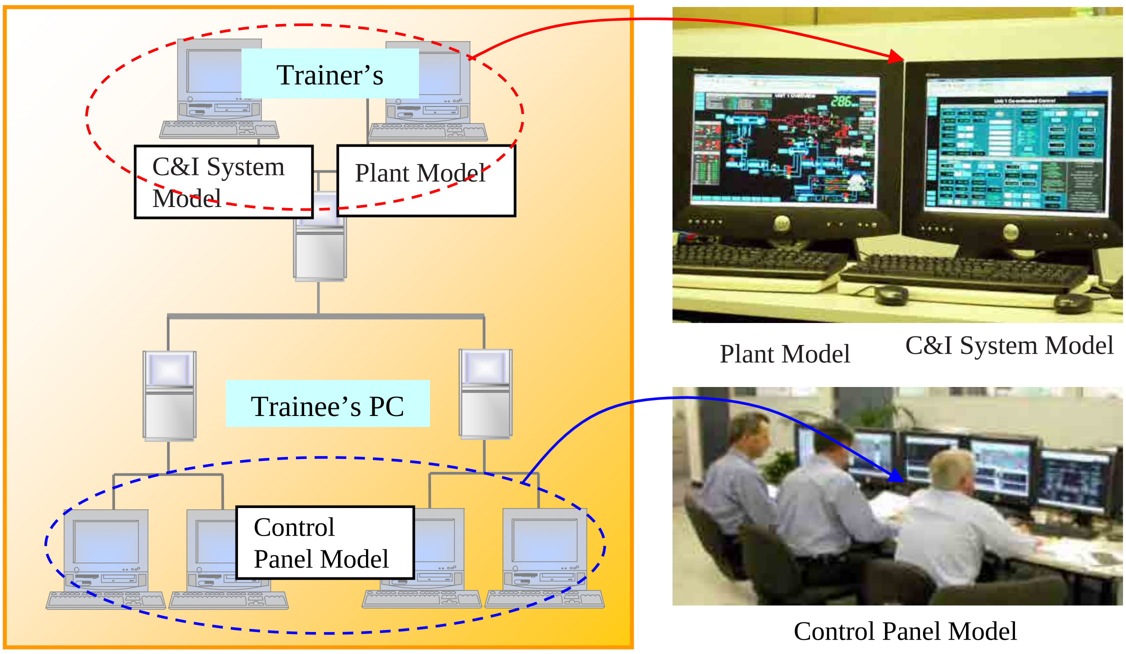


Figure 13.3-1 Introduction of Simulator at P/P

(Example: Yokogawa Electric Corporation, Eraring 660MW, Australia)

3) Implementation of trainings for trainees by invitation of the experts

The experts provide instructions on a series of operation modes such as ignition preparation, boiler ignition, turbine start-up, parallel, and rated load operation, and parallel off. A PC-based simulator equips the trouble mode. An instructor creates some troubles in line with a given scenario and trainees shall estimate the trouble point and causes, and take measures to solve the given trouble.

4) Implementation of training for the trainer's candidates by invitation of the experts

The experts from the simulator manufacture provide training to the trainers (TOT). Implementation of TOT is an important process to foster internal trainers within CPGCBL in order to improve and maintain the training level on the simulator.

13.3.5 Outline of training plan and necessary facilities

(1) Outline of the training plan in each step

The Responsible official for overall training is a GM Human and a Human Resources Manager has the responsibility for the business about training. On the other hand, the person in charge of a concrete training plan and implementation is a P/P Manager and Personnel Affair Department makes a detail training plan and manages implementation of training at construction and installation & test run period. And after commercial operation, Personnel Affair Department, Operation Department and Maintenance department makes a detail training plan and manages implementation. Outline of the tanning in each step is shown in following table and the details of the training are described at previous section.

Table 13.3-6 Outline of Tanning Plan in Each Step

<table>
<tr><th></th><th>Construction</th><th>Installation & Test run</th><th>Commercial Operation</th></tr>
<tr><td>Responsible official</td><td colspan="3">GM Human
(Human Resources Manager)</td></tr>
<tr><td>In charge of implementation</td><td colspan="3">P/P Manager</td></tr>
<tr><td>Planning and implementation</td><td colspan="2">Personnel Affair Dept.</td><td>Personnel Affair Dept
Operation Dept.
Maintenance Dept.</td></tr>
<tr><td>Training contents</td><td>Training through overseas job assignments
Training of O&M during the period of construction work</td><td>Training through construction supervisor
Training through test run supervisor</td><td>New employee training
Operation training
Maintenance training
Simulator training</td></tr>
<tr><td>Trainee</td><td colspan="2">Leaders who will become the key men of the operation department and maintenance department of the power plant</td><td>All employee</td></tr>
</table>

(2) Necessary facilities

It is necessary to build the training facilities in parallel with construction of power plant. It needs to be installed in a training wing inside of power plant include of the three lecture rooms, a simulator room where the simulator is installed, a maintenance training room where the models of large-sized facilities, such as a boiler, a turbine, a generator, environmental equipments, and auxiliary equipments are installed, and the OA room as main facilities, in addition installation of a stuff office, a dining-room, accommodations and amusement facilities is desirable.

The cost which should be prepared in order to carry out efficiently the training menu of the power plant staffs as mentions the preceding chapter is shown below. The construction cost of the training facilities include the simulator for operator training and the labor cost for training through overseas job assignments is needed in the period of construction, and the maintenance cost of training facilities and the labor cost for administration of training is needed after commercial operation. However the training after commercial operation carries out as OJT in each workplace mainly, and the training using training facilities is carried out as a complementary role about the training which cannot be covered with OJT.

Table 13.3-7 The Initial Cost for Plant Staff Training

Item	Estimated cost	Necessary facilities
(1) Training facilities in the power plant	0.5 million USD	・ Lecture room: three rooms ・ Instructors room and staff office ・ Maintenance training room where the models of large-sized facilities, such as a boiler, a turbine, a generator, environmental equipments, and auxiliary equipments are installed ・ Simulator room ・ OA room where the PCs are installed ・ Stationery, such as a projector ・ Dining-room and accommodations
(2) Overseas job assignments	0.4 million USD	・ Number of overseas job assignments : 20 ・ Period of overseas job assignments : 1 year
(3) Installing simulator	0.8 million USD	・ The simulator which operates on a personal computer. ・ The simulator can operates for the OJT ・ The simulator for instructors is included.
Total	1.7 million USD	

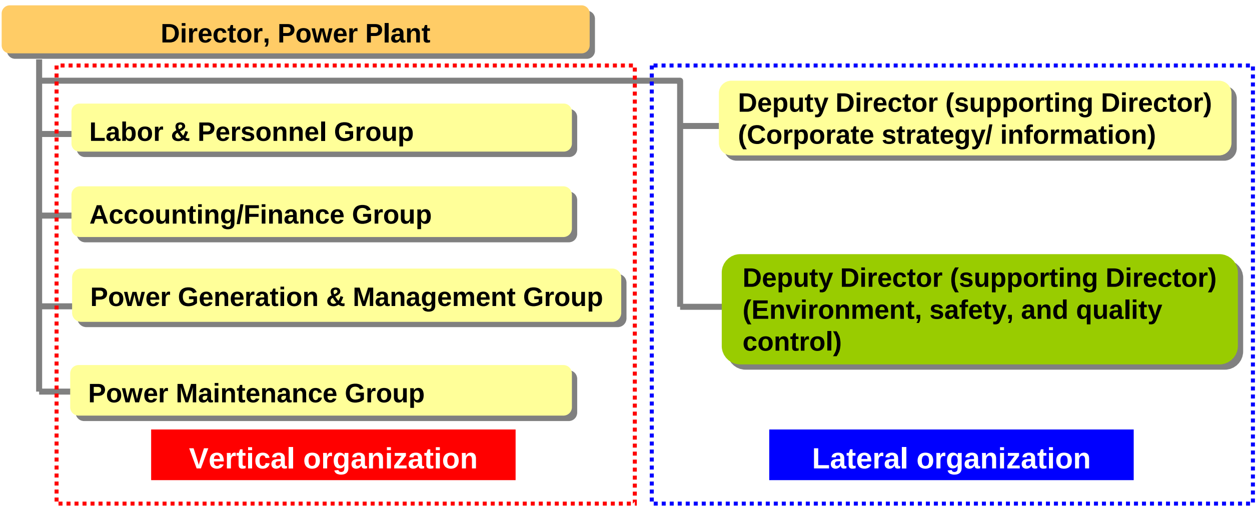
(Source: JICA Study Team)

The total initial cost for plant staff training in the period of construction before commercial operation is 1.7 million USD. In addition, the annual cost for training after commercial operation is about 50,000 USD, which is the labor cost for administration of training, the remuneration to a lecturer and the purchase of stationery, OA equipment and training material.

13.4 Environmental Management

13.4.1 Organizational framework

It is proposed to introduce the position of deputy director who will be in charge of environment, safety, and quality control, within the organizational framework of the power plant. The aforementioned position is critical in that it plays an important role in gathering and analyzing environmental data through day-to-day operations such as setting the goals of the power plant and assessing and reviewing performance, and because it has complete responsibility for the immediate provision of information to the director and executive officers of the power plant as well as to the Chief Officer in Charge of Environment at the headquarters.



(Source: JICA Study Team)

Figure 13.4-1 Environmental Management System on Power Plant

13.4.2 Environmental preservation measures

(1) Air quality conservation

1) Measures for SOx

The amount of SOx emissions depends on the sulfur content of the main coal and the specification of the flue gas desulfurization equipment. The project site is located in the coastal line. Therefore, there is no problem for the sea water intake which is used as an absorbent. It is proposed to introduce the flue gas desulfurization equipment utilizing sea water whose system is a more simple process than the others.

The main stream of the flue gas desulfurization is a wet lime-gypsum process. In recent years, the desulfurization equipment utilizing sea water which was installed in the thermal power plants in the coastal areas of the Southeast Asia is operated at an efficiency of 90-98% without exhibiting much difference from the wet lime-gypsum process. In the case of the sea water process, it is possible to discharge the absorbent to the sea water even if the aeration treatment for the absorbent is finished.

2) Measures for NOx

There are two kinds of NOx due to the combustion of fuels in the furnace; Fuel NOx and Thermal NOx. The ratio of Thermal NOx for coal-fired power generation accounts for 10-20%, which depends on the fuels and combustion method. Measures to suppress Thermal NOx in coal-fired boilers are decreasing the combustion temperature, decreasing the oxygen concentration in the burning zone, and improving the combustion such as shortening the retention time of the combustion gases in a high-temperature burning zone.

As for the concrete measures for Thermal NOx suppression, it is proposed to introduce low NOx burning appliances (decreasing of flame temperature in the burner exit), two-stage combustion method (the theoretical amount of air is supplied in the burner, and on the top of the burner, the amount of air lacking is supplied to complete the combustion).

3) Measures for particulate matter emission

There are plans to install cold side electrostatic precipitators (cold side ESP), which are the most popular and the most successfully used among electrostatic precipitators, in the low-temperature zone of the boiler air pre-heater exit. Also, dampers are introduced in the ESP exit due to the particulate matter release control at the start of operations of the dust removal device.

Box. Air quality conservation equipment

- ♦ Japanese flue gas desulfurization equipments maintain world-class specifications, and many desulfurization equipments are used not only in Japan, but are also exported overseas.
- ♦ Low NOx burning appliances and a two-stage combustion system are developed by Japanese technologies ahead of other countries, and have a very successful track record.
- ♦ Japan has many coal-fired power plants and oil-fired power plants that have installed ESPs and much operation experience in ESPs.

4) Measures for coal dust dispersion

During the process of coal handling at a coal-fired power plant, coal dust will be dispersed. The expected cases when coal dust dispersion occurs are summarized below:

- Coal landing by unloader
- Transportation on the conveyor line
- Stacking by stackers
- Coal storage to coal yard
- Discharging by reclaimer
- Transfer points between the discharge conveyors

The general measures are described below:

- Coal dust control fences in the coal yard
- Water sprinkler
- Transfer points between the conveyors are set up in the building
- Covering the conveyors

After the position of the coal yard is determined and the annual measurement data of the direction and velocity of the wind are collected, a coal dust dispersion forecast is provided to review the range of dispersion above the border line.
It is possible that spontaneous combustion occurs due to the temperature increase of the inside of the piles in the coal yard. Therefore, a water sprinkler line is set up taking into account coal dust dispersion and fire.

(2) Water quality conservation

1) Measures for thermal effluents

The temperature change at the point of the cooling water intake/discharge in any operation is designed in accordance with the regulations in Bangladesh. For instance, it is designed in consideration of the cooling surface of the condenser and the small tube closure ratio. If it is difficult to secure enough cooling surface compared with the designed surface due to increasing leaking pipes and closed tubes, it is necessary to conduct repairs and restoration as soon as possible. In addition, a warning prohibiting entry near the water intake/discharge is addressed to the fishery residents around the power plant.

2) Wastewater Treatment Measures

The wastewater clarification in the power plant is described as below.

Table 13.4-1 Clarification of Wastewater in the Power Plant

Clarification	Points of occurrence
Steady wastewater	♦ Wastewater from water pretreatment system ♦ Wastewater from water make-up demineralizer system ♦ Wastewater from condensate demineralizer ♦ Wastewater from ash disposal ♦ Wastewater from flue gas desulfurization
Non-steady wastewater	♦ Wastewater from furnace cleaning ♦ Wastewater from air preheater cleaning ♦ Wastewater from precipitator cleaning ♦ Wastewater from gas duct cleaning ♦ Wastewater from chemical cleaning of boiler
Other wastewater	♦ Domestic wastewater

(Source: JICA Study Team)

It is efficient to dispose steady wastewater and non-steady wastewater all at once. Most of the power plants in Japan have synthetic wastewater treatment equipment. The synthetic wastewater treatment equipment is a system which collects wastewater from many points to the water tank, disposes wastewater through neutralizing coagulation and sedimentation treatment, and discharges treated water into the sea following pH control. The main system of the wastewater treatment system is a chemical system composed of the pH control tank, flocculation tank, settling tank, and the thickener.

In the coal yard, it is proposed that an independent wastewater treatment system be set up.

(3) Oil Leakage Measures

In the case that the fuel oil for the boiler oil burner and the house-boiler oil burner is transferred from the power plant oil berth utilizing smaller tankers, assuming fuel oil spoiling over the sea, it is proposed to set up the oil fence to prevent spreading of oil slicks. Also, oil scavengers are prepared to absorb leaked oil.

In order to prevent oil leakage, regardless of the amount of stored oil, oil storage tanks are surrounded by an oil fence.

(4) Waste management

In terms of industrial waste from the coal-fired power plant, there are many kinds of waste such as fly ash caused from coal combustion, slime sludge collected from the wastewater treatment, waste oil from periodic inspection maintenance or other maintenance work, concrete remnants, metal remnants, and sessile marine organisms around the cooling channels. Disposal measures for each of these are required. It is necessary to control the waste management system because the neighborhoods can suffer from such waste, they can complain to the power plant, and also the power plant needs to take much time and cost to solve the issues if the outsourcing forwarding agents commit an unlawful dumping.

For the Matarbari Power Plant, it is proposed to introduce a reclamation measure for fly ash disposal. It is necessary to repeat soil improvement and roller compact before filling the fly ash to prevent fly ash dispersion.

(5) Measures for Noise and Vibration Prevention

1) Noise control

In the thermal power plant, noise is generated from the main facilities such as boilers, turbines, transformers, blowers, and pumps. As general measures for noise prevention, it is necessary to cover the facility/equipment making noise within the building and design the facility far from the border. However, regarding the layout of the power plant and a location plan of the facilities, it is important to evaluate not only noise control for certain facilities, but also to conduct a comprehensive evaluation.

There is an example where the infrasound problem which is difficult for the human ear to detect occurred after the operation of the power plant, and it took much time to solve it.

2) Vibration control

In the power plant, vibrations are generated from air compressors, mills, pumps, and blowers. It is proposed to introduce the vibration control of the power plant according to a design which is suitable to the specifications of the facility/equipment. As well as the noise control, the layout of the power plant is the design with the facility/equipment causing vibrations far from the border.

13.4.3 Environmental monitoring management

(1) Corporate ethics

Operational administrative data on environmental preservation should be saved in the database so that the data can always be submitted to outside organizations immediately upon request. It is necessary to instill corporate ethics among all the employees. The Deputy Director in charge of environmental management, safety management and quality management of the power plant has the responsibility to educate all of the employees in corporate ethics.

(2) Management of environmental monitoring data

The important points in controlling the information are summarized below:

Operational administrative data on environmental preservation should be saved in the database so that the data can always be submitted to outside organizations immediately upon request.

In addition, the measuring equipment for air quality conservation and water quality conservation facilities should be placed under strict control so that it operates properly offering management value without fail.

Related measuring equipment must be assessed every month at regular intervals and be ensured of accurate performance.

With respect to the noise level on the perimeter of power plants, the stationary measurement points before operational start should be decided and the noise level during trial runs must be measured at all points.

Stationary measurements must be carried out after the full-scale periodic inspection of the power plant.

Steady wastewater needs a sample analysis per the drain outlet once a month to ensure that management quality is maintained.

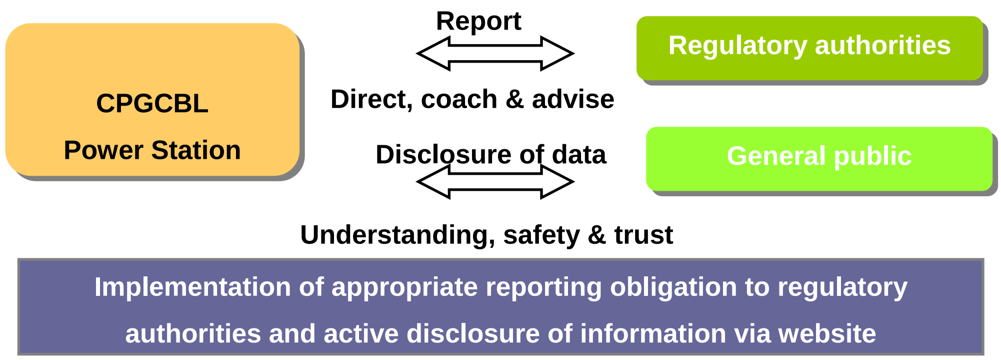
In regards to non-steady wastewater, an acceptable discharge value must be inspected at the exit of the drainage tanks before water discharge commences.

The operational, measurement, and maintenance data of environmental facilities, as well as the repair data for related measuring equipment should be stored in the operational data processing computer system to record the maintenance history.

13.4.4 Harmonious coexistence with the local community

(1) Implementation of active information disclosure

Given the business characteristics of power facility construction in the regions and power supplying to local residents, it is extremely important for the power business to build a relationship of mutual trust with the stakeholders (including shareholders, business partners, and the local community, etc.) In addition to reporting to regulatory agencies in an appropriate and responsible manner, it is essential to build a relationship of mutual trust with the local communities through active information dissemimation of daily operations, environmental data, and immediate countermeasures being taken against accidents to stakeholders including the general public, in the annual report or via the website.



(Source: JICA Study Team)

Figure 13.4-2 Environmental Management System (Public Level)

(2) Harmonious coexistence with the local community

As regards to the site location of the power plant, it is recommended to adopt basic policies for environmental preservation by participating in a community-friendly building project "by constructing a popular power plant", opening the power plant to the public, i.e., "constructing a usable power plant", and harmonizing with the local community "with an expansive power plant", and implementing these policies in all aspects of the construction and operations.

During the construction of the power plants, it is essential to preserve and create the natural environment by conserving the existing green spaces as much as possible and planting trees onsite to coexist with the local community. The specific measures to achieve these goals are:

- Building a popular power plant: by planting many trees onsite and aiming at developing a power plant with lots of greenery that will contribute to the expansion of building a healthy and productive environment for the community as a whole, in cooperation with the local residents.
- Building a usable power plant: A controlled area in the power plant is "double-controlled": the power generation facility area and the sub-controlled area. The power generation facility area is open to limited persons who have an entry permit, and the outer area is designed as a sub-controlled area. In the sub-controlled area which is open to the neighborhood, many public facilities are constructed such as company housing, a playground for cricket and soccer, mosques, health centers, ATMs, super markets, and primary/secondary schools, aimed at developing the power plant to be used by the local community. The open area is designed for planting so that the total scenery measure including the power plant is developed.

- Build a power plant with an open atmosphere: by allowing general public access to the inside of the power plant on a regular basis, therefore constructing a power plant with an open and welcoming atmosphere.
- In terms of coexistence with the local community, the positive promotion of employment from within the local community for the logistic positions such as drivers, cleaning, and cooling is highly recommended.

13.5 Safety Management

13.5.1 Basic policy

"Safety" as defined by the International Organization for Standardization (ISO) is a situation where there are no risks, which can never be acceptable. In this chapter, safety management is defined as the implementation of preventive activities for the facilities, equipment, and human life to remove or mitigate the existing risks to the level, which can be acceptable, or controllable, and to nip potential accidents in the bud before they happen. In addition, to identify accident causes via a root-cause analysis, and do appropriate ex-post activates to prevent recurring errors and accidents.

In CPGCBL, "Highly Reliable Power Supply" is one of the "Corporate Vision" as described by Chapter 12.1.2. Therefore, "Total Quality Management in O&M Activities" and "Ensuring Safety" is most important targets for power plant operation. The idea of giving priority over all to ensure safety makes fully understood among all workers, and it aims at no accident and no disaster.

In order to ensure safety work, it is necessary to endure slight sacrifices in efficiency. For example, if a worker is covered with a helmet, wears safety shoes, and carries a safety belt, his or her freedom of movement will be constrained a bit resulting in a slight decrease in work efficiency. However, once an accident occurs, the damage to body and life would be far worse. Furthermore, we are also concerned about such situations that could potentially lead to being sued and then having to payout huge amounts of compensation, such as a delay in work, and/or a stop of operations. For this reason, work safety is ensured as much as possible from the viewpoint of risk management even if it sacrifices on efficiency a little.

It is important for safety work to be given top priority. Such a mindset should not be limited to just employees but extend also to other company staff, so that all workers who step foot inside the power plant recognize that they all have to observe the same safety rules, and put safety controls into practice.

13.5.2 Current analysis

(1) Safety management guideline

Workers' safety is ordained by the "Bangladesh Labour Act, 2006" (hereinafter referred to as the Act) in Bangladesh. The Act consolidates the laws relating to employment of labour, relations between workers and employers, determination of minimum wage, payment of wages and compensation for injuries to workers, formation of trade unions, raising and settlement of industrial disputes, health, safety, welfare and working conditions of workers, and apprenticeship and matters ancillary thereto. The contents of the Act are shown in following Table.

Table 13.5-1 Contents of Bangladesh Labour Act, 2006

Chapter	Contents
Chapter 1	PRELIMINARY
Chapter 2	CONDITIONS OF SERVICE AND EMPLOYMENT
Chapter 3	EMPLOYMENT OF ADOLESCENT
Chapter 4	MATERNITY BENEFIT
Chapter 5	HEALTH AND HYGIENE
Chapter 6	SAFETY
Chapter 7	SPECIAL PROVISIONS RELATING TO HEALTH, HYGIENE AND SAFETY
Chapter 8	WELFARE
Chapter 9	WORKING HOURS AND LEAVE
Chapter 10	WAGES AND PAYMENT
Chapter 11	WAGES BOARDS
Chapter 12	WORKERS COPENSATION FOR INJURY BY ACCIDENT
Chapter 13	TRADE UNION AND INDUSTRIAL RELATIONS
Chapter 14	DISPUTES, LABOUR COURT, LABOUR APPELLATE, TRIBUNAL, LEGAL PROCEEDINGS, ETC.
Chapter 15	WORKERS PARTICIPATION IN COMPANIES PROFITS
Chapter 16	REGULATION OF EMPLOYMENT AND SAFETY OF DOCK WORKERS
Chapter 17	PROVIDENT FUNDS
Chapter 18	APPRENTICESHIP PROCEEDINGS, ETC.
Chapter 19	PENALTY AND PROCEDURE
Chapter 20	ADMINISTRATION, INSPECTION. ETC.
Chapter 21	MISCELLANEOUS

And regulatory authority is the “Ministry of Labour and Employment”. In Bangladesh, the inspectors under the Ministry of Labour and Employment are the sole government body to implement the Occupational Safety and Health (OSH) provisions in different workplaces throughout the country as per the Bangladesh Labour Act, 2006.

In order to carry out the construction and the operation of the power plant safely, it is necessary to follow the Act, especially chapter 5,6,7,8,12,16. The proposal about a safety management and quality control is described in the following chapter in consideration of the Act. Moreover, since this is JICA project, it is necessary to check the safety management and quality control by the Safety and Quality Control System Checklist published by JICA, a result is attached. In addition, the Safety and Quality Control System Checklist needs to follow the Act and Environmental, Health, and

Safety Guidelines published by International Finance Corporation. The contents of the Safety and Quality Control System Checklist are covered by the Act.

Since CPGCBL is a company which has just established, the safe manual is not owned. A safe manual is one of the fundamental rules of a company, and before construction is started, it is necessary to prepare it. The safety management in the public electric power sector of the Bangladesh is basically performed carried out using the each sector's safe manual according to the safe manual which BPDB owns. Although the safe manuals of BPDB are required sufficient contents and the procedure of the safety management is carefully described, it is very thick at that many contents to be. For this reason, only few workers check the manual and follow it now. In order to improve this situation, in "the Project on Strengthening Management and Performance Standards in Power Sector of Bangladesh through Promotion of TQM" carried out by supporting of JICA from 2006 to 2009, the pocket edition of the O&M manual also including the contents of safety management was created and distributed to the individual.

When CPGCBL creates a safe manual, it is necessary to refer to the safe manual of BPDB like the other public electric power sector. In that case, while including particular contents of coal fire power plant, fully in consideration of the JICA's Safety and Quality Control System Checklist and the contents of the Environmental, Health, and Safety Guidelines published by International Finance Corporation, it is necessary to build the mechanism of ensuring labor safety.

(2) Bangladeshi Safety Awareness

In Bangladesh, one can often see people nonchalantly riding on the top of moving trains and buses, and directly crossing streets or roads instead of using bridges. Thus, Bangladeshi safety awareness is assumed to be a very low. For this reason, it is difficult to ensure safety work via individual/independent safety measures. Hence, we propose a compulsory framework to ensure that work is conducted in a safe manner.

Figure 13.5-1 Pictures of Low Bangladeshi Safety Awareness

(3) Safety Management in IPP

In IPP which is a private capital firm, the recognition of the importance of safety is at satisfactory levels and orderly safety management is put into practice. The pictures below are some examples of safety management being put into practice.

Thoroughly instructed to wear safety equipment (uniform, helmet, protective goggle and safety shoes)

Thoroughly instructed to wear safety equipment (always wear helmets, protective goggles and safety shoes)

Equipped with safety fences (for fall prevention)

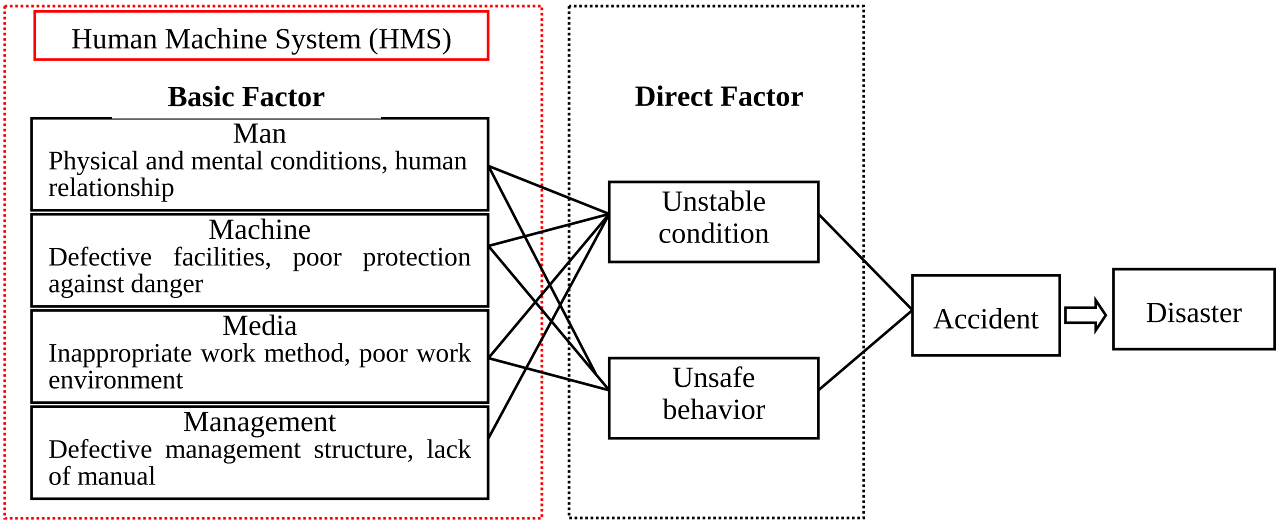
Figure 13.5-2 Pictures of Safety Management

In addition, in NWPGCL which is a public electric power sector, the same safety control system as IPP, such as thoroughly instructed to wear safety equipment and obligation about that of instruction video viewing and listening about safety in the case of going into a construction site, is introduced, and it has been constructing with no accident and no disaster until the present.

13.5.3 Approach for achieving reduction of risk

(1) Disaster Occurring Mechanism

A disaster is caused by unstable conditions and unsafe behavior. P/P does not consist of machines alone. It consists of humans and machines. And other elements stand between the humans and machines, including media and manuals such as the work method and environment, and management such as the management structure. If we perceive these basic elements as the Human Machine System (HMS) of P/P, we need to approach the disaster occurring mechanism from a 4M perspective, namely, Man, Machine, Media and Management.



(Source: JICA Study Team)

Figure 13.5-3 Human Machine System and Disaster Occurring Mechanism

(2) Concept of Disaster Risk Reduction

The concept for reducing the number of disasters shall be based on a very simple formula as follows.

Number of disasters = Number of tasks performed that may lead to disasters × Probability of errors occurring per every task performed

Figure 13.5-4 Concept of Reducing the Number of Disasters

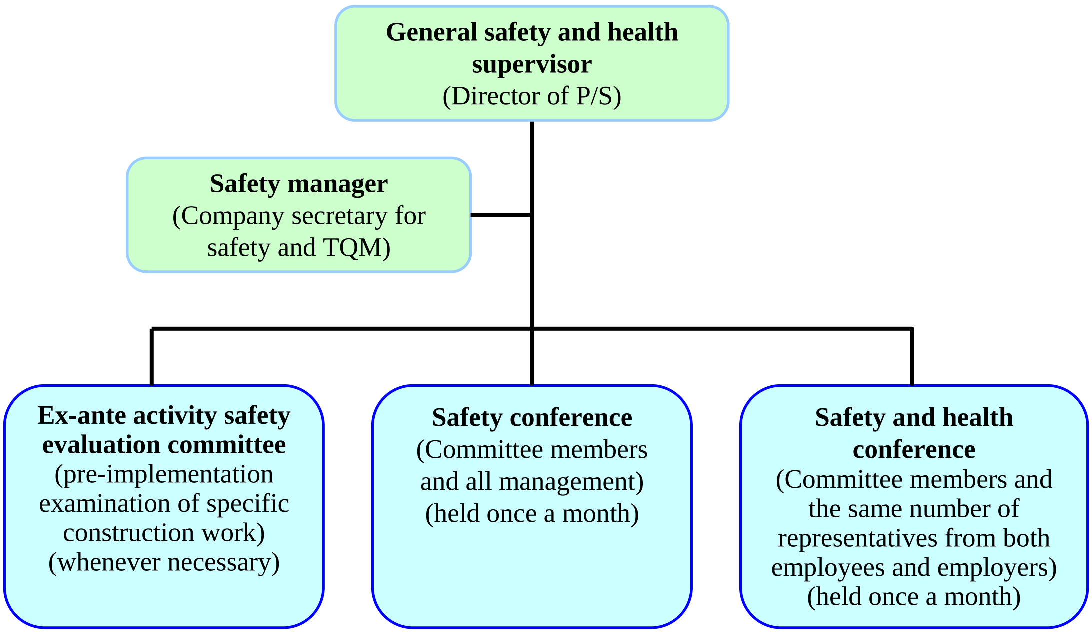
This means that it will be necessary to reduce either the number of tasks performed or the probability of potential errors that could occur per every task performed. However, it is difficult to reduce the probability to zero. Therefore, it is also important to assume that errors could occur at any time and be prepared to prevent them from escalating into an accident or disaster. Concrete measures shall be taken as follows.
In addition, there are many more disasters especially the following points in a coal-fired power plant, therefore strict management is required.

- A fire set off by a spark from welding, cutting of metal or other work involving fire
- A fall due to a poorly structured scaffold
- Oxygen deficiency due to poor ventilation during work at a closed-in place
- A crane dropping an object due to a faulty crane wire
- An electrical shock and a burn injury

13.5.4 Proposal of organizational and institutional aspects

(1) Establishment of an Organizational Structure for Safety Management and Identification of Safety Responsibility

A safety committee shall be established within CPGCBL power plant by appointing its head as the chairperson to strengthen safety management and identify the organizational responsible structure for safety management. The safety and health management structure is shown below.



(Source: JICA Study Team)

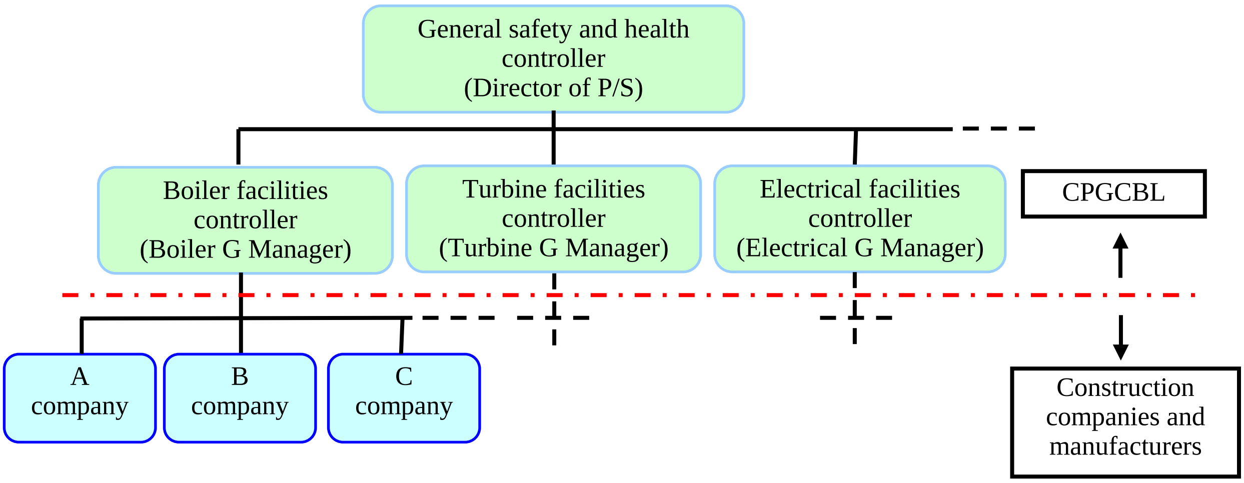
Figure 13.5-5 Safety and Health Management Structure

The committee shall consist of a union representative and management level employees. To improve safety measures within the power plant, the committee shall continue to implement its annual activity plan, including the safety meeting plan, solicitation of the report on Hiyari Hatto (near accident) incidents, solicitation of posters to improve safety activity (a medal of honor shall be awarded for excellent work), periodical patrols, and a 5S awareness campaign.

In addition, the “prior safety evaluation committee” shall be held to evaluate the safety of tasks prior to the adoption of new work or a construction method, commencement of work with explosions or fire hazards, lifting and moving of large equipment with large-size heavy machinery, and the shutdown of the protection circuit to conduct a circuit inspection or replace the relay during operations within the power plant. The Chairman of the safety committee shall select members of all committees each time. Those who used to work for a construction company and outside knowledgeable persons may be asked to participate in the committee as necessary. At the safety committee, the person who is in charge of safety and who is a Deputy Director of the power plant supervises all committees and events to be held within P/P.

The Secretariat is headed by the deputy chief of the personnel division and its members are managers of each division

During new construction and the regular inspection period, a large number of workers visit P/P. Therefore a safety conference shall be organized for all workers including those from construction companies and manufacturers. During regular inspections, a construction site patrol shall be conducted once a week and instructions shall be given to improve unsafe behavior and a poor work environment. The first and second warnings of incidents of unsafe behavior will be a “caution”. Without strict disciplinary rules that stipulate, for example, that the first and second warnings shall constitute a “caution” and that the third warning shall result in a dismissal, safety will never become established. It is important for the Head of P/P and other executives to improve their attitude, as they are constantly compared with one another.



(Source: JICA Study Team)

Figure 13.5-6 Safety Conference Structure（major overhaul）

(2) Introduction of Reward and Penalty System

1) Safety Award

Award for a remarkable improvement proposal that clearly ensures worker safety, including one that aims to install a sign to prevent erroneous operations or improve the patrol route.
A commendation certificate from the director of the power plant or company president and a reward is provided according to the grade the improvement.

2) Visualization of staffs who finish on-premise safety precaution training

Those who finished on-premise safety precaution training shall be given a sticker which to be put on their helmets as an indication that they undergone safety precaution training. In addition, a duty of attendance of on-premise safety precaution training is imposed upon all staff in the power plant. Furthermore, only staff with this sticker will be allowed to enter the power plant.

3) Penalty

If a worker who after completing the safety precaution training is found to be engaging in questionable behavior such as not wearing the required protective equipment, ignoring safety operation instructions, or ignoring on-premise safety precautions, depending on the number of times such breaches occur, he or she will be subjected to a verbal reprimand, cautions, re-education, a forced absence, recommendation for a resignation, and dismissal.

(3) Safety Training

1) Safety Training materials

Videos demonstrating good safety practices shall be taken and used as teaching materials for the power plant staffs and construction company workers during the new construction and regular inspection period at the power plant for safety training. Specifically, the contents as shown below are applicable.

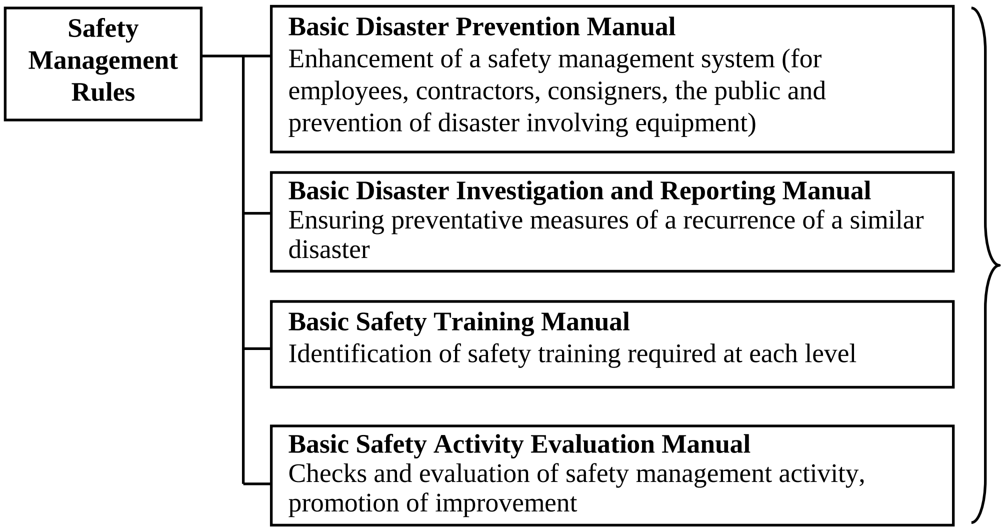
Correct procedures to put on fatigues, protective footwear and protective helmet
High-place work (fall prevention measures)
Work that requires the use of fire (fire, explosions, sparks)
Heavy-duty lifting (dropping heavy goods, contact with goods during lifting operation)
Ventilation measures for the closed work site (oxygen deficiency, hydrogen sulfide)
Electric shock prevention measures (use of protective equipment, voltage detection)
Restricted areas the within work area and display

2) Implementation of repetitive training

A fire company for self-defense shall be organized separately for work hours during daytime hours of work and for holidays and the nighttime, with the latter consisting of duty persons. These fire companies shall repeatedly conduct drills, including water-discharge drills, fire extinguishing drills, and emergency call drills during the holiday and nighttime.

(4) Safety Manual

It is necessary that CPGCBL creates a safety manual before the start of the construction work and to ensure that all staff observes the safety rules including the construction company.
It is necessary to create a safety manual system as shown in the figure below, and to formulate concrete rules that are most appropriate for the job site to carry out rules and measures for each division.
It is therefore necessary to create and distribute a portable, easy-to-understand, pocket manual in the local language of all the staff. This pocket manual should be utilized for new entry workers for safety training.
MD’s staff (Environment, Safety, TQM) is a person in charge of the safety manual (creation, operation and maintenance) at headquarters. And also Manager attached to GM (Safety, TQM, and Environment) is a person in charge in the power plant.

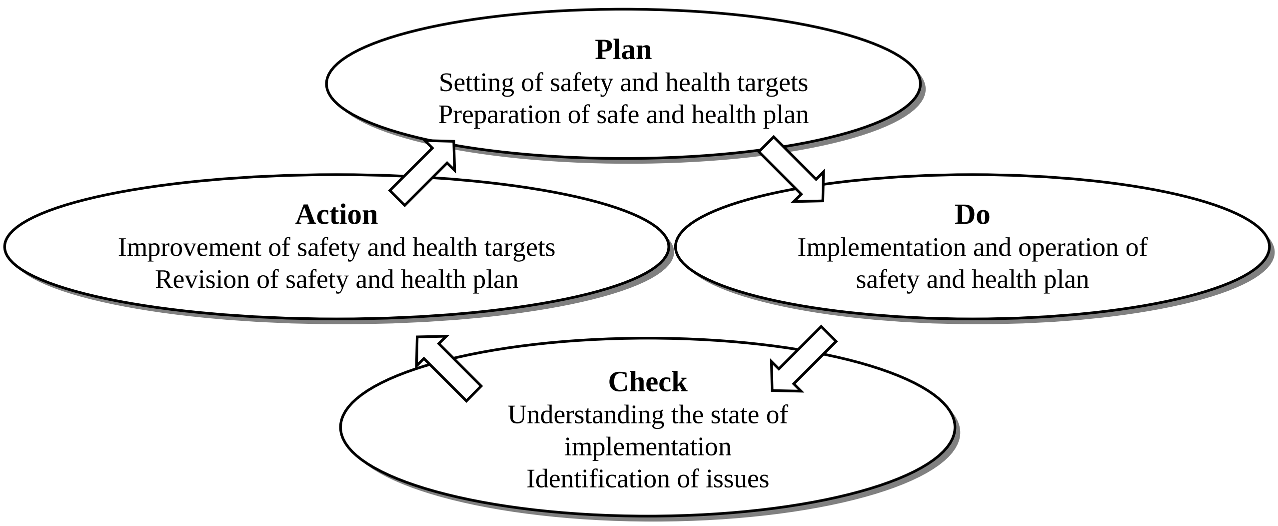


(Source: JICA Study Team)

Figure 13.5-7 Safety Management Manual System

(5) Management Flow Based on PDCA Cycle

Introducing a mechanism to creat a PDCA cycle, which utilizes the opinion of frontline workers and that of top management as the two wheels of one cart, make it possible to construct a solid safety management system. The safety management manual in the previous section constitutes the key element of a successful PDCA cycle.



(Source: JICA Study Team)

Figure 13.5-8 Management Flow Based on PDCA Cycle

13.5.5 Ex-ante activity (preventive activities)

(1) Clarification of dangerous areas

In the P/P, various dangerous objects which may cause fires and explosions are stored, handled and used. Strengthening surveillance measures of how dangerous objects are handled, especially at the coal-fired power plant, is required to eliminate the risk of disaster such as the spontaneous combustion of an outdoor coal yard, the ignition of accumulated pulverized coal at the conveyor belt connection part and the ignition of the stagnant coal in mixing the coal hopper and the coalbunker for the mill for a long time.

There is safety equipment for discharge, storage, mixing and conveyance of coal. This safety equipment detects where there may be a danger and automatically operates to prevent disasters. However, worker surveillance, patrols, proper facility management, and repairs are important.

It requires the operation and maintenance of not only the coal but the oil stock tank for starting oil burners required for coal ignition, piping and pump equipment, the oil stock tank for auxiliary boilers, the oil stock tank for the emergency diesel generator and the oily dangerous object. There are cases where the leaked oil from this equipment may cause a fire.

Moreover, including the steam turbine generator, with many large-sized rotating machines, lubricating oil is kept in large quantities and is always used. The proper maintenance and repairs of the leaked oil of the flanged connection part of the fuel oil and a lubricous oil system, and the valve grand packing part is required.

The creation of safety rules is important for preventive activities, such as the arrangement of a hydrant and various correspondence fire extinguishers, periodical functional checks, advance application procedures of fire usage work in the power generation area and the posting of fire prevention work.

(2) Security and disaster prevention

Provide a layout plan of the premises next to the guard station where check-in procedures are performed.

Display dangerous areas, firefighting equipment, fire hydrants and emergency contacts in the layout plan.

Alert those who enter the premises by car or truck for the first time to keep out of and away from dangerous areas.

Hydrogen collecting equipment for cooling the power generator: There is oil-seal equipment and N2 gas-seal equipment that prevents explosions by mixing leaked hydrogen and air. A Different Sound, vibration and an oil leak is checked by patrols every day. (It is kept off except by a power plant worker. A worker's entry is permitted after substituting CO_2 or N_2 gas for hydrogen gas at the time of maintenance.)

(3) Fire protection/preventive equipment in the power plant

Lay a looped fire-fighting pipe all around the P/P. Install water-in taking hydrant boxes (with a fire hose) at pivotal points.
Install both the electric-driven pump and the engine-driven pump.
Install powder fire extinguishers and foam fire extinguishers at pivotal points for the initial firefighting of possible fuel gas/oil fires and electric facility fires. The typical fire extinguishers are shown below by function. Put serial numbers on the fire extinguishers that are always equipped at the P/P to prevent them from being transferred or lost. Check twice a year to see if they are stored in place.

(4) Collecting near-miss cases and compiling them into a brochure

Even if an incident was a “near-miss” case that did not end in disaster, there are many cases where even the slightest mistake could lead to a serious disaster. Thus, it is necessary to clarify any dangers in the workplace as a risk factor even if it could only lead to a minor disaster, assess it as a risk and respond to it by creating rules or measures that will serve as preventive measures.

(5) Clarification of TBM-KY activity and work instruction

Before the start of work, it is important that all workers jointly clarify the risks associated with their work to be done on the day to prevent accidents, which is called TBM-KY (Tool Box Meeting – Kiken Yochi (Risk Prediction)) activity. Every work instruction needs to be given not verbally but in the form of paper to mutually confirm steady communication among the workers.

Box. TBM-KY (Tool Box Meeting – Kiken Yochi (Risk Prediction))

- ♦ In Japan, Tool Box Meeting is held every day in a small group before work begins. They predict latent risk in today's work and confirm the safety method at the meeting. And all of them recognize risks and safety measures.
- ♦ To predict risks is called "Kiken Yochi" in Japanese. Therefore this activity is called “KY activity”.

It is important to develop core personnel who will be in charge of TBM-KY activities. The TBM-KY Trainer attends the various work sites in the power plant, makes workers cognizant of their work environment, potential risks and the required technical skills.

It is a means to greatly contribute to the enhancement of an employee's technical skill level and is a good system to apply on-site supervision to the CPGCBL engineers.

Table 13.5-2 TBM-KY Board

Date:		
Today's Work:		
Abnormal experience(s)		
Countermeasures Applied:		Performed by:
Team Safety Target		
Prohibited Unplanned Work		
Special instructions		Person In charge:

About the dangerous work such as replacement work without a protection sequence and a live part approach work, a manager participates in a meeting.

(Source: JICA Study Team)

Confirming details of today's work

TBM-KY

Figure 13.5-9 Pictures of TBM-KY Activity

13.5.6 Ex-post activity

(1) Ex-post reporting system

The person responsible for responding to disasters shall be the safety personnel. The assistants shall serve as assistants (staff) to the chief officer and the person in charge of labor management in the administrative department. (Responds to daily repair work and disasters for the construction company workers.)

If an accident occurs, lifesaving is given the highest priority. In the case of a fatal disaster, the area shall be designated as a no-go zone to preserve the scene. In the case of disasters resulting in minor or serious injury, victims shall be transported first and then the area shall be designated as a no-go zone to preserve the scene. Also, an accident shall be reported to associated external organizations (police, the Labor Standards Inspection Office and hospitals) as well as the associated departments of electricity producers.

The accidents shall be investigated by conducting interviews on the following matters and confirming the scene, and be compiled into reports from a multilateral perspective. Reports shall be made respectively for minor injuries with no lost workdays, minor injuries with hospitalization, serious injuries with hospitalization and fatal disasters. The reports and photos shall be stored in a predesignated file in the OA server.

Details of work that was instructed to the victims and the workplaces, both on the day of accident

- ♦ Whether the victims were wearing protective equipment or not
- ♦ Whether there were any co-workers or not (investigate the place and status of the co-worker(s) working at the time of the disaster)
- ♦ What were the direct causes of injuries arising from the disaster
- ♦ Whether the factors of the direct cause could have be prevented or not if appropriate work instructions, etc. had been given
- ♦ Whether the distribution and the number of workers were adequate or not
- ♦ Whether the accident was caused by a worker’s random action or not, and whether the worker was wearing protective equipment or not
- ♦ Whether the temporary scaffolding for the work was adequate or not, etc.

(2) Emergency responses

In the case of large-scale disasters such as the one producing plural victims and the one affected by the explosion/fire during plant operations or scaffolding, accident countermeasure headquarters shall be set up with the P/P chief officer as the chairman. Measures shall be taken mainly by the countermeasure task force consisting of safety personnel, assistant to the chief officer, associated people in the administrative department, the power plant department and the repair department and a chief officer of the construction company.

If an accident/disaster occurs during power plant operations, the designers of the manufacturer and external academic experts shall be invited to pursue the cause and develop preventive measures.

When a disaster occurs, the first person who becomes aware of it shall report it to the central control room first. Then, the central control room shall urgently communicate it based on a contact chart which lists who to contact at the time of a disaster.

13.5.7 Safety equipment

The safety equipment owned by the P/P shall be checked regularly.

The safety equipment brought by a construction company to the power plant shall be checked in the presence of both parties to confirm if there is any risk of activation failure, damage or functional inhibition. The equipment permitted for use shall be attached with an emblem for identification.

(The improper equipment shall be taken out of the P/P immediately.)

Table 13.5-3 Safety Equipment

Personally served for rental	Work wear, work shoes, safety helmet
Owned by P/P	Safety bands, gas detectors, oxygen respirator, safety signs, safety slogans, partition net (for daily repair)
Prepared by construction company	Partition net, fall prevention net, ropes for safety band attachment (with attachment fittings), fire extinguishers for places where fire is used (check the use warranty period), water for firefighting (portable bucket), safety signs (Keep out, Pay attention to falling objects, etc.)
Reference	Articles that need to be checked to ensure safety work, though they are not equipment: Welding masks, welding rod holders, cables, wires (strand breakage, kink, no uniform wire size), electric wire reel

(Source: JICA Study Team)

13.5.8 Strengthening the safety management system during the new construction and the major inspection and maintenance period

The daily repair department and the construction company shall create a work plan for the following day, discuss it with the equipment management section and the construction management department, through which all members can be made aware of construction information.

On the day of work, the central control office and the repair department in charge of the work shall be informed of the start of the work before it is started.

The work instructions of the day shall be confirmed by all members of each work group in the field, followed by TBM-KY before the start of the work. Never conduct an work that is unscheduled or work based on workers’ random decisions. At the end of the work, all members shall ensure that the workplace is clean and tidy and inform the central control office and repair department that the work has been completed. Particularly when work using fire is completed, the workplace shall be sprinkled with water to prevent fire caused by embers.

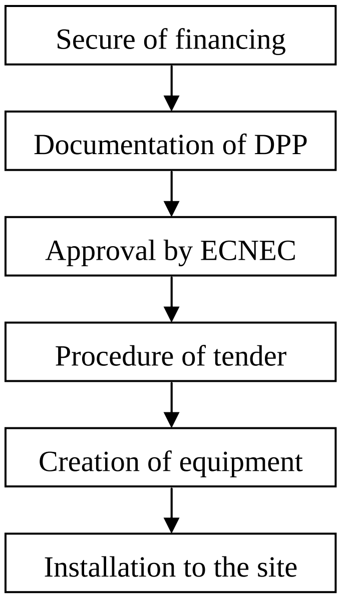
The workers who work in the P/P for the first time shall be provided beginner’s training based on the P/P compliance manual. Also, it is necessary to create separate manuals such as the “Work instruction manual for the use of fire”, the “Work instruction manual for preventing oxygen deficiency in closed workplaces”, “Work instruction manual for the handling of specified chemicals” and a “Safety manual for welding work” in sequence that are all routinely used at the thermal P/P.

13.6 Future Direction of Operation and Maintenance

13.6.1 Current issues

Since the Unit 6 of Ghorasal Power Plant got broken down in July 2010, it has not been operated without repairing as of February 2013. The main reason causing the breakdown is that all the generation facility continued to operate without the periodical inspection and the proper maintenance due to shortage of power supply. This situation happens not only in the Ghorasal Power Plant, but also in other public power plants managed under BPDB.

The workflow for restarting the operation after the shutdown is described in the following figure. (in the case of utilizing donors' fund, because the self-funding is not sufficient)



(Source: JICA Study Team)

Figure 13.6-1 Workflow for Restarting the Operation after the Breakdown

It takes much time to procedure the workflow, because each work is done after the former step is done. In the case of a big trouble, it takes more than 2 years to restart the operation. For instance, if it takes 2 years to finish the repair after the breakdown since the power plant has been continuously operated for 10 years, it totally operated 10 years in 12 years. That means the power plant can affect the power supply to contribute 10-month operation and 2-month shutdown for maintenance on average per year. In fact, if the plant continues the operation without any maintenance or periodical inspection, the generation efficiency gets worse and the power output decreases. Therefore, from the point of contribution of power supply, it is more effective to shutdown the plant and conduct the proper maintenance every year periodically.

The vicious circle of power shortage in Bangladesh is described in the following figure.

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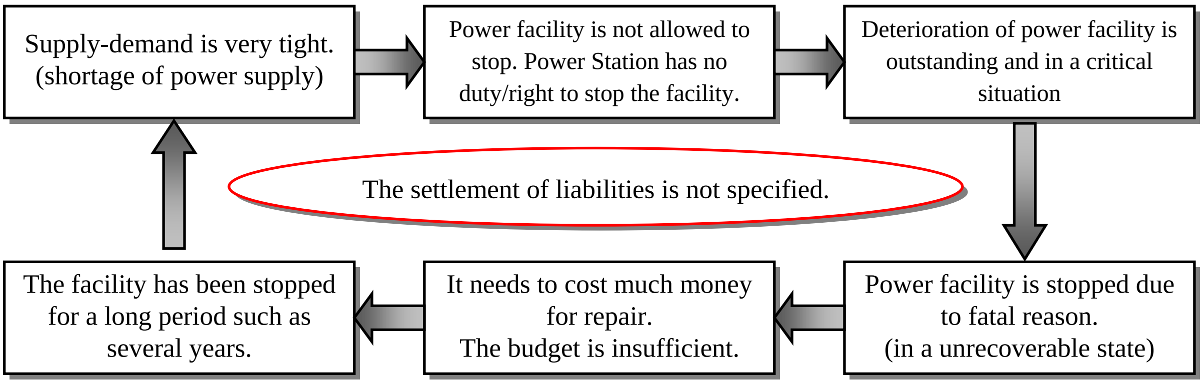


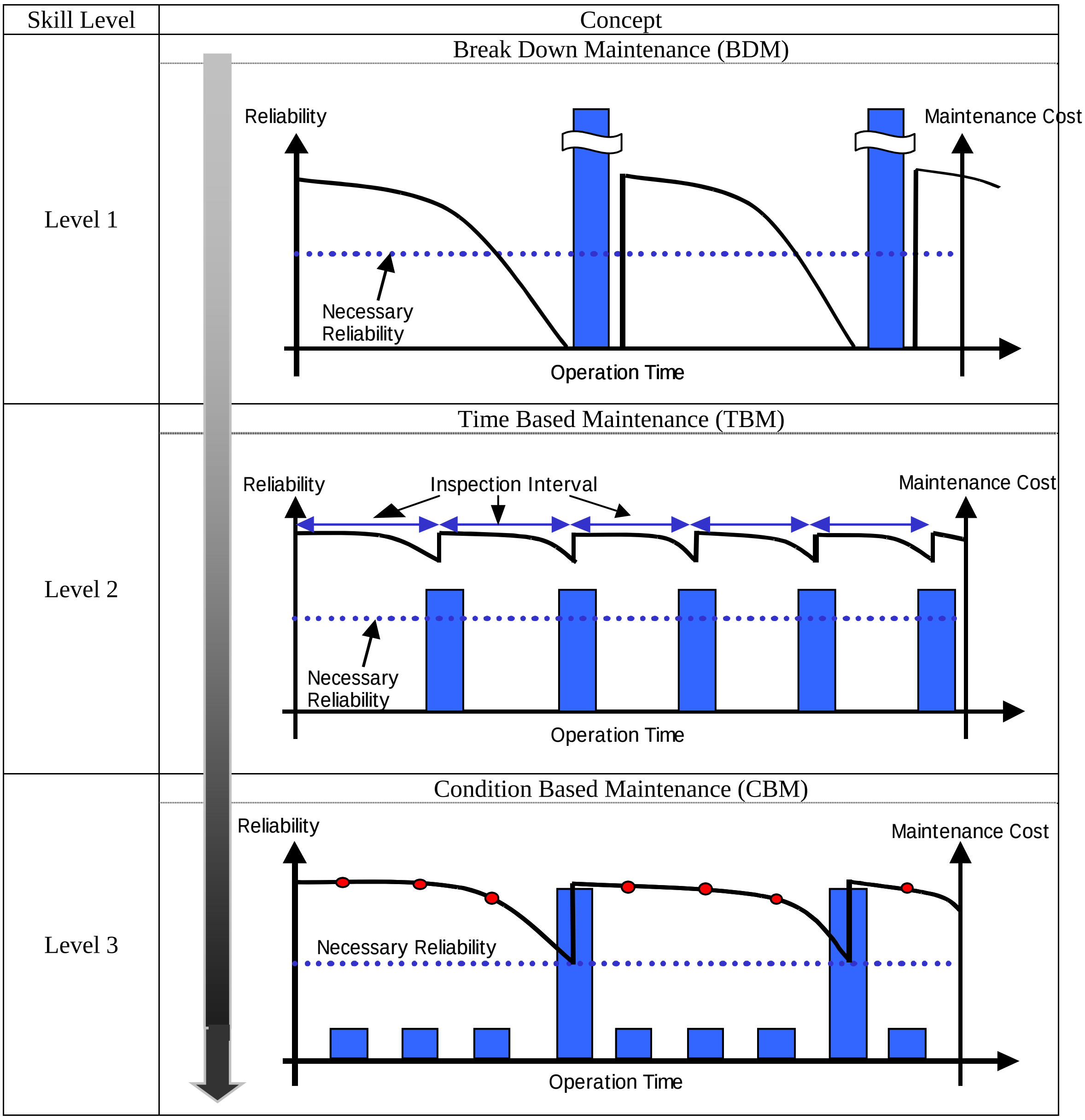
(Source: JICA Study Team)

Figure 13.6-2 Negative Cycle of Shortage of Power Supply

Toward this negative situation, the Study Team's recommendation for the future O&M structure for the power plant is written in the following pages.

13.6.2 Long-term maintenance plan

The maintenance measures are divided into the following 3 types. Each feature is described in the Figure 13.6-3



(Source: JICA Study Team)

Figure 13.6-3 Conceptual Image of Maintenance Measures

As described in the former section, many power plants in Bangladesh "operate until the breakdown" as "Level 1". In Japan, there is a regulation to conduct periodical inspection by regulators. TBM (Time-Based Maintenance) as "Level 2" has been mainly implemented. As the result of many reviews for regulators' periodical inspection and electricity utilities' maintenance work, many power plants in Japan generally transfers to "Level 3". Level 3 is

the measure including both CBM (Condition Based Maintenance) and TBM (Time Based Maintenance) that the power plant is operated continuously and extends the interval of periodical inspection if its safety and remaining life assessment are secured. Also, it is necessary to be checked by regulators.
Based on experiences in Japan, it is proposed that Bangladesh should target “Level 2” for the first step.

As mentioned in Section 13.2, coal-fired boilers require the periodical shutdown once a year to remove and clean coal ash inside the boilers. As shown in Table 13.2-3, it takes approximately 30 days to finish the cleaning. At the same time, simple check such as visual inspection of pressure-resistance parts of the boilers should be conducted in the point of deterioration and the result can be utilized for the next maintenance plan in the following year. If any part needs to be repaired, it should be repaired or replaced so that the secure operation can be continued until the next maintenance.
It is necessary to conduct the same inspection more than once a year. In addition, the inspection of boilers and turbines should be planned in some period to restore the function of facility or repair/replace the deteriorated parts. The periodical inspection measure is described in the following table. The frequency and shutdown period of each inspection is different from each other because of deterioration level or replaced parts.

Table 13.6-1 Periodical Inspection

	Frequency	Standard Shutdown Period	Contents
Inspection A	Every year	30 days	Removal of ash inside the boiler, Simple check, Minor repair
Inspection B	Once in 2 years	45 days	Boiler & turbine inspection, Minor repair of environmental facility
Inspection C	Once in 4 years	60 days	Boiler & turbine inspection, Repair of environmental facility
Inspection D	Once in 8 years	100 days	Boiler inspection, Turbine open inspection, Turbine detailed inspection
Inspection E	Once in 16 years	150 days	Major overhaul, Replacement of malfunctioned or deteriorated facility

(Source: JICA Study Team)

According to frequency of the inspections, it is effective to implement the periodical inspection schedule as the following table.

Table 13.6-2 Implementation Schedule of Periodical Inspection

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Maintenance	A	B	A	C	A	B	A	D	A	B	A	C	A	B	A	E

（After the 17th year, the same cycle is repeated.） (Source: JICA Study Team)

Regarding the implementation, it is necessary to check the deterioration level at every inspection and modify the next maintenance schedule of the following year. Also, it is required to try to decrease the shutdown period at the inspection and to finish the payment the production of spare parts in advance. Especially, it is important to consider the leading time to procedure the procurement of the spare parts without any trouble if a large part needs to be replaced.

Generally, a time-related deterioration causes overlapping damages of creep damage and thermal fatigue. In order to maintain the performance of time-related deteriorated parts and to improve the lifetime of equipment, it is necessary to implement the following actions.

- ■ At overhaul, the parts which have possibility of creep damage need metallographic inspection and non-destructive inspection for trend management of various data.
- ■ Detailed examination of the managed parts is conducted 8-10 years after the commercial operation starts and the deterioration is estimated to reflect the middle/long term maintenance plan of the parts.
    - ◆ In the case of turbine rotor, it takes approximately 1.5-2 years of lead time for ingot manufacturing in steel factories, processing in turbine factories of plant makers and installing rotor blades. Considering the lead time, it is necessary to decide the timing of ordering spare parts and starting construction. For this project, it needs additional 3-5 month shutdown for construction period including bringing parts in, installation and field balancing.
    - ◆ The procedure of replacement of the final reheater of boilers and panels of the final reheater is also the same of that for turbine rotor. In the case of boiler panels, it takes 5-6 month shutdown to remove of existing panels, install new panels, combine the welded parts, conduct welding, implement non-destructive inspection, and monitor the water level.
- ■ At a major overhaul, it is necessary to conduct performance improvement and replacement of deteriorated parts besides maintenance work. Before and after an overhaul, simple performance inspection is conducted. After an overhaul, the improvement level of the performance is checked. (At present, it is possible to check

the performance with software in a calculator.)

13.6.3 Organizational structure for maintenance

(1) Secure of Maintenance Cost

The maintenance cost is basically included in the Capacity Payment of PPA. If the maintenance schedule is conducted in accordance with the plan, the maintenance cost is secured. However, if some trouble happens after the warranty period (normally for 1 year) or if the replacement is required earlier than expected, it costs the CPGCBL for repair cost by itself.

Just after the start of operation, it is difficult to estimate what kind of trouble happens. Because at the first stage after the start of operation, the financial constitution of the CPGCBL is not stable, it is very likely that the CPGCBL cannot manage a big trouble due to shortage of self-funding and cannot start to repair until financing. If the shutdown period lasts longer, the CPGCBL cannot gain the income and cost additionally. Therefore, the cash flow gets worse extremely.

For the trouble situation, the following countermeasures are proposed.

(a) The warranty period is set to be for a long term (for 5-10 years), and the manufacturers repair free of charge in the case of trouble against defects.

(b) LTSA (Long Term Service Agreement) contract: the guaranteed parts are specified in advance. In the case of a trouble or unavailable situation due to depletion, manufacturers implement the LTSA contract and repair responsibly regardless of defects.

(c) CPGCBL enrolls the insurance.

Those countermeasures are compared as the following table.

Table 13.6-3 Comparison of Countermeasure to Secure Maintenance Cost at the Trouble

	(a) Long-term warranty period	(b) LTSA Contract	(c) Insurance	(d) No plan
Plant Cost	Increases a little	More than (a)	Same as Base	Base
Cost for every year	No additional cost	No additional cost (possible to reduce the maintenance cost)	Additional cost (however, a fixed amount of cost)	No additional cost if no trouble happens. At the trouble, it is impossible to estimate the additional cost.

	(a) Long-term warranty period	(b) LTSA Contract	(c) Insurance	(d) No plan
At the trouble	After the shutdown, it is possible to repair immediately. No additional cost is required.	After the shutdown, it is possible to repair immediately. No additional cost is required.	After the shutdown, it is possible to repair immediately. No additional cost is required.	Additional cost is required. If the additional cost is not secured, it is impossible to repair, the shutdown lasts longer, and the cash-flow gets worse extremely.
Others	The longer the warranty period is, the more difficult it is to identify the defects. The manufacturer has incentives if its high-quality product is installed to the plant.	Out of the guaranteed parts, it requires funds. The manufacturer has incentives if its high-quality product is installed to the plant.	Until receive of the insurance money, it is necessary to procure repair cost.	It is not recommended for the first stage with an unstable financial constitution.
Priority	2	1 (best)	3	4 (worst)

(Source: JICA Study Team)

At any countermeasure, it costs CPGCBL an additional cost. In the case of (a) and (b), it is possible to suppress the increasing of the maintenance cost more than expected if the additional cost is included in the contract money at purchase of plant facility, although the plant cost increases.

If the warranty period is set to be long (5 years or more), some sub-consumable parts such as coal burner equipment or air preheater elements needs to be replaced during the warranty period. The service life of such parts depends on usage, coal characteristics and especially quality. If replacement of parts is conducted in the interval period less than expected service life, it requires more maintenance cost than included in the Capacity Payment of PPA and causes CPGCBL' s financial deterioration.

For instance, here it takes an example of 3 year-service-life parts. Considering the replacement in 3 years, the cost of replacement to the spare parts is included in the Capacity Payment of PPA. If the parts need to replace in 2 years due to heavy damage and even if it happens in the warranty period, it is difficult to identify the manufacturer's defects and it costs CPGCBL for the replacement. The cost can be burden for CPGCBL out of the original maintenance plan. In the case of LTSA Contract, it costs manufactures for the replacement of guaranteed parts, and it costs CPGCBL nothing. In other words, if the manufacturers produce and supply the better-quality equipment/facility which can operate for a long period, the manufacturers gain their

incentives to decrease the additional cost to repair or replacement. That is how to install the LTSA Contract and how the incentives make manufacturers supply better-quality products.
With LTSA Contract, serious defects (for example, errant usage out of the manuals, careless O&M) caused by CPGCBL cannot be guaranteed. In order to manage the LTSA Contract properly, it is important to establish the operation structure as described in Section 13.6.4.

In the case of gas turbines or combined cycle power plants, it is general that the LTSA Contract is made between a plant supplier and a user and the contract period is set to be 6 years (around 50,000 hours). During the LTSA Contract period, a manufacturer dispatch engineers as instructors to supply high-temperature components, dismantle/assemble a equipment and operate a trial run. There is no experience in Japan to make LTSA contract in the coal-fired power plants. However, it is possible to make LTSA contract if the guaranteed parts are specified in the same way as gas turbines. Regarding the contract period, it is proposed to put prospects the 8th year when a large inspection (Inspection D) is conducted. Considering the leading time to procure the spare parts, damaged parts which are found at the Inspection D is repaired/ replaced in the 10th-year Inspection B, extending the construction work. Therefore, taking account of the leading time since finding the damage, it is proposed that LTSA Contract should be for 10 years.

The proposal of guaranteed parts is described as follows.

- Coal burner equipment
- Boiler tubes (repair of several tube leakage, preventive maintenance for boiler evaporator tube thinning due to sulfidation corrosion, replacement of final superheater tube/ final superheater tube thinning, measures for steam oxidization scale)
  Reinforcement of ash erosion protector
- Replacement of air preheater elements due to corrosion or thinning
- Steam turbine
  Bearing, high-pressure/ middle-pressure primary nozzle erosion, shaft seal
- Generators
  Bearing
- Mills
  Pneumatic tired rollers, turntable, classifiers
- Response system large valve, safety valves of boiler
- Clinker disposal device (dry disposal or wet disposal, crushers in the case of immersion type)
- Shaft seal for feed pumps

Since the LTSA contract becomes effective after the warranty period is finished, it is not matter if the LTSA contract is made after commercial operation starts. However, if LTSA contract is committed near the starting date of commercial operation, elements of competition does not work at all because the counterpart of the contract has been already decided. Therefore, there is possibility that the counterpart of the contract quotes the higher contract price more than expected in the stage of negotiation for the LTSA contract. As result, it is also possible that the negotiation for the contract fails.
As a proposal of the Study Team, the tenderers should submit the proposal of O&M support structure after the commercial operation including LTSA contract and training programs for CPGCBL members before the commercial operation and the financial proposal of O&M support and training programs are submitted at tendering besides the plant price. The final tender winner should be chosen from the evaluation of a proposal of not only the plant price and also O&M support structure.

(2) Implementation Structure for the Maintenance

It is proposed that CPGCBL holds up a management vision, “Continual Development” aiming at a long-term capacity building for the workers. According to the vision, an implementation structure for the maintenance is proposed as the following table.

Table 13.6-4 Direction of Implementation Structure for the Maintenance

Early period (for 5 years after commissioning)	Middle period (6th ~ 10th year)	Long period (after 11th year)
Engineer of manufacturer Collection of information ↑ ⇩ Instruction CPGCBL Maintenance Staff	Engineer of manufacturer ↓ Instruction CPGCBL Maintenance Staff	CPGCBL Maintenance Staff Outsource ⇩ ↓ Instruction Maintenance Company in Bangladesh
■ LTSA contract ■ Periodic checks are mainly conducted by the manufacturer. ■ The maintenance staff of CPGCBL tries to improve their technical capabilities by collecting information.	■ LTSA contract ■ The periodic checks are conducted mainly by the maintenance staff of CPGCBL. ■ When necessary, the dispatch of engineers from the manufacturer can be required for guidance.	■ The staff of Maintenance Company in Bangladesh conducts the periodic checks according to the contract with CPGCBL. ■ The maintenance staff of CPGCBL manages the periodic checks and major overhauls.

(Source: JICA Study Team)

At the primary period of periodical inspection, it is recommended that the CPGCBL members for repair should attend the inspection to inquire the skill and knowledge whether the manufacturers dispatches the trainers and inspectors based on the request from CPGCBL or not.

After then, CPGCBL should conduct periodical inspections independently as early period (the 6^{th} – the 10^{th} year) as possible. If any question/trouble occurs, CPGCBL ask for support from the trainers of engineers of the manufacturers.

On the next step (after the 11^{th} year), CPGCBL consigns the maintenance work to a maintenance company in Bangladesh, and maintenance staff of CPGCBL take in charge of management (establishment of maintenance plan, supervision of construction work, and so on). Regarding outsourcing contractors, there is a measure to establish a subsidiary company of CPGCBL after maintenance staff of CPGCBL has had several experience of periodic check.

It is proposed that the subsidiary company of CPGCBL should aim at improving their skill and at receiving order of check and maintenance work in the other power plants so that the subsidiary company can take in charge of periodic check in the other power plants and a large-scale improvement work such as replacement of boiler panel.

13.6.4 Operation structure

As Table 13.2-1 shows, there is a large difference between coal-fired power plants and gas-fired power plants. Especially, the fuel for coal-fired power plants is coal whose characteristic is solid and not consistent. Therefore, it requires much higher-level skill for the stable operation than that of gas-fired power plants. In addition, a once-through boiler for this project is the first boiler installed in Bangladesh. That means operation staff of CPGCBL operate the first facility in Bangladesh. As the proposal of Section 13.3, it is extremely difficult to implement the stable operation only by CPGCBL even if a key person at the operation gain a experience to operate the same facility in other counties and takes a training with the operation simulator.

In the primary period, it is general that problems with generation facility arise. Several kinds of problems from big one and small one arise. The automatic shutdown system is established to operate correctly to secure the safety of facility if a big trouble occurs. If a small trouble occurs, an alarm rings, but the operation does not stop. There is no other alarm, however it is possible to find strange noise and smell at the patrol. Operation staff needs to recognize the severity of the alarm and warning immediately and correctly and to deal with emergency treatment for them. The following items are examples.

- Determine whether the operation continues or not
- Countermeasures for the continued operation
  - How to deal with the treatment for which parts
  - Necessity of emergency treatment
  - Determine whether the operation continues or not how long the operation can continue if the emergency treatment is completed
  - Which level staff should be dispatched (whether repair by own staff or by the manufacturer)
- Countermeasures for the stopped operation
  - Explanation of necessity to stop the operation
  - How to deal with the treatment for which parts
  - Which level staff should be dispatched (whether repair by own staff or by the manufacturer)

Operation staff can grow up as skilled personnel after having experiences to deal with and solve some trouble on the site by themselves enough to train the other staff. As for the other work, it is important to have an experience. In Bangladesh, it is very difficult to secure enough number of skilled personnel on the primary period. Therefore, at the beginning of commercial operation, it is recommended that CPGCBL should consign international O&M supporting experts who have many experiences of operation in a large-scale coal-fired power plant in other countries and should train the CPGCBL staffs on-the-job training due to transfer of technical knowledge and raising staffs who can be a trainer.

The consigned supporting experts should support CPGCBL not only for operation work but also for the all O&M work as the following table. Aiming at transfer of technical knowledge, the sufficient number of supporting experts is 2-3 persons who have many experience of operation in a coal-fired power plant, and the contract period is for 2-3 years.

Table 13.6-5 Supporting Work of International O&M Supporting Experts

Contents	Work
Monitoring and check in operation	Tendency management of several items (temperature, pressure, flow rate, water level, oil level) in order to find indication of trouble early. At the same time, the changes of vibration, sound, smell and colors which is hard to find by measurements and the leakage of oil or water should be found through a dairy patrol.
Prevention of trouble	If the indication of trouble is found, the collected data is analyzed to specify the reason. Additionally, if necessary, the operation is stopped to check and audit the facility. After then, the evaluation of seriousness is conducted and the countermeasure is determined.
Repair and inspection	Before the periodical inspection, the contents of necessary work for the shutdown period including repair of trouble parts is added to the normal periodical work, a detailed work schedule and necessary spare parts are prepared in advance. Regarding the trouble found at the inspection, the countermeasures (emergency treatment and long-term treatment) are determined considering seriousness of the trouble and leading time to procure the spare parts. The contents of inspection and the result of measurement remain on the proper document format. Tendency management of each inspection with the data is utilized for remaining life assessment.
Arrangement of repair plan	Sorts of maintenance, shutdown date and shutdown period are decided. The date and period is fixed after discussion with central load dispatching center, considering power demand. The deterioration of facility and the emergency of shutdown need to be considered to shutdown definitely in the proper season.
Repair of the accident and Investigation of the cause	If emergency accident (in operation/ in inspection) occurs, site survey and situation grasp and grasp of the main cause of accident should be conducted using the database of operation records and inspection records. Also, the trouble part found in the periodical inspection is repaired temporary if it is too late to procure the material.
Performance management and fuel management	Heat performance is managed with the data extracted from the process control computers. The reports are made dairy, monthly, quarterly and yearly. The composition, calorific value and blend rate of coal is checked.
Management of water and lubricating oil	In order to operate the power plant stable, it is necessary to establish the management system for water, chemicals for water treatment and waste water treatment, lubricating oil, hydrogen gas and nitrogen gas which requires dairy, and to plan the middle/long-term consumption schedule.

(Source: JICA Study Team)

13.6.5 O&M cost for power plant

The O&M cost after the commercial operation is estimated. The following items are integrated as cost.

- Personnel expenses for permanent staff
- Maintenance expenses
- Purchase expenses of spare parts for dairy replace
- Outsourcing expense (outsourcing work)
- Other miscellaneous expenses
- Administrative expense

Basically, O&M cost is divided into fixed cost which does not change according to operation rate and variable cost which changed according to operation rate. However, the operation keeps at the maximum output if the power plant is in a good condition. The change of O&M cost is very few if the operation rate is changed. Therefore, O&M cost is estimated as fixed cost which does not change according to operation rate.

(1) Personnel expenses for CPGCBL permanent staff in Power Plant (P/P)

The necessary number of the personnel and the necessary level of managerial positions in power plant are described in Section 13.1. Also, the salary level of each managerial position is explained in Section 12.3.3. The following table shows the result of calculation of personnel expenses for permanent staff. Necessary money for personnel expenses is estimated twice as much as salary because it includes welfare expense.

Table 13.6-6 Personnel Expenses for CPGCBL Permanent Staff in P/P

Rank		Annual Salary (1000 Tk)	Number	Total (1000 Tk)
General Manager	GM	1,680	1	1,680
Deputy General Manager	DGM	1,440	2	2,880
Manager	M	1,080	14	15,120
Deputy Manager	DM	840	11	9,240
Assistant Manager	AM	672	24	16,128
Junior Manager	JM	480	21	10,080
Staff Level	S	360	62	22,320
Others (Driver etc.)	O	192	52	9,984
Shift duty				3,130
Total			187	90,562

(Source: JICA Study Team)

The operation staff is engaged in shift work. The salary for them is paid 20% more than the others' salary. The total amount of the personnel expenses is 91 million Tk/ year.

(2) Maintenance cost

The maintenance cost is estimated following the maintenance plan mentioned in Section 13.6.2. The following table shows the necessary number of staff for each inspection and cost for the replaced parts (one unit). Personnel expense is calculated with a 1200Tk daily allowance per one staff. Equipment expense is cost to replace parts at the inspection comparing with the construction cost. At the most large inspection of Inspection E, approximately 8% of the all parts is replaced and the cost is the same as 8 % of construction cost (excluding civil construction cost). For the equipment replacement, high-skilled engineers are required, and the personnel expense is included in the equipment expense. The shutdown period is added 5 days to standard shutdown period considered as necessary period to solve the trouble found at the inspection.

Table 13.6-7 Maintenance Cost for Each Periodical Inspection

（Unit of expense: million Tk）

	Frequency	Outage days	Number	Expense for 1 time			Expense for 16years	
				Personnel	Facility	Total	Number	Total
A	Every year	35 days	100	4	167	171	8	1,369
B	Once 2years	50 days	200	12	835	847	4	3,387
C	Once 4years	65 days	300	23	1,670	1,693	2	3,386
D	Once 8years	105 days	500	63	4,174	4,237	1	4,237
E	Once 16yeras	155 days	1000	186	6,679	6,865	1	6,865
Average expense for 16 years								1,203

(Source: JICA Study Team)

It is estimated that the maintenance cost for 1 unit for 16 years is 1,203 million Tk/year, and 2,406 million Tk/year for 2 unit.

(3) Spare parts cost

At the beginning of commercial operation, cost for spare parts for the moment should be included in the contract at the purchase of plant facility. After the commercial operation, cost for spare parts is added up as the cost of new spare parts. Based on this concept, 167 million Tk/year (0.1% of facility construction cost) is estimated for spare parts which require to be replaced daily.

(4) Outsourcing expense (outsourcing work)

Cost for consigned work is basically personnel expense. Personnel expense of each outsourcing staff is estimated to be the same as 70% of the average salary level. The following table shows the quantity of outsourcing work and personnel expense of each outsourcing staff.

Table 13.6-8 Outsourcing Cost

		DM	AM	JM	S	O	
Guard	29			1	4	24	shift
Gardening	7			1	2	4	
Cleaning	11			1	2	8	
Others (company cafeteria)	13			1	2	10	
Operation of Port	34	2	4	8	8	12	shift
Operation of Coal yard	34	2	4	8	8	12	shift
Treatment of waste	26	1	1	4	8	12	shift
Daily maintenance							
Boiler	13	1	1	2	3	6	
Turbine	13	1	1	2	3	6	
Electrical	13	1	1	2	3	6	
I&C	9	1	1	1	2	4	
Environmental facility	9	1	1	1	2	4	
Specialist	8	1	1	2	4		
Total number of persons	219	11	15	34	51	108	
Annual Salary (1000 Tk)		588.0	470.4	336.0	252.0	134.4	
Total annual expenses	52,315	6,468	7,056	11,424	12,852	14,515	

(Source: JICA Study Team)

In practice, the outsourcing expense in shift work becomes 125% of the basic salary. Also, 10% of the total amount of personnel expense is considered as a profit of outsourcing contractor.

(5) Other miscellaneous expenses

Among other miscellaneous expenses, the following items are included.

- Purchase money for expendables such as lubricating oil, chemical agents, seawater desalination facility filter, fuel for emergency diesel generator
- Training cost for permanent staff
- Operation cost (purchase of office supplies, repair of building, traveling expenses, gasoline, event, social expense, regional contribution)

The 3% of the total amount calculated from (1) to (4) (excluding VAT) is estimated because it is difficult to estimate those expenses by each.

(6) Administrative expense

The expense of headquarter as cost center is estimated at 5% of power plant cost (excluding VAT).

(7) Annual O&M cost for power plant

Above-mentioned cost is summed up in the following table. VAT is calculated by the items using the ratio of importing parts (5%) and the ratio of service (10.5%).

Table 13.6-9 Annual O&M Cost

(Unit: million Tk/year)

	Expense	VAT	Total
(1) Personnel	91		91
(2) Maintenance	2,406	168	2,573
(3) Spare parts	167	8	175
(4) Outsoucing	66	7	73
(5) Others	88		88
(6) Overhead	151		151
Total	2,952	183	3,135

(Source: JICA Study Team)

Annual O&M cost is 2,952 million Tk/year excluding VAT and accounts for approximately 1.4 % of facility construction cost.

(8) Other cost for O&M in the power plant

1) LTSA contract

If LTSA contract is included in contract with an EPC contractor, though it does not matter if it is included in construction cost, it is highly possible to increase the construction cost proposed in Section 14.1. On the other hand, in practice LTSA contract plays a role of insurance. The effect of contract lasts for the contract period equally every year.

Considering the characteristic of LTSA contract, it is necessary to add up the specific cost every year for 10 years of LTSA contract period. In the case of LTSA contract which is different from simple insurance, the cost for maintenance and spare parts is reduced because the replacement of expired parts is conducted.

Annual cost is estimated as the following measure.

- Increasing construction cost in the case of LTSA contract: 5,000 million Tk（per 1 unit）
- Considering as annual cost, 500 million Tk（per 1 unit）
- Decreasing cost for annual maintenance and spare parts: 200 million Tk（per 1 unit）
- Annually increasing cost following LTSA contract: 600 million Tk（per 2 units）

2) Cost included in construction cost

The following costs are included in construction cost and provided by EPC contractor.

- Prefabricated scaffolding for the inside of boiler
- Training facility (refer to Section 13.3.5)
- Traveling expense for overseas training (refer to Section 13.3.5)
- Simulator for the operation work (refer to Section 13.3.5)
- Dispatched international O&M supporting experts (approximately 3 years after the commercial operation) (refer to Section 13.6.4)

3) Equipments for O&M (Cost included in construction cost)

Necessary equipments for the O&M of the power plant are as follows.

- Vehicles
- Equipments for workshop
- Meters for daily maintenance
- Temporary equipments necessary for emergency work
- Office equipments
- Others (Safety equipments)

The equipments which CPGCBL cannot buy by the start-up loan (local currency) from BPDB are as follows. These are summed up as the part of the construction cost (foreign currency portion) in consideration of the 200% custom duty.

Table 13.6-10 Equipments Cost

(Unit: 1000 USD)

		Units	Unit price	Total
Vehicles	Truck	3	100	300
	Forklift truck	1	90	90
	Unic Crane	2	100	200
	Road roller	1	200	200
	Fire truck	1	300	300
	Bulldozer	4	110	440
	Sub total			1,530
Equipments for workshop	TIG Welding machine	1	20	20
	AC Welding machine	1	3	3
	DC Welding machine	1	4	4
	Lathe	2	10	20
	Drill press	2	2	4
	Miller	1	20	20
	Grinder (installed type)	1	5	5
	Grinder (handy type)	3	1	3
	Pipe bender	1	10	10
	Compressor	1	4	4
	Other Tools	1	20	20

		Units	Unit price	Total
	Sub total			113
Meters for daily maintenance	Infrared thermograph	1	70	70
	Radiation thermometer	1	1	1
	Ultrasonic thickness gage	1	4	4
	Oximeter	1	2	2
	Noise level meter	1	4	4
	Gas detector	1	4	4
	pH meter	1	2	2
	Other meters	1	10	10
	Sub total			97
Temporary equipments necessary for emergency work	Drainage pump (engine driven)	1	4	4
	Drainage pump (electromotive)	1	1	1
	Ventilation fan (big)	2	3	6
	Ventilation fan (small)	1	1	1
	Others	1	10	10
	Sub total			22
Office equipments	Personal computer	120	2	240
	Copy machine	3	6	18
	Handy Video	2	1	2
	Camera	5	0.4	2
	Projector	3	2	6
	TV monitor	5	1	5
	Sub total			273
Others (Safety equipments)	Fire extinguisher (200L)	3	12	36
	Fire extinguisher (100L)	5	6	30
	Fire extinguisher (50L)	10	2	20
	Fire extinguisher (20L)	80	0.5	40
	Oil fence	2	6	12
	Sub total			138
Total				2,173

(Source: JICA Study Team)

It is necessary 2,173 thousand USD in total for equipment cost for O&M in power plant.

4) O&M cost for port and coal yard (operational expenses)

Among the O&M cost for port and coal yard, the personnel expense for cargo handling, piling up the coal in the coal yard and discharging coal is included in outsourcing expense (see Table 13.6-9).

Operation of port is attempted by an external consignment company by the following content.

a) Content of consignment business

- Management of incoming and outgoing ships (Coal ship, Oil ship)
- Guide for the vessel (incoming, pier docking, outgoing)
  including tugboat operation
- Unloading of coal and oil (operation of unloader)
- Customs clearance procedure

CPGCBL consigns dredge work and maintenance work of the port equipments such as unloaders to another consignment company.

b) Organogram of port operation company's office at Site

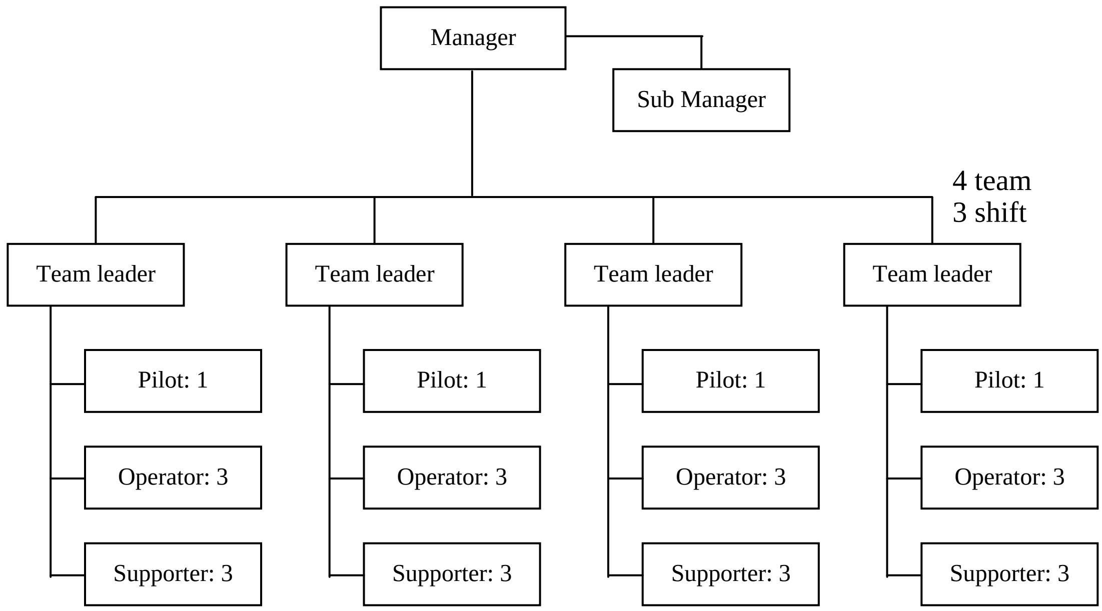


Figure 13.6-4 Organogram of Port Operation Company's Office at Site

c) Outsourcing cost

The consignment expense is mainly the labor cost of 34 persons above-mentioned, and is about 14.2 million Tk during year is expected.

On the other hand, there are many large-scale heavy machines such as unloaders, stackers, reclaimers in the port and coal yard. It is necessary to check those machines periodically and replace the expendable parts. Among the port construction cost, the construction cost which belongs to foreign portion is mainly purchase cost for large-scale heavy machines. Therefore, 1% of the construction cost (142 million Tk) which belongs to foreign portion among port construction cost is estimated as maintenance cost of heavy machines.

The sailing route is designed as artificially excavated port. Periodical dredging for the sailing route is required to keep enough depth for the port because it is possible that the depth of port becomes shallow by tidal current and sand flow due to cyclone. In Bangladesh, the dredging cost is approximately 1,000 Tk/m^3. As result of sedimentation simulation, the annual amount of dredged sand is approximately 360,000m^3. The annual dredging cost is 360 million Tk.

5) O&M cost for transmission lines (operational expenses for PGCB)

Transmission lines are constructed for the necessity to supply from the Matarbari power plant to area of power demand. After the operation start, O&M for the transmission lines is managed by PGCB. CPGCBL has no duty to pay for the transmission lines because PGCB collects the O&M cost from wheeling charge.

The PGCB's O&M cost for transmission facilities is estimated as follows.
According to PGCB Annual Report, the annual O&M cost for transmission facilities is reported as the following Table.

Table 13.6-11 Annual O&M Cost for Transmission Facilities

		Unit	30.06.2011	30.06.2010
Transmission expenses		1000 Tk/yr	1,343,277	872,651
Administrative expense		1000 Tk/yr	201,762	134,173
Total length of T/L	230kV	Ckt. Km	2,647	2,647
	132kV	Ckt. Km	6,018	5,670
Average T/L expenses		Tk/yr/Ckt. Km	89,000	61,000

(Source: JICA Study Team)

* T/L expenses is the half of (Transmission expense + Administration expense), because PGCB manages T/Ls and S/Ss.

For this project, the construction of 400kV 60km double circuit transmission line is planned. The O&M cost for this project is assumed as the following calculation formula. Due to high voltage, the cost is 1.2 times as the conventional cost.

$$(89{,}000 + 61{,}000) / 2 \times 1.2 \times 60 \times 2 = 10{,}800{,}000 \text{ Tk/yr}$$

(The sum comes to 130,000 USD/yr at a rate of 81.7 Tk per USD. That accounts for approximately 0.3% of the construction cost for transmission facilities cost, 42.3 million USD.)

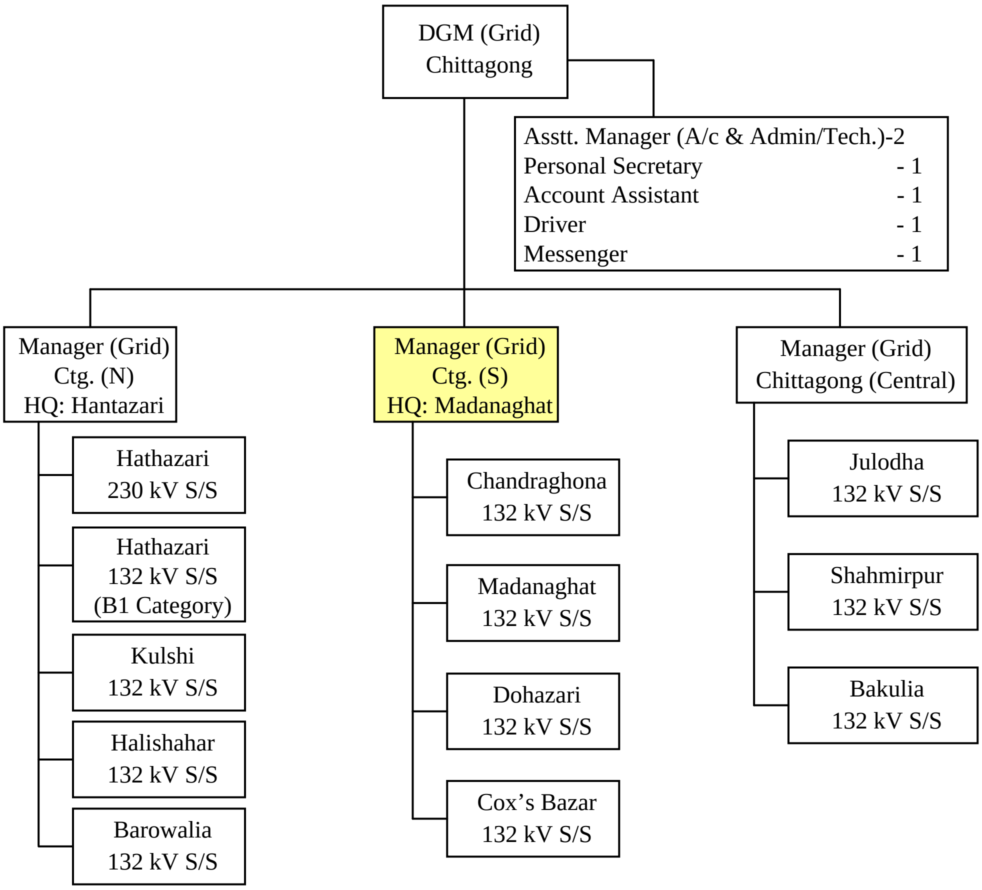
6) O&M cost for access road (operational expenses for RHD)

Access roads are constructed for the necessity of construction and O&M for power plant. The roads are not used only for the power plant, but the all areas are also for the public. After the operation start, of access roads, the road owners manage O&M. Basically CPGCBL has no duty to pay for O&M cost for the access road. If CPGCBL is requested for some parts of the payment for which is used for the power plant, the amount would not be so large and CPGCBL can afford it from other miscellaneous expenses.

13.7 Operation and Maintenance of Transmission Line

(1) Present maintenance management of Chittagong district

The organization chart of Grid Maintenance Division (GMD) in the Chittagong district which may be maintenance entity after the Project start is shown below.



(source: Company Structure of PGCB)

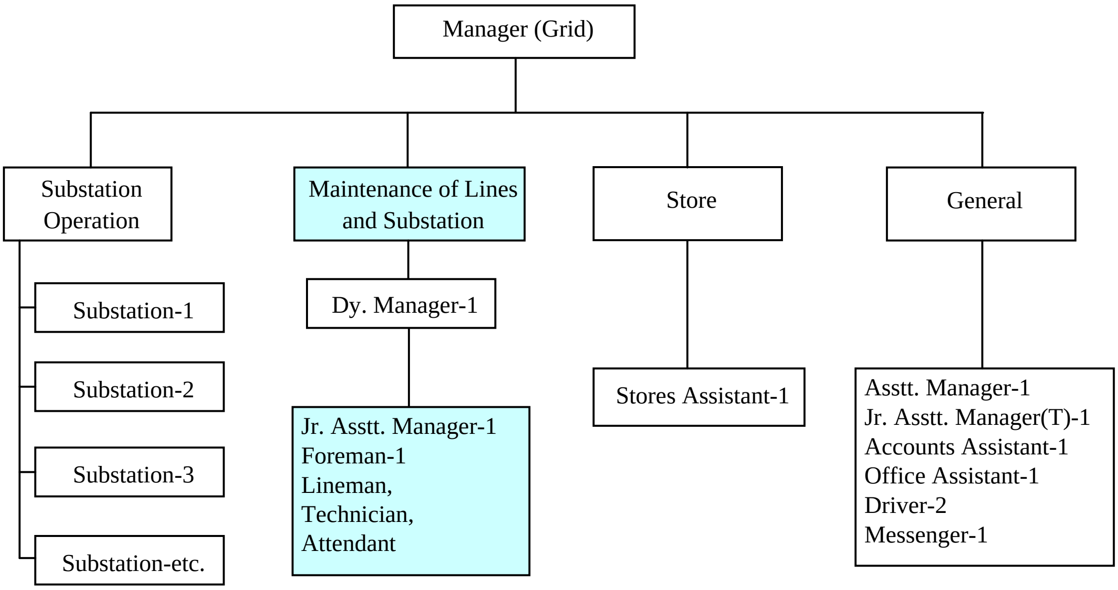
Figure 13.7-1 Organogram of Chittagong GMD

12 - 14 employees are arranged in each substation, and they operate the substation. On the other hand, the maintenance business of the transmission line and the substation is divided into three areas (north, central, and south), and executed in each office.

(2) Maintenance management of the Project (Transmission line part)

The operation and maintenance of the transmission line and switch yard constructed by the Project will be carried out by the Chittagong (South) Manager (Grid) Office which located in Madanaghat substation.

The organization chart of Chittagong (South) Manager (Grid) Office is shown below.



(source: Company Structure of PGCB)

Figure 13.7-2 Organogram of Chittagong (South) Manager (Grid) Office

Maintenance of Lines and Substation Group executes the maintenance business of the transmission line. According to the result of the interview, one Lineman is allocated every 20km of the transmission line. The distance of the transmission line constructed by the Project is about 62km, it is assumed that 3-4 linemen are arranged as a maintenance worker.

PGCB has already owned 2,500km of 230kV transmission lines and also implemented O&M for the line. Besides that, PGCB has much experience of O&M for ultra-high power transmission. For this project, the proposed transmission line is 400kV which is one level higher than the others. It is possible for PGCB to implement the same O&M work as that of 230kV because it does not mean that the technical level is also much higher.

13.8 Implementation, Operation and Maintenance of Access Road

13.8.1 Implementation agency

(1) Overview of RHD

The Roads and Highways Department (RHD) was created in 1962 when the old Construction & Building (C&B) organization was split into 2 separate bodies (the other being Public Works Department). RHD is responsible for the construction and the maintenance of the major road and bridge network of Bangladesh. Since the Department was established the size of the major road network in Bangladesh has grown from 2,500 km to the present network of 20,866.36 km.

The RHD is headed by a Chief Engineer who is supported by a number of Additional Chief Engineers. The total number of posts in the Department is almost 20,000.

RHD has a sustainable capacity to plan, manage and deliver its full range of responsibilities in respect of the main road and bridge network and to be accountable for these duties.

(2) Organization Chart of The Staff of RHD

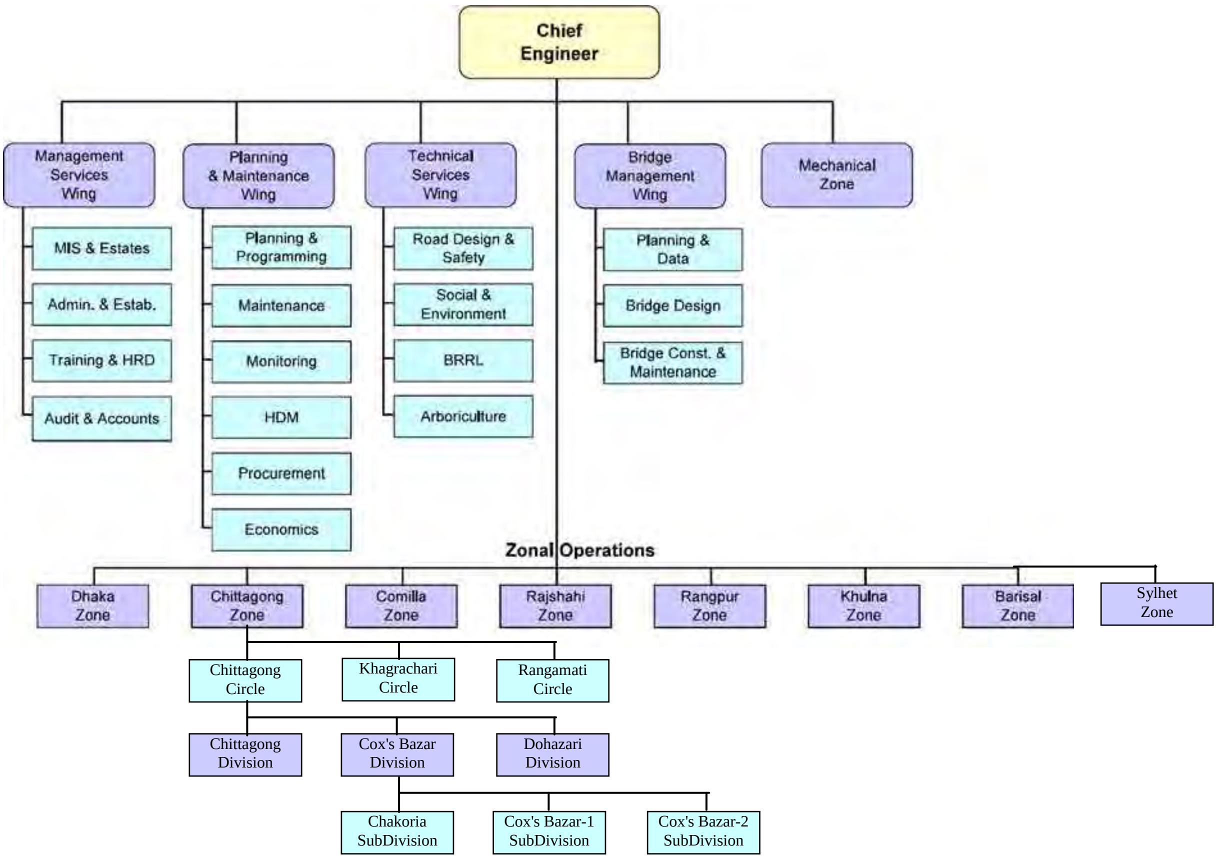


Figure 13.8-1 Organogram of RHD

(3) Technical Ability of Engineer

It may be mentioned that nearly all Engineers in different positions have been undergone training in almost all technical and management, procurement laboratory quality control, Structural design, Information Technology, Geographical Information System (GIS)

Geographical Positioning System (GPS) in different times. A training unit in RHD is giving training in above fields as per training schedule for a period of one to two weeks.

The Government of Bangladesh also allows nominated Engineers to undergo training in overseas Countries. As such almost every RHD engineer are quite efficient in discharging their duties.

(4) Relation Between Headquarters and Regional District Offices

Relation between headquarters and regional district offices are excellent. The respective executive engineer are directly responsible to superintending engineer of the region who is responsible to additional chief engineer for his overall duties and official work as per rules and regulation of the government. The additional chief engineer is responsible to chief engineer for all official work and duties.

(5) Implementation System for The System

Implementation system for the system of RHD is mentioned as below.

- Carryout Feasibility study & Preliminary design
- Choose best option from the alternatives
- Preparation of Final design
- Approval of Development Project Proposal (DPP)
- Establishment for PIU(Project Implementation Unit)
- Start project implementation phase
- Monitoring during project implementation
- Evaluation after project implementation.

(6) Budgets and Expenses (for the last 5 years)

Annual maintenance budget of RHD is as shown in Table 13.8-1. Annual maintenance budget for Access Road is 1) Recurrent BDT 5.0 million and 2) Periodic BDT 150 million/5-7 year/36.2 km. Thus required budget for maintaining the Access Road is fully provided by RHD's annual maintenance budget.

Table 13.8-1 Amount of Budget and Expenses of RHD

(million Taka)

Budget Type	Item	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Maintenance Budget	Amount of budget application	41140.0	42050.0	40040.0	47450.0	51000.0	-
	Amount of budget approval	6273.7	7175.1	6100.0	6678.0	7049.0	9809.4
	Expenses	6273.7	5301.0	6065.2	6589.7	7017.80	-
Annual Development Program	Amount of budget application	-	-	-	-	-	-
	Amount of budget approval	18522.9	13992.8	23096.7	20636.1	24405.1	30165.8
	Expenses	15270.8	12131.4	19665.7	18425.9	23171.4	-

(7) Current Situation of the Road

1) Pavement ratio length by category

Table 13.8-2 Pavement Ratio Length

(km)

Road category	Paved	Unpaved	Total
National Road	3,531.9	12.16	3544.060
Regional Road	4,193.436	84.63	4278.066
Zilla Road	10,665.93	1,706.94	13654.126
Total	18,391.27	1803.73	21476.25

(source : RMMS database of RHD)

2) Road condition by type of road surface

Table 13.8-3 Road Condition By Type Of Road Surface

(km)

Road condition	Paved	Unpaved	Total
Very Good/Good	2882.965	-	2882.965
Fair	5172.539	-	5172.539
Poor	3109.522	-	3109.522
Bad	1524.074	-	1524.074
Very Bad	296.22	-	296.22
Total	12985.32	-	12985.32

(source : Roughness survey result of the year 2012)

(8) Status for Donor Assistance for Road Sector

Table 13.8-4 Status For Donor Assistance for Road Sector

(Million Taka)

No.	Name of the Project	Name of the donor	Period	Amount
1	Construction of Dapdapia Bridge on Barisal-Patuakhali Road	KUWAIT	1/7/2000 -30/6/2013	3022
2	Construction of Third Karnafuly Bridge	KUWAIT	1/7/2003 -30/6/2013	5900
3	Construction of Shahid Buddhijibi Bridge(3rd Buriganga),2nd Sitalakkha Bridge and Tista Bridge	KUWAIT	1/7/2003 -30/6/2013	3165.3
4	Road Network Improvement & Maintenance Project-2(RNIMP-2)	ADB	1/7/2004 -30/6/2013	9803.4
5	Eastern Bangladesh Bridge Improvement Project (EBBIP)	JICA	1/7/2009 -31/12/2013	11875.5
6	Construction of 3rd Sitalakkha Bridge in Bondar Upazill of Narayanganj.	Saudi Arabia	1/11/2010 -31/12/2013	3776.3
7	Construction of Paira Bridge(Lebukhali Bridge) over Paira River on Barisal-Patuakhali Highway	KUWAIT	1/4/2012 -31/12/2016	4132.9
8	Construction of Three Bridges along with 7th Bangladesh-China Friendship Bridge(Kazirtek Bridge) over Arial Kha River on Madaripur(Mostofapur)-Sariatpur-Chanpur Road.	China	1/5/2012 -3/6/2014	2752.7
9	Greater Dhaka Sustainable Urban transport Project	ADB/AFD	1/12/2012	20398.5

			-1/12/2016	
10	Technical Assistance for Sub-regional road Transport Project Preparatory Facility	ADB	1/7/2010 -30/6/2013	86315
11	Technical Assistance for Road Safety Improvement Program	ADB	1/7/2011 -28/2/2013	51.9
12	SASEC Road Connectivity Project :Improvement of Joydevpur-Chandra-Tangail-Elenga Road (N4) to a 4-lane Highway	ADB	1/4/2013 -31/3/2018	27884.56
13	The Kanchpur,Meghna and Gumti 2nd Bridges Construction & Existing Bridges Rehabilitation Project	JICA	1/4/2013 -31/10/2021	84869.383

(source : RHD)

(9) Road Maintenance Plan

The annual maintenance and rehabilitation needs report illustrates the required investments for maintenance of the whole road network of RHD. The Highway Development and Management (HDM-4) Model (HDM-4 software), mainly an economic tool, has been used to project the total maintenance need of RHD Road network and also to select and prioritize maintenance work on the basis of NPV/Cost ratio. For this purpose, the analysis has been carried out in the two sequences. . Firstly, All roads have been analyzed to assess the overall long-term maintenance need of the RHD road network. The overall maintenance need has been found to be 70,913.82 million taka for the year 2012-2013, 20099.14 million taka for the year 2013-2014, 13322.68 million taka for the year 2014-2015 and 11470.38 million taka for the year 2015-2016 and 10358.24 million taka for the year 2016-2017. It is evident from the analysis that, the investment needs tend to decrease considerably provided that the first year requirements are met fully. So, efforts should be given to maximize the first year maintenance in order to minimize backlogs. Secondly ongoing projects, which are in progress and were not completed before the start of roughness survey, have been excluded from the HDM run to project the immediate maintenance requirement and it has been projected to be 39791.33 million taka. Since the prioritization of projects using NPV/Cost favors the more heavily trafficked roads, zilla roads will not have priority for maintenance and rehabilitation works due to their low traffic volume. So, a separate prioritization process has been adopted for the recovery of zilla roads as suggested by the Road Master Plan.

Recently the Road Fund Board Act has been approved by the parliament. The board will collect fund from 19 different sources including both public and private, and allocate the fund for road maintenance by RHD. The board will be headed by the Secretary, RHD and CEO will be appointed by the government, a chief engineer of RHD will be a board member. The board will approve the annual maintenance program prepared by RHD based on scientific analysis. The relationship between the board and RHD is still not clearly defined in the act. The rules needed to be drafted for the implementation and defining roles of different stake holders.

After completion of the access road, there will be two types of maintenance needed;

a) Recurrent: This is repetitive in nature and will be needed every year (routine). This includes: routine maintenance outside carriageway, patching potholes, crack sealing, edge repair, etc. It will cost around BDT 5.00 million per year.
b) Periodic: this type of maintenance work is needed periodically. Normally 5-7 years after completion of a periodic overlay is needed. The maintenance need is determined by analyzing the road data through HDM analysis. If the road is designed for 20 years it needs at least 2 periodic treatment in its life cycle. A standard overlay of 36.2 km road will be around BDT 150 million as per RHD7s current schedule of rates. As the road will be completed in 2020, price escalation shall be considered.

The road is inspected at least once a year by the HDM circle of the head office to collect road condition and riding quality data. The field office inspects the road regularly to know the condition of the road and performs routine maintenance.

(10) Conclusion

RHD is qualified for the implementation agency because they has much experience, budget and power for the work.

RHD will cooperate with related agency for the project to complete the project successfully.

13.8.2 Organogram of project implementation unit

(1) General

PIU will implement the project on behalf of RHD. PIU office will be established at the project site and the Coordinator's office in Dhaka.

The members of PIU will act as employers' representative and specific job description of each of the position will be defined. This will be a field unit and will report the up to date progress to the headquarters. The staff of PIU Office will be as shown in Table 13.8-5. Staff for the project director office is eight (8), the project manager office is nine (9), the deputy project office is six (6), in total, 23 staff will be posted in the access road project.

Table 13.8-5 Staff of PIU Office

a) Office of the Project Director (Superintending Engineer, RHD)

No.	Name of Post	Grade	No. of post	Remarks
01	Project Director (Superintending Engineer)	04	1	
02	Assistant Engineer	09	1	
03	Accounts officer	09	1	On Deputation
04	Estimator	10	1	
05	Head Assistant	11	1	
06	Computer Operator	13	1	
07	Driver	16	1	
08	MLSS	20	1	
	Sub-Total		8	

b) Office of the Project Manager (Executive Engineer, RHD)

No.	Name of Post	Grade	No. of post	Remarks
01	Project Manager (Executive Engineer)	05	1	
02	Assistant Engineer	09	1	
03	Accountant	10	1	On Deputation
04	Computer Operator	13	1	
05	Senior Accounts Clerk	14	1	
06	Office Assistant	16	1	
07	Driver	16	2	
08	MLSS	20	1	
	Sub-Total		9	

c) Office of the Deputy Project Manager (Sub-Divisional Engineer, RHD)

No.	Name of Post	Grade	No. of post	Remarks
01	Deputy Project Manager (Sub-Divisional Engineer)	6	1	
02	Sub-Assistant Engineer	10	2	
03	Computer Operator	13	1	
04	Driver	16	1	
05	MLSS	20	1	
	Sub-Total		6	
	Total		23	

PIU will be established with RHD staff, but collaboration of BWDB is essential for road construction in Matarbari, because a part of road will be constructed on BWDB embankment in

Matarbari. Accordingly, BWDB will collaborate with RHD for improvement of the embankment and installation of new hydraulic structures such as a regulator and a sluice gate. BWDB personnel will not sit in PIU office, but work closely with PIU in order to ensure effective project implementation. The detailed role sharing between RHD and BWDB shall be stipulated in a Memorandum of Understanding (MOU). MOU will make BWDB as a specialized unit for hydraulic structures such as embankment, regulator, sluice, etc.
The PIU structure and collaboration with BWDB mentioned above is described in Figure 13.8-2.

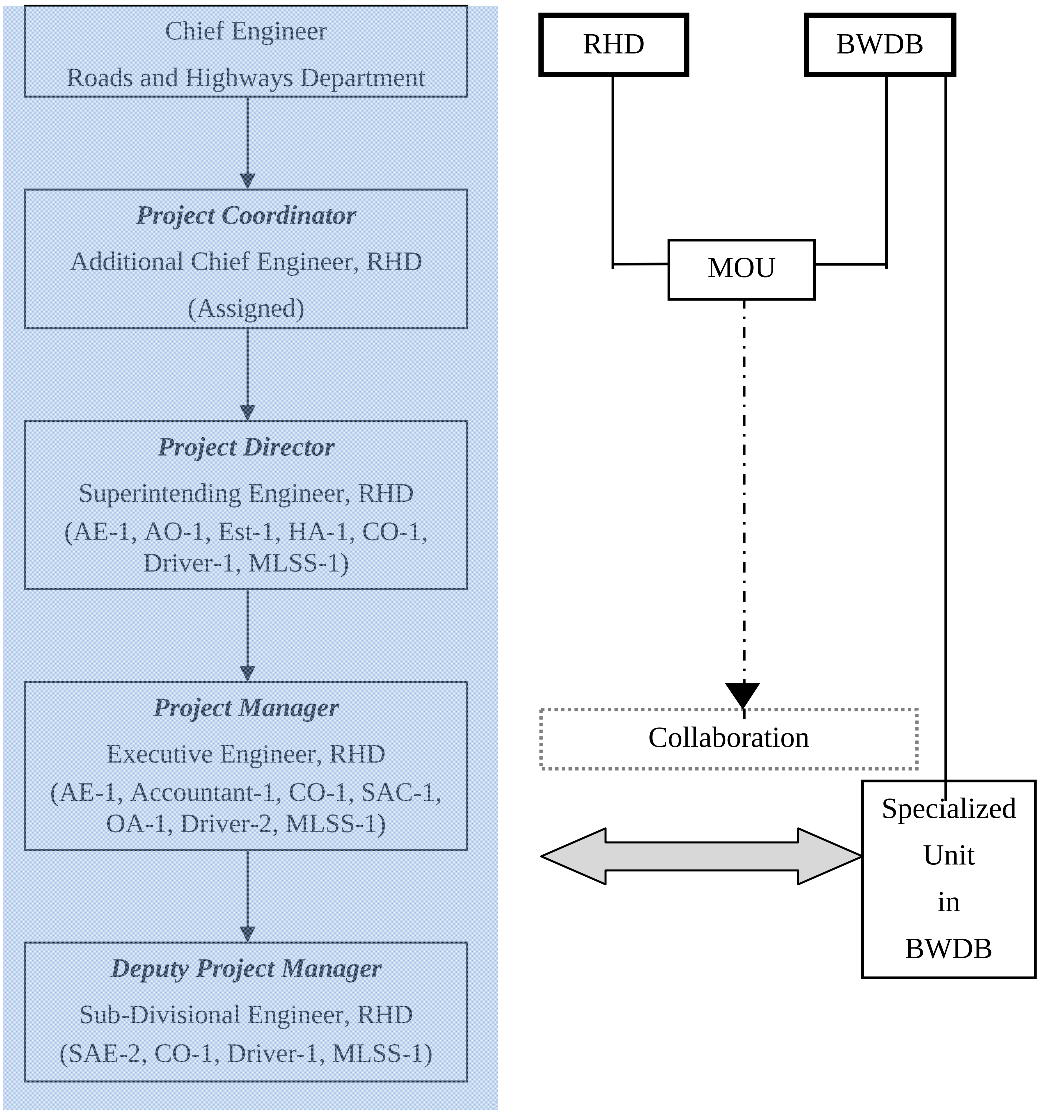


Figure 13.8-2 PIU Structure of Access Road Project

(2) Memorandum of Understanding (MOU)

A Memorandum of Understanding (MOU) which will stipulate role and work scope of RHD and BWDB is in progress. The details of work demarcation become available after finalizing of the MOU.

The assumed demarcation of RHD and BWDB for the road construction on the embankment is as follows.

1) Procurement procedures in design and construction stages

All procurement procedures including road, embankment and hydraulic structures will be conducted by RHD. The procurement documents will be prepared by the Consultant and submitted to RHD. RHD then after scrutiny will send to JICA. The procurement document for BWDB portion also will be prepared by the Consultant and after scrutiny by BWDB, and submitted to RHD by the Consultant. The loan originated fund will not go into BWDB.

2) Design and construction works

RHD will be responsible for the pavement design and construction, and BWDB will be responsible for design and construction of the hydraulic structures. BWDB will certify the designs of hydraulic structures (embankment, slope and sluice etc.) and during construction stage, BWDB will certify measurement and quality of the same in coordination with the Consultant. The Consultant will connect BWDB and PIU.

3) Operation and maintenance

In the operation stage, RHD and BWDB will maintain each related structures by each own budget.

At least once a year, a joint team consisted of RHD and BWDB will meet to review the status of collaboration. If needed, special meeting can be arranged. If for the existence of the road any special initiative is needed, RHD will take the initiative.

13.8.3 Related agencies

(1) Bangladesh Water Development Board (BWDB)

1) Outline of BWDB

The Roads and Highways Department (RHD) was created in 1962 when the old Construction & Building (C&B) organization was split into 2 separate bodies (the other being Public Works
In the year 1954 there was a severe flood in Bangladesh to alleviate the regional damage and loss of food, UN mission was established in the year 1959, then 2002, Pakistan Water and Power Development Board was established.
After the liberation of Bangladesh and under presidential order No. 59, a separate organization namely Bangladesh Water Development Board (BWDB) was established.
On the basis of national water policy rule 1999 and national water management plan 2004 and in consideration of other regulation, BWDB implements projects through direction of planning, maintenance and procurement evaluation.
The main tasks have been assigned by BWDB is divided into two parts:

2) Structural

(a) To control river, levees, canals etc. and to protect all water drainage, irrigation, embankment, regulator and any other structures are constructed.
(b) To protection town or market, historical places and places of National importance
(c) To protect coastal embankment including new construction
(d) To save country side from salinity and draught
(e) And others

(2) Non-structural and related Assignment

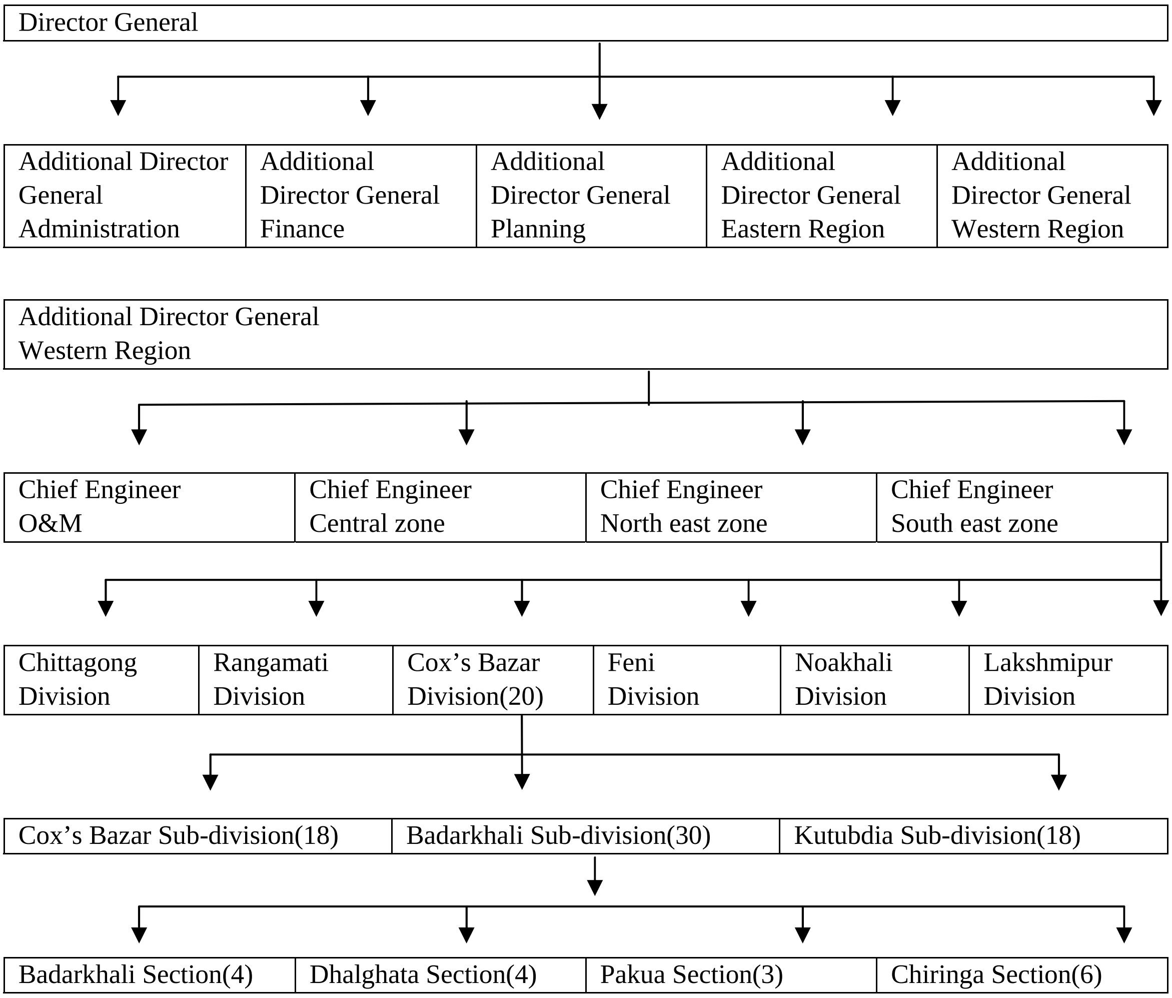
(a) Weather forecasting
(b) Signal for draught and flood
(c) Research regarding water science
(d) Maintenance of environmental development of forestry in own land, fisheries and road over the embankment
(e) Conduct research on the total activity of BWDB

As per set guide line of National Water Management Policing, people's participation have been given maximum emphasize prior to implementation of project. For the project affected persons, special meeting are arranged to review the opinion of the local people and for acquiring technical ability, special training are arranged. There are close ordination between Water Management Organization, Water Management group and Water Management Association and Water Management Federation, BWDB gives extreme emphasize on the water management issue and opinion from local people. There is website for people view and comment i.e. www.bwbd.gov.bd for and people can early send their opinion through email, for long term flood and draught warning system, they have the provision for warning/ forecasting through different media television, radio they forecast flood water in advance. With the air of having technical knowledge and ability BWDB have provision for sending efficient engineers to Foreign Countries.

3) Organization

Total staffs are 6061 persons, head office 1765, field office 4296.

The organization evolution of BWDB can be illustrated as follows;



(Source: BWDB, ( ): Manpower)

Figure 13.8-3 Organogram of BWDB

4) Function

① Office of the Director General

a) Top management of BWDB in fulfillment of the mandate set down in Bangladesh Water Development Board Act and other applicable Laws, Regulations and Policies of the Government.

b) Overall charge of BWDB and all its offices for efficient functioning of the Body.

c) Carrying out responsibility as the Head of BWDB and taking decisions on all essential matters related to its operation.

② Administration Wing

a) Management of matters relating to human resources recruitment, development, assignment and control for conduct of BWDB's business.

b) Management of matters relating to the acquisition of movable and immovable property for conduct of BWDB's business

③ Planning Wing

a) Providing inputs and technical reviews for the preparation of National Level Perspective and the Five Year Development Plans.

b) Micro planning for water resources development consistent with the National Water Policy and within context of the National Water Management Plan (NWMP).

c) Hydrological studies, data collection, management and research.

d) Undertaking activities for formulation and preparation of planning documentation for BWDB projects.

e) Maintaining updated management information related to planning of water sector development.

f) Supporting WARPO and other water sector agencies in the development of efficient water resources management and utilization of plans and updating various Guidelines on water management.

④ Finance Wing

a) Management of matters relating to human resources recruitment, development, assignment and control for conduct of BWDB's business.

b) Management of matters relating to the acquisition of movable and immovable property for conduct of BWDB's business.

⑤ Implementation Wing

a) Management of all financial matters of BWDB including budgeting and disbursement of funds.

b) Administration of financial rules and procedures of BWDB including maintenance of financial discipline and account and audit requirements.

⑥ O&M Wing

a) Preparing and updating of inventory of completed projects containing all basic project information.

b) Operation and maintenance of completed projects over 5000ha as outlined in the NWPO.

c) Providing management guidelines and necessary assistance to local and community organizations and the local governments for O&M of schemes with command area below 5000 ha.

d) Rehabilitation of projects under GOB funding and as directed by the Board from time to time.

e) Transfer of rehabilitated/operating projects of 1000ha or below to the local governments.

f) Water management activities as indicated in the NWPO.

g) All activities under the Food For Works (FFW) programme.

h) Cost recovery, command area development and matters related to participatory water management.

i) Preventive work to forestall damage to water infrastructures due to natural disasters, damage assessment and emergency repairs following natural disasters.

5) Budget Allocation of BWDB

The budget of BWDB is divided into Development and Non development. The development budget is used for implementation of new projects. Non development budget includes salary, office expenses, etc., operation and maintenance, non- development programs, etc.

Table 13.8-6 Budget of BWDB for Past 5 Years

(Million Taka)

FY	Non Development Budget	Development Budget			
		GOB	Donor	Total	Grand total
2007-08	5003.7	6740.6	2592.6	9333.2	14336.9
2008-09	5921.2	5798.3	2906.9	8705.2	14626.4
2009-10	7138.8	7675.8	4805.8	12481.6	19620.4
2010-11	7038.9	10068.0	4327.4	14395.4	21434.3
2011-12	7516.7	11452.7	3898.0	15350.7	22867.4

(Source: BWDB)

6) Project implementation

Recent Success: (as of June 2009)

Number of Completed Projects (709)

On Statement of Irrigation Flood Protection and Water

Coastal embankment- 4530 km

Other embankment – 5694 km

And others

River Bank Protection and Maintenance

- Revetment work-561 km
- And others

7) Management of Flood Disaster

For Management of all cyclones, Flood, tidal waves, and to reduce huge loss due to Flood/ Cyclone disaster, BWDB is engaged for standing order for disaster.

During Flood, all concerned BWDB official are fully engaged and take necessary measures/ steps to reduce the damage done by the flood.

BWDB upkeeps the coastal embankment from cyclone, tidal waves, flail storm and hence general public are protect from abnormal on such of water. There are many cyclone shelters that were constructed with the area of protecting general public and property. Erosion of River bank is another alarming disaster. Protection of towns and river banks has been taken up and presently ongoing.

8) Vision, Mission and Coal

① Vision

National Water Management Policy Planning of Nation Water Management guideline through taking part in this sector and as per rules and regulation of BWDB perfect management of water and development in near future all issue like small water management up to (about 1000 ha) will be handed to local management committee.

Medium and Large project like about 1000 ha and above will be taken up jointly by coordinating with local association. The following will be involved people of all works of life to take part for raising standard of living.

Perfection, responsibility and feedback rule to be complied fully to ensure smooth administration to secure poor people who are homeless due to flood, water surge etc. by providing them shelter etc. To follow all environmental friendly development.

② Mission

a. To take part long lasting development through smooth management of water bodies.
b. To redress all constraints, grievance, and take grievance redress measures due to flood, draught, water stagnation, flow of inter Country River, salinity.
c. To make long lasting development of agriculture, fisheries, forestry to attain economic emancipation ensuring equal opportunity to all genders and to increase knowledge and ability of local people so that they can set up water management plan by themselves.

③ Goal

The main goal of BWDB is to redress the follow issues as per National Water Management Policy.

Poverty Alleviation

To ensure food security
To attain economic sustainability
Develop standard of living
Keep balanced environment

9) Relation between RHD, BWDB and Local Government Engineering Department (LGED)

RHD and BWDB will cooperate for maintenance work for the Access Road of Matarbari side. BWDB will take responsibility for the maintenance for slope protection and embankment of the road. BWDB has much experience, budget and power for the work.

LGED is one of the largest public sector organizations entrusted for planning and implementation of local level rural, urban and small scale water resources infrastructure development programs. LGED works closely with the local stakeholders to ensure people's participation and bottom–up planning in all stages of project implementation cycle. The broad objectives of LGED's development activities are to improve the socio-economic condition of the country through supply of infrastructures at local level and capacity building of the stakeholders. Therefore if need arises and where appropriate, collaboration with LGED shall have a beneficial effect on the project.

(2) Local Government Engineering Department (LGED)

1) Outline of LGED

Local Government Engineering Department (LGED) is one of the largest public sector organizations in Bangladesh entrusted for planning and implementation of local level rural, urban and small scale water resources infrastructure development programs. LGED works closely with the local stakeholders to ensure people's participation and bottom–up planning in all stages of project implementation cycle. The broad objectives of LGED's development activities are to improve the socio-economic condition of the country through supply of infrastructures at local level and capacity building of the stakeholders. LGED promotes labour-based technology to create employment opportunity at local level and uses local materials in construction and maintenance to optimize the project implementation cost with preserving the desired quality. LGED works in a wide range of diversified programs like construction of roads, bridges, culverts, markets to social mobilization and environmental protection. The organizational background of LGED can be traced to implementation of Works Program (WP) comprising Rural Works Program (RWP), Thana Irrigation Program (TIP) and Thana Technical Development Committee (TTDC). A ''Cell'' was established in the Local Government Division (LGD) under the Ministry of Local Government, Rural Development and Cooperative (MLGRD&C) in 1970s. To administer WP national wide, the Works Program Wing (WPW) was created in 1982 under the development budget. It was reformed into the Local

Government Engineering Bureau (LGEB) under revenue budget of the Government in October, 1984. LGEB was upgraded as the Local Government Engineering Department (LGED) in August, 1992.

2) Organization

The organization evolution of LGED can be illustrated in Figure 13.8-4.

Chief Engineer

Additional Chief Engineer						
Maintenance Asset Management	Urban Management	Implementation	Planning & Design	IWRM	Dhaka Division	Rajshahi Division

Superintendent Engineer					
Training Unit	Quality Control Unit	Maintenance	Urban Management	Project Monitoring & Evaluation	ICT Unit

Superintendent Engineer					
Design Unit	Planning Unit	Procurement Unit	Building & Road Design Section	WR O&M Unit	WR Planning & Design

Executive Engineer				
Maintenance	Road safety	City Corporation	District Pourashava	Upazilla Pourashava

Executive Engineer				
Monitoring & Evaluation	ICT Section	Bridge Design Section	Planning	Procurement Section

LGED Regions: (Manpower: 108)

Superintendent						
Rangpur Circle	Rajshahi Circle	Khulna Circle	Faridpur Circle	Barisal Circle	Dhaka Circle	Mymensingh Circle

Superintendent						
Sylhet Circle	Comilla Circle	Chittagong Circle	Patuakhali Circle	Jessore Circle	Dinajpur Circle	Bogra Circle

LGED District Level: (Manpower: 1026)

64 Executive Engineer (64 District)

LGED Upazilla Level: (Manpower: 9188)

484 Upazilla Engineer (484 Upazilla)

Figure 13.8-4 The Organization Evolution of LGED

3) Organization chart of LGED Cox's Bazar

Table 13.8-7 Organization of LGED Cox's Bazar

(This table has been removed because of confidential information.)

4) Technical ability of engineer

It may be mentioned that nearly all engineers in different positions have been undergone training in almost all technical and management, procurement, laboratory quality control, structural design, information technology, geographical information system (GIS), geographical positioning system (GPS) in different times. A training unit in LGED is giving training in above fields as per training schedule for a period of one to two weeks .The Government of Bangladesh also allows nominated engineers to undergo training in overseas countries. As such almost every LGED engineers are quite efficient in discharging their duties.

5) Relation between headquarters and regional district offices

The relationship between headquarters and regional district offices is excellent. The Executive Engineer is responsible for his official duties to Superintendent Engineer. Superintendent Engineer is responsible to Additional Chief Engineer who submits all reports, proposals, etc. to Chief Engineer for approval. Any violation, misdeeds thereof is strictly dealt with overall administration of LGED office. Chief Engineer is empowered to run all LGED offices as per Government rules and regulation.

6) Budget (for the last 5 years)

Table 13.8-8 Annual Budget Past 5 Years

(Million Taka)

Item	2008	2009	2010	2011	2012
Amount of budget application	400	450	500	220	250
Amount of budget finality approval	400	450	500	220	250
National funds	100	120	150	200	230
Road Fund	320	350	400	180	200
Donor country funds etc.	300	330	350	20	20
Others					

(Source: LGED)

7) Project Management Unit (PMU)

The Project Management Unit headed by the project director consists of offices like Executive Engineer / Assistant Engineer / Sub Assistant Engineer / Estimator/ Computer operator, Photocopier etc.

8) Maintenance Unit of LGED

Local Government Engineering Department (LGED) runs a maintenance unit since long time with the aim of addressing repair and maintenance for affected damaged rural roads, embankments, LGED Head Quarter Building, culverts, sluice gates, river boat landing stations, market, schools, and slope protection in every year. These maintenance plays are vital role in keeping all infrastructure of LGED and assuring smooth functioning of these valuable properties. Usually these maintenance programs are taken up for short and long term. In case of natural disaster like cyclone, tidal wave action, severe floods damaging all such infrastructures a prioritized maintenance program is taken up on emergency basis to rapidly restore these damaged infrastructures. All maintenance activities are carried out of allocated fund only to restore all civil works. So the importance of maintenance unit cannot be overemphasized.
The Government has been allocating all maintenance project budget, fund under revenue budget for the maintenance of all existing LGED infrastructure since 1992-93, and gradually increasing the maintenance fund in considering importance and service to the beneficiaries.

① Allocation of Budget and Expenditure

Most of the maintenance allocation is earmarked for maintenance of rural/regional road, bridge, culvert, slope protection, growth center, market, school, building, union Parishad building, cause way, etc. In the year 2011-2012 the government has allocated an amount of 630.70 crore TAKA for maintenance of roads, bridges, approach roads, slopes, markets, school, building the amount being 4.8 % higher than the last year.

Table 13.8-9 Statement Of Annual Maintenance Cost (For The Year 2011-12)

No	Name of Main Components	Quantity	Financial Expenditure (Crore Tk)	Remarks
1.	Regular Road maintenance	19500 km	81.68	
2.	Continual Road maintenance	5207 km	486.32	
3.	Maintenance of Bridge and Culvert	11400 km	57.00	
4.	Small scale Water Management Infrastructure	43350 ha	5.75	

(Source: LGED)

9) Current Situation of the Road and Bridges under Cox's Bazar LGED

Current pavement ratio based on the road categories are as follows;

Table 13.8-10 Pavement Ratio Based On The Road Category

Surface Type / Road Category	Paved (Km)	Unpaved (Km)	Total (Km)
National Road /Upzilla Road	311	97	408
Feeder /Regional road etc/Union road	322	222	544
Village Road	624	2617	3241
Total	1257	2936	4193

(Source: LGED)

Current road condition at each type of road surface as follows;

Table 13.8-11 Road Condition At Each Type Of Road Surface

Surface Type / Road Condition	Paved (Km)	Unpaved (Km)	Total (Km)
Very Good	850	400	1250
Good	320	1080	1400
Fair	50	1100	1150
Bad	30	270	300
Very bad	7	86	93
Total	1257	2936	4193

(Source: LGED)

10) Relation between RHD and LGED

LGED has formally announced to cooperate with RHD for the project to complete the project successfully.

Chapter 14

Economic and Financial Analysis

Chapter 14 Economic and Financial Analysis

The Project is to be assessed by calculating the economic internal rate of return to determine economic viability and the financial internal rate of return to determine financial viability. The following are the major areas that will be analyzed in order for the JICA Study Team to determine the final evaluation and assessment.

14.1 Project Costs

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14.1.1 Basic calculation method

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14.1.2 Construction costs of the project

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14.1.3 Estimation of construction costs

＜Blank＞

14.2 Financial and Economic Evaluation

＜Blank＞

14.2.1 Basic assumptions

＜Blank＞

14.2.2 Financial simulation

＜Blank＞

14.3 Financial Evaluation

＜Blank＞

14.3.1 Methodology of evaluation and basic parameters

＜Blank＞

14.3.2 Financial cost

＜Blank＞

14.3.3 Financial benefit

＜Blank＞

14.3.4 FIRRs

＜Blank＞

14.3.5 Sensitivity analysis

＜Blank＞

14.3.6 Conclusion and recommendation

＜Blank＞

14.4 Economic Evaluation

＜Blank＞

14.4.1 Methodology of evaluation and basic parameters

＜Blank＞

14.4.2 Economic costs

＜Blank＞

14.4.3 Economic benefits

＜Blank＞

14.4.4 Economic analysis

＜Blank＞

14.4.5 Sensitivity analysis

＜Blank＞

14.5 Key Performance Indicators

14.5.1 Quantitative effect

The following operation and effect indicators shall be set for monitoring the power plant performance, supervising the management of operations and maintenance as well as verifying the effects of the Project. The indicators are set based on the "Operational and Effect Indicators Reference 2nd Edition" (JBIC, October, 2001).

Table 14.5-1 Operational and Effect Indicators

Indicators	Unit	Base Line	Target	Remark
Generation Plant				
[Operation Indicators]				
1. Maximum Output	MW/unit	N/A	600	・At generator terminal
2. Plant Factor	%	N/A	80	・Defined as following: Power Factor = Annual generation power (MWh) / {Maximum Output (MW) x 8,760 (h/yr)} x 100 (%) ・80% is predicted as a base load plant
3. Availability Factor	%	N/A	85	・Defined as following: Availability Factor = Annual operation hours (h/yr) /8,760 (h/yr) x 100 (%) = {8,760 (h/yr) – Outage Hours (h/yr)} / 8,760(h/yr) x 100 (%) ・85% is predicted as a base load plant.
4. Auxiliary Consumption Ratio	%	N/A	6.48	・Defined as following: Auxiliary consumption rate = Auxiliary power consumption (MW) / Generation Output (MW) x 100 (%) ・6.48% is estimated based on the fuel and steam cycle conditions for the Project.
5. Gross Thermal Efficiency	%	N/A	41.29	・Defined as following: Gross thermal efficiency =

Indicators	Unit	Base Line	Target	Remark
				Generation power (kW) x Conversion factor (kcal/kWh) / {Fuel Higher Heating Value (kcal/kg) x Fuel consumption (kg/h)} 100 (%) =Steam turbine thermal efficiency (%) x Boiler thermal efficiency (%) / 100 (%) ・Thermal efficiencies of steam turbine and boiler are estimated as 47.46% and 87.00% based on the fuel and steam cycle conditions for the Project.
6. Outage Hours	hours/yr	N/A	Not more than 1,314	・Predicted as a base load unit. ・If a breakdown has to be made, it is as following: ・Human Error: 0 ・Machine Trouble: 2.5% (9 days) ・Periodic Overhaul: 12.3% (45 days) ・Total: 15.0% (54.7 days)
7. Outage Times	times/yr	N/A	Not more than 10	・Normally a few times a year for a base load unit and in consideration of simple inspection & cleaning of condenser tubes during weekend at the time of low power demand in every few months, most unlikely to exceed 10.
[Effect Indicator]				
8. Net Energy Production	GWh/yr	N/A	7,865	・Calculated from the item Nos. 1 and 2 above as following: Net Energy Production (GWh/yr) = Maximum output (MW) x {1 - Auxiliary consumption ratio (%)/100(%)} x 8760 (h/yr) x Plant factor (%) / 100(%) /1000 (GW/MW)
[Environmental Effect Indicator]				
CO2 emission	Thousand Tons per unit & per yr	N/A	3,416	・Calculated based on the above operation indicators, and coal properties and pollutant concentrations in flue gas as

Indicators	Unit	Base Line	Target	Remark
NOx emission	Thousand Tons per unit & per yr		6.1	follows: HHV: 4,700kcal/kg Carbon in coal:50.0%, NO_x: 460mg/Nm^3 SOx: 820mg/Nm^3 Particulate Matter: 50mg/Nm^3 (at dry, 6%O_2) ・CO_2 emission is calculated by following formula: CO_2 emission (t/yr) = Annual coal consumption (kg/yr) x Fuel carbon contents (%) / 100(%) x (44.010/12.011) , 44.010 and 12.011 is the molecular weights of CO_2 and carbon respectively. ・The emission of the pollutants such as NOx, SOx and particulate matter are calculated as following: Pollutant emission (t/yr) = Pollutant concentration (mg/Nm^3, dry, 6%O_2) x (20.95 - O_2%) / (20.95-6.0%) x Flue gas flow at Maximum output (Nm^3/h, dry and actual O_2%) x 8760 h/yr x Plant factor (%) / 100 (%) ・The actual O_2 content in flue gas is predicted as 3.89%, and the dry flue gas flow rate is derived as 1,660,400 Nm^3/h from the combustion calculation.
SOx emission	Thousand Tons per unit & per yr	N/A	10.9	
Particulate Matter	Thousand Tons per unit & per yr	N/A	0.7	
Fuel Consumption		N/A	1,863	
B-Transmission Lines				
[Operation Indicators]				
1 Transmission Loss	%	N/A	0.4	・T/L length: 61.5km ・Resistance per circuit: 1.0904ohm/circuit ・Power output of transmission end: 600MW/circuit ・Power current of transmission end: 866A/circuit = 600MW/($\sqrt{3}$ X 400kV) ・Resistance: 312R 866 X 866 X 1.0904 X 3 circuits =2.45MW/circuit ・Expected transmission loss factor: 2.45/600 = 0.4%

Indicators	Unit	Base Line	Target	Remark
C-Port & Harbor				
[Operation Indicators]				
Berth Occupancy Ratio	%	N/A	60	・Good balance value between cost and performance of the facility
Total Cargoes	Million tons	N/A	400	・50 coal vessels X 80,000 ton
Total Gross Tonnage	Million tons	N/A	400	・50 coal vessels X 80,000 ton
Dredged Amount	Cubic meters	N/A	360,000	・By simulation of sediment transport
D Access Road				
[Operation Indicators]				
Traffic volume related to the Power Plant	No. of vehicles by category / month	N/A	To be determined	
Traffic volume at the new bridge	No. of vehicles by category / month	N/A	To be determined	
[Effect Indicator]				
1. Traffic volume related to the Power Plant	No. of vehicles by category / month	N/A	To be determined	
2. Traffic volume at the new bridge	No. of vehicles by category / month	N/A	To be determined	
3. Traffic volume during the rainy season	No. of vehicles by category / month	N/A	To be determined	
4. Increase in traffic volume thru the new bridge and Matarbari Bridge	No. of vehicles by category / month	N/A	To be determined	*Traffic count survey at the two bridges is required

(Source: JICA Study Team)

The target of each indicator is set based on the international experience of the JICA Study Team. The target values of the indicators shall be initially set according to the minimum requirements. While monitoring will be conducted periodically, the target values will be reviewed and revised in order to attain the final goal.