People's Republic of Bangladesh
Power Grid Company of Bangladesh Limited (PGCB)

People's Republic of Bangladesh
Preparatory Survey on
Dhaka - Chittagong Main Power Grid Strengthening Project

Final Report

BOOK-1
Main Report

September 2015

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company
Tokyo Electric Power Services Co., Ltd.

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Abbreviations

Abbreviation	Word
AAAC	All Aluminum Alloy Conductor
ABT	Availability Based Tariff
AC	Alternate Current
AC	Aluminum-Clad Core
ACSR	Aluminum Conductor Steel Reinforced
ADB	Asian Development Bank
ADP	Annual Development Plan
AE	Assistant Engineer
AFC	Automatic Frequency Control
AGC	Automatic Generation Control
Ah	Ampere hour
AIS	Air Insulated Switchgear
ALDC	Areal Load Dispatch Centers
AM	Assistant Manager
BDT (tk)	Bangladesh Taka
BERC	Bangladesh Energy Regulatory Commission
BFD	Bangladesh Forest Department
BFIDC	Bangladesh Forest Industries Development Corporation
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electricity Board
BSS/B. Com.	Bachelor of Social Science, Bachelor of Commerce
BWDB	Bangladesh Water Development Board
CCL	Cash Compensation under Law
CCPP (CC)	Combined Cycle Power Plant
CDM	Clean Development Mechanism
CE	Chief Engineer
CFPP	Coal Fired Power Plant
CHT	Chittagong Hill Tracts
CIF	Cost, insurance and freight
CIGRE	Conseil International des Grands Réseaux Électriques International Council for Large Electric Systems (English)
C/P	Counterpart
CO_2	Carbon Dioxide
COD	Commercial Operation Date
CPGCBL	Coal Power Generation Company Bangladesh Limited
CPU	Central Processing Unit
CR	Critically Endangered
DAM	Department of Agricaltural Marketing
DB	Database
dBA	A-weighted decibel
DC	Deputy Commissioner
DC	Direct Current
DESCO	Dhaka Electric Supply Company
DGM	Deputy General Manager
DM	Deputy Manager
DOE	Department of Environment
DOF	Department of Fisheries
DPP	Development Project Proposal

DPDC	Dhaka Power Distribution Company Limited
DSM	Demand Side Management
ECA	Ecologically Critical Area
ECC	Environmental Clearance Certificate
ECNEC	Executive Committee of the National Economic Council
ECR	Environmental Conservation Rules
EDC	Economic Dispatch Control
EDS	Every Day Stress
EE	Executive Engineer
EGCB	Electricity Generation Company of Bangladesh
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rates of Return
ELD	Economic Load Dispatch
EMaP	Environment Management Plan
EMoP	Environmental Monitoring Plan
EMS	Energy Management System
EN	Endangered
EPCB	Environmental Pollution Control Board
FC	Foreign Currency
FD	Finance Division
FGD	Focus Group Discussion
FIRR	Financial Internal Rates of Return
FO	Fosil Oil
F/S	Feasibility Study
FY	Financial Year
GCB	Gas Circuit Breaker
GDP	Gross Domestic Product
GEF	Grid Emmision Factor
GHG	Greenhouse Gas
GIB	Gas Insulated Bus-bar
GIS	Gas Insulated Switchgear
GOB	Government of Bangladesh
GOJ	Government of Japan
GPRS	General Packet Radio Service
GRC	Grievance Redress Committees
GSW	Galvanized Steel Wire
GT	Gas Turbine
GWL	Ground Water Level
ha	hectare
HFO	Heavy Fuel Oil
H-GIS	Hybrid Gas Insulated Switchgear
H.S.C.	Higher Secondary Certificate
HSD	High Speed Diesel
HQ	Headquaters
HW	Hardware
Hz	Hertz
ICB	International Competitive Bidding
IEC	International Electrotechnical Commission
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IKL	IsoKeraunic Level

IMF	International Monetary Fund
IPP	Independent Power Producer
IPCC	Intergovernmental Panel on Climate Change
IT	InformationTechnology
IUCN	International Union for Conservation of Nature and Natural Resources
JAM	Junior Assistant Manager
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
kA	Kilo-Amperes
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hours
LAO	Land Acquisition Officer
LC	Local Currency
LFC	Load Frequency Control
LILO	Line In Line Out
LIWV	Lightning Impulse Withstand Voltage
LL-ACSR	Low Loss Aluminum Conductor Steel Reinforced
LNG	Liquefied Natural Gas
M.B.B.S.	Bachelor of Medicine, Bachelor of Surgery
MCM	Milli-Circular-Mil
MIS	Management and Information System
MOEF	Ministry of Environment and Forests
M/P	Master Plan
MPEMR	Ministry of Power, Energy and Mineral Resources
M.S.C.	Master of Science
MVA	Mega Volt-Ampere
MW	Mega Watt
N/A	Not Applicable
NEMAP	National Environment Management Action Plan
NGO	Non Governmental Organization
NLDC	National Load Despatch Center
NO	Not Threatened
NOx	Nitrogen Oxides
O&M	Operation and Maintenance
ODA	Official Development Assistance
OPGW	Optical Fiber Composite Overhead Ground Wire
PAP	Project Affected Person
PAX	Private Automatic Exchange
PBS	Pally Bidyut Samities (English: Rural Electric Society)
PC	Power Cell
PD	Power Division
PDH	Plesiochronous Digital Hierarchy
PGCB	Power Grid Company of Bangladesh Limited
PIU	Project Implementation Unit
PLC	Power Line Communication
PMU	Phasor Measurement Unit
PP	Power Plant
PPA	Power Purchase Agreement
PS (P/S)	Power Station

PSS	Power System Stabilizer
PSS/E	Power System Simulator for Engineering
PSMP2010	Power System Master Plan 2010
PWD	Public Works Department
P&D	Planning and Designing
ROW	Right of Way
RPCL	Rural Power Company Limited
RS	Resource Scheduling
RTU	Remote Terminal Unit
RUS	Rated Ultimate Strength
RV	Replacement Value
R&D	Research and Development
SAE	Sub Assistant Engineer
SCADA	Supervisory Control and Data Acquisition
SCC	Site Clearance Certificate
SCF	Standard Conversion Factor
SDE	Sub Divisional Engineer
SDH	Synchronous Digital Hierarchy
SIE	Super-Intending Engineer
SIPP	Small Independent Power Plant
SIWV	Switching Impulse Withstand Voltage
SLA	Subsidiary Loan Agreement
SOx	Sulfur Oxide
SPS	Stand-alone Power Station
SS (S/S)	Substation
S.S.C.	Secondary School Certificate
ST	Steam Turbine
STM	Synchronous Transport Module
SPT	Standard Penetration Test
TEPCO	Tokyo Electric Power Company
T/L	Transmission Line
TM	Telemetry
TOR	Terms of Reference
UFR	Under Frequency Relay
UGS	Ultra-High Strength Galvanized Steel Wire
UNO	Upazila Nirbahi Officer
USD	United States Dollar
UTS	Ultimate Tensile Strength
VCS	Verified Carbon Standard
VPN	Virtual Private Network
VQC	Voltage Reactive Power Control
WACC	Weighted Average Cost of Capital
WB	World Bank
WTP	Willingness To Pay
WZPDCL	West Zone Power Distribution Company Limited
XLPE	Cross Linked Polyethylene
3LGO	Three Phase Line Grounding and Opening

Chapter 1
Introduction

Chapter 1 Introduction

1.1 Background of the Survey

In the "Master Plan of Coal Thermal Plants (2010)", the Government of Bangladesh (GOB) has formulated a plan for the construction of a port fronting the deep sea area in and around Chittagong for importing fuels such as liquid natural gases or coals and the installation of power plants utilizing their fuels. The future expansion of power generation is predicted, causing issues about the enhancement of the power transmission capacities with high voltage between Chittagong and Dhaka for stable power transmission to Dhaka, which has high electric power demand. The functions of the installed National Load Dispatching Center (NLDC) are not well utilized, causing difficulties with maintaining a stable electric power supply. The improvement of its functions is urgently needed. In response to this situation, the Japan International Cooperation Agency (JICA) agreed with the GOB through discussions to have the feasibility study regarding 4123the high voltage transmission lines between Dhaka and Chittagong.

1.2 Outline of the Project

The outline of the Project is as below.

Name of the Project	Dhaka – Chittagong Main Power Grid Strengthening Project
The Purpose Of The Project	To contribute to the stable power supply in Bangladesh for its economic growth and climate change mitigation by constructing high voltage power transmission lines between Dhaka and Chittagong and rehabilitating its central load dispatching center.
Outline of the Project	Construction of 400 Kilovolt (kV) transmission line (between Dhaka and Chittagong) Expansion of 400 kV / 230 kV substations Construction of 230 kV / 132 kV substations Construction of 230 kV and 132 kV transmission lines Rehabilitation of the Central Load Dispatching Center Their related facilities including access roads Consulting Services (detailed design, support for bidding, or construction supervision, etc.)
Target Areas	Dhaka district and Chittagong district
Executing Agency	Power Grid Company of Bangladesh Limited (PGCB)

The proposed scope was formulated as shown in the next page through the course of the study based on the evaluation of its power system reliability, necessity of power transmission capability and economic viability. The entire project is composed of the following components.

Phase I
- 400 kV Meghnaghat – Madunaghat Transmission Line
- 230 kV Meghnaghat Subtation bay extension
- 230 kV Madunaghat Switching Station
- Line in line out (LILO) from 230 kV Hathazari – Sikalbaha Transmission Line

Phase II
- 400 kV Madunaghat – Matarbari Transmission Line
- 400 kV Meghnaghat Substation
- New 400 kV Madunaghat Substation
- 230 kV double circuit transmission line between Existing Madunaghat and New Madunaghat SS.
- Upgrade of Existing 132 kV Madunaghat SS to a 230 kV SS

Among the abovementioned components, Phase I is better to be operated at the earlier stage of the Project's implementation to transmit the power from Dhaka to Chittagong when the large scaled power plants such as Matarbari or Moheskhali would not yet have been in operation.

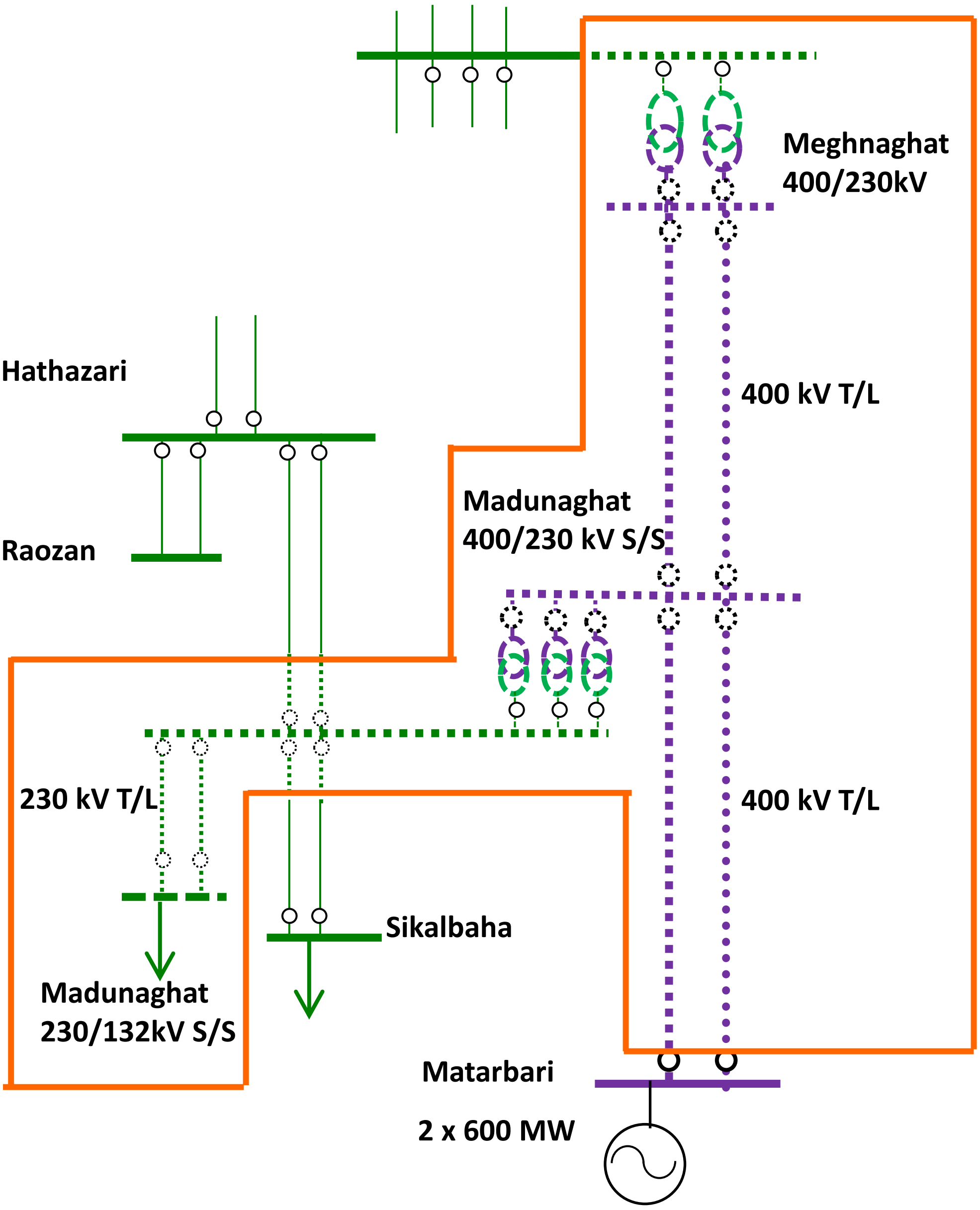


Figure 1.2-1 Scope of the Project

1.3 Tasks of the Survey

The tasks of the Survey are shown in the following table. The Survey starts from the beginning of April 2014 and the final report will be submitted at the end of February 2015.

	Tasks	8.	Examination of Application of Japanese Technology
1.	Confirmation of Background and Objectives	9.	Preparation of Invitation of Counterparts (C/Ps) for Seminar and Training in Japan
2.	Study of the Current Conditions of the Target System and Its Existing Facilities	10.	Support of Approval Procedure of the Project in the Government of Bangladesh
3.	Selecting the Optimal Plans	R1	Inception Report (Beginning of April 2014)
4.	Study of the Natural Conditions by Measurement and Geological Surveys	R2	Progress Report (Middle of June 2014)
5.	Facility Design	R3	Interim Report (Middle of September)
6.	Social and Environmental Considerations	R4	Draft Final Report (Middle of November 2014)
7.	Description of Project Outline	R5	Final Report (End of February 2015)

1.4 Technical Transfer

1.4.1 Counterpart (C/P) Training in Japan

The C/P training in Japan was held from 13th to 24th June 2014. The purpose is to strengthen PGCB’s implementation capabilities regarding 400 kV Low Loss Transmission Lines, substations, and Load Dispatching Center.

The program of the seminar is shown below.

	Date	Program	Site
1	June 14th (Sat)	Departure from Bangladesh (Dhaka)	- Flight: TG322 (13:35)
2	June 15th (Sun)	Arrival in Tokyo, Japan (Narita)	- Flight: TG640 (08:10)
3	June 16th (Mon)	- Kick-off meeting - Visit to 500 kV Underground SS - Courtesy Call on JICA Headquaters (HQ)	- TEPCO HQ - TEPCO 500 kV Shin-Toyosu Substation - JICA HQ
4	June 17th (Tue)	- Visit to LL Conductor Manufacturer	- J-Power Systems
5	June 18th (Wed)	- Visit to 500 kV SS&500 kV OH Transmission Line (T/L) - Visit to Central Load Dispatching Center - Move to Nagoya	- TEPCO 500 kV Shin-Tama Substation - Central Load Dispatching Office of TEPCO - Nozomi 243
6	June 19th (Thu)	- Visit to Insulator Manufacturer - Visit to LL Conductor Manufacturer - Move to Sendai	- NGK Nagoya Factory - VISCAS Numazu Factory - Kodama664, Yamabiko155
7	June 20th (Fri)	- Visit to LL T/L site, 500 kV-GIS SS, and CLDC	- Tohoku Electric Power Company
8	June 21st (Sat)	- Move to Utsunomiya - Visit to T/L Testing Site - Move to Tokyo	- Yamabiko 210 - VISCAS Nikko Testing Site - Bus
9	June 22nd (Sun)		
10	June 23rd (Mon)	- Visit to SS Equipment Manufacturer - Visit to Thermal Power Plant - Wrap-up meeting	- TOSHIBA Hamakawasaki Manufacturer - Thermal Power Plant of TEPCO - Same as above
11	June 24th (Tue)	Transfer to Bangladesh (Haneda, 23rd midnight)	- Flight: TG661(00:20)-TG321(12:10)

1.4.2 Technical Seminar in Bangladesh

The technical Seminar was held on 5th November in Dhaka. Its invited manufacturers explained Low-Loss type Conductors, Switch Gear, Out-door GIS, Insulators, and other related technologies.

The program of the technical seminar is shown below.

Agenda

<5th November>

9:00-9:20	Registration
9:20-9:30	Opening Address from the PGCB Executive Director, Mr.Chowdhury Alamgir Hossain
9:30-9:40	Greetings from the PGCB Project Director, Mr. Yeakub Elahi Chowdhury
9:40-10:00	Mr. Kei Toyama, Senior Representative, JICA Bangladesh Office JICA Project Introductions
10:00-10:40	Presentation of EHV SS Equipment by HITACHI (Including Q&A)
10:40-10:45	5 min break, changing companies to VISCAS
10:45-11:25	Presentation of Low Loss Conductor by VISCAS (Including Q&A)
11:25-11:30	5 min break, changing companies to TOSHIBA
11:30-12:10	Presentation on EHV SS Equipment by TOSHIBA (Including Q&A)
12:10-12:20	10 min break, changing companies SUMITOMO Electric Industries (JPS)
12:20-13:00	Presentation on Low Loss Conductor by JPS (Including Q&A)
13:00-14:00	Praying and LUNCH BREAK
14:00-14:10	Preparation for the afternoon session
14:10-14:50	Presentation on EHV Substation Equipment by Mitsubishi Electric (including Q&A)
14:50-15:00	10min break, changing companies to NGK Insulator
15:00-15:40	Presentation of Insulator by NGK Insulator (Including Q&A)
15:40-16:00	Closing Address from Executive Director, Chowdhury Alamgir Hossain
16:00-17:30	All companies meeting with MD/ED/PD for 15 min each at JICA Bangladesh Office

Chapter 2

Present Situation

of

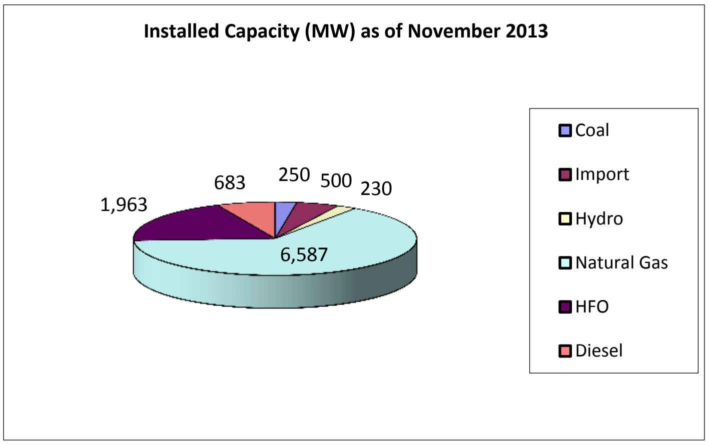
the Power Sector in Bangladesh

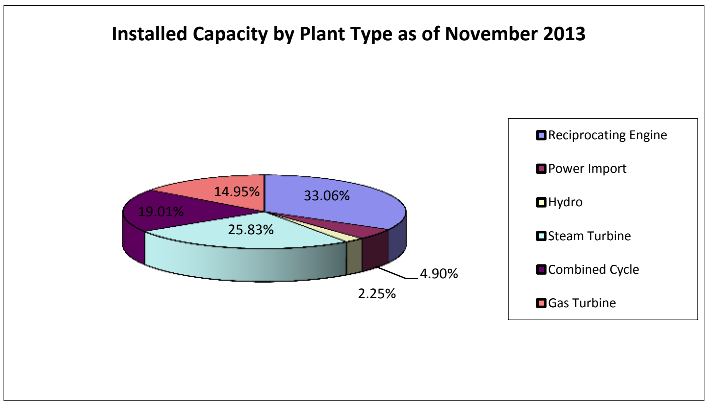
Chapter 2 Present Situation of the Power Sector in Bangladesh

2.1 Overview of the Power Sector in Bangladesh

2.1.1 Generation, Transmission and Distribution

The Power Sector in Bangladesh has undergone tremendous growth since the independence of the country in 1972. At that time the installed capacity was only 200 MW, but it grew to a total of 10,213 MW as of November 2013. Out of this, 58% is managed by the public sector, the remaining 42% by the private sector. Approximately 2,300 MW of Heavy Fuel Oil (HFO) and diesel generation capacity has come on-line since 2010 as part of the Bangladesh Government policy for countering power shortages, but natural gas still remains the main fuel Source: used, at 64.50% of all power plants.





(Source: Bangladesh Power Development Board (BPDB) Website)

Figure 2.1-1 Power Plant Capacity by Fuel Type and Plant Type

A list of all grid connected power plants in Bangladesh and their annual generation in fiscal year 2011-12 is provided in the table below.

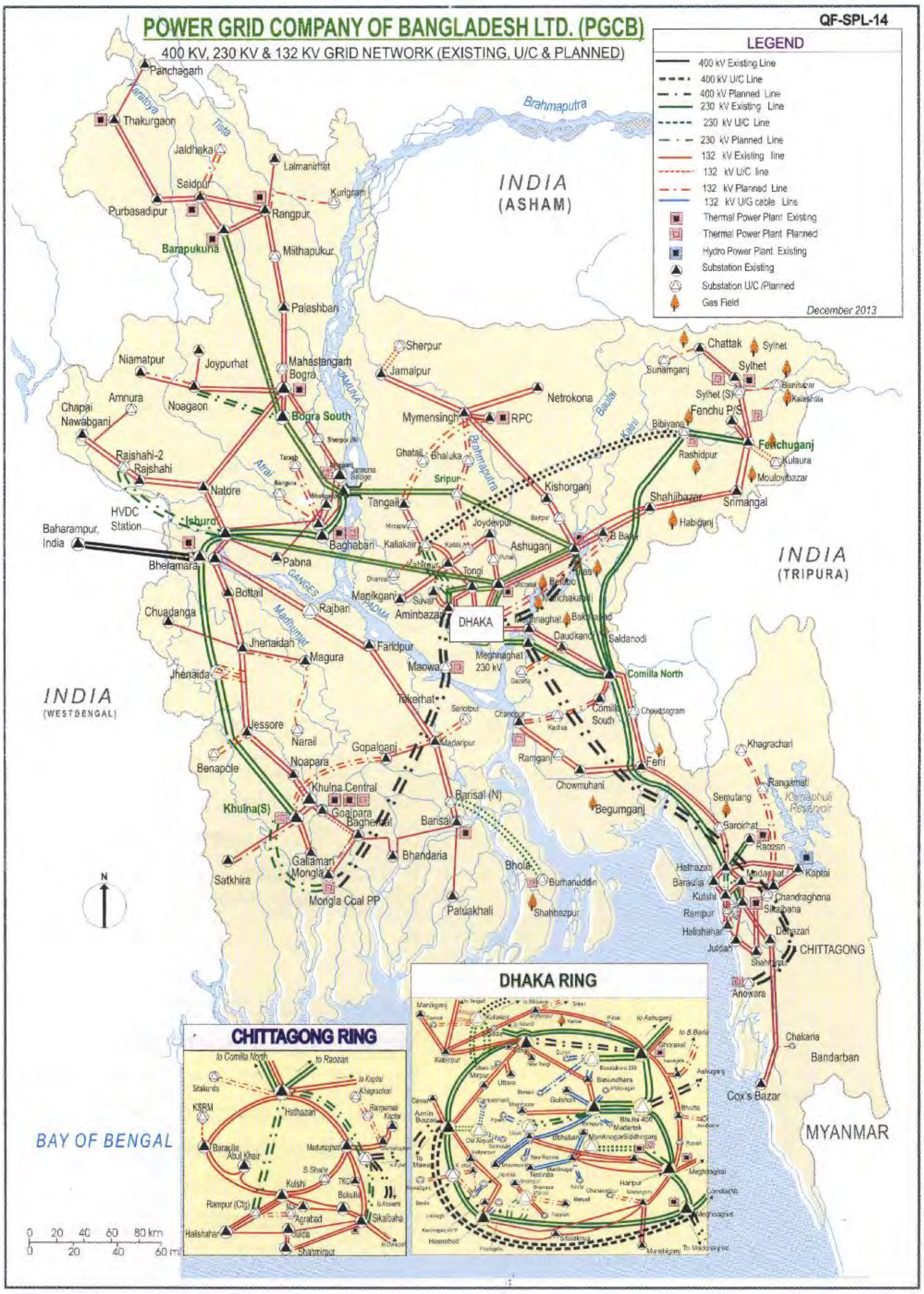
Table 2.1-1 Power Plants in Bangladesh

Plant Name	Fuel Type	Generation (2011-12) (kWh)
60 MW Shikalbaha	Gas	38,550,126
Shikalbaha 150MW PS	Gas	313,326,759
Ashugonj 2x64 MW S.P.S (1,2)	Gas	306,946,203
Ashugonj 3x150 MW ST (3,4,5)	Gas	2,609,158,392
Ashugonj 90 MW CC	Gas	316,044,350
Ashugonj 56 MW GT	Gas	315,844,548
Ashugonj 50 MW	Gas	394,250,928
Shiddirgonj 2X120 MW SPS EGCB Ltd.	Gas	675,752,832
Shahazibazar GT 57 MW	Gas	19,188,120
Shahazibazar 60 MW (8,9)	Gas	414,179,764
Ghorasal 2x 210 MW ST (3,4)	Gas	2,052,899,311
Ghorasal 2x 55 MW ST (1,2)	Gas	312,782,856
Ghorasal 2x 210 MW ST (5,6)	Gas	1,269,977,592
Haripur 100 MW GT	Gas	353,686,580
Shiddirgonj 210 MW SPS	Gas	- 2,070,036
Tongi 109 MW GT Power Station	Gas	434,191,565
Sylhet 20 MW GT	Gas	13,250,190
Sylhet 150 MW GT	Gas	101,985,761
210 MW Rauzan # 1 (Chittagong)	Gas	507,983,964
210 MW Rauzan # 2 (Chittagong)	Gas	104,860,720
Fenchugonj 90 MW CC	Gas	527,326,240
Fenchugonj (Unit-2, 90 MW)	Gas	440,327,175
Baghabari 71 MW GT	Gas	362,487,535
Baghabari 100 MW GT	Gas	733,417,871
Chandpur Combined Cycle	Gas	91,558,285
Barapukuria Power Station	Coal	883,302,714
Bera Peaking Power Station 71MW	HFO	68,496,206
Baghabari 50 MW Peaking PS	HFO	95,846,605
Hathazari	HFO	72,616,800
Sangu,Dohazari	HFO	78,897,595
Titas 50MW Peaking Power Plant	HFO	73,100,211
Isolated	HSD	1,728,799
Khulna 110 MW SPS	HFO	130,993,355
Khulna 60 MW SPS	HFO	21,541,686
Bheramara3x20 MW GT	HSD	55,718,983
Saidpur 20 MW GT	HSD	19,109,890
Rangpur 20 MW GT	HSD	20,045,183
Bhola (old) Diesel PS	HSD	249,450
Barisal 2x20 MW GT	HSD	40,168,158
Barisal Diesel PS	HSD	93,856
Faridpur Peaking Power Station 50MW	HFO	53,381,290
Gopalgang Peaking Power Station 100MW	HFO	98,284,251

Plant Name	Fuel Type	Generation (2011-12) (kWh)
Private Sector /IPP		
Rural Power Company Ltd.(RPCL)	Gas	1,306,528,608
WESTMONT POWER	Gas	241,766,400
Haripur Power Ltd.	Gas	2,601,598,000
Meghnaghat Power Ltd.	Gas	3,662,692,810
KPCL(Khulna Power Company 19*8 MW D)	HFO	516,346,900
NEPC Consortium (8*15 MW GT)	HFO	377,675,500
Rental Power		
Bogra RPP (24MW)	Gas	167,580,700
Energy Prima, Bogra 55 MW	Gas	84,241,728
Ghorashal, Max Power 78.5 MW	Gas	303,755,212
Doreen Power Ltd.(Tangail 22 MW)SIPP	Gas	138,592,661
Doreen Power Ltd.(Feni 22 MW)SIPP	Gas	159,618,420
Summit Purbanchol Po.Co. Ltd(Jangalia 33MW)SIPP	Gas	214,637,197
Precision Energy Ltd (Ashuganj 55 MW)	Gas	420,192,863
Aggreko Int.B.Baria RPP (70 MW)	Gas	508,908,110
Ashuganj (United Power Ltd.) (53 MW)	Gas	419,662,387
Energyprima Ltd.[Kumargao] (50MW)	Gas	267,446,540
*Sahzibazar RPP (86 MW)	Gas	589,434,220
Energyprima Ltd.[Shajibazar] (50 MW)	Gas	281,947,689
Desh Combridge Kumargaon Ltd.(10 MW)	Gas	48,106,980
Barakatullah Elec Dyna.Ltd.(Fenchugang 51MW)	Gas	304,429,342
Energyprima Ltd.[50MW Fenchuganj)	Gas	192,104,985
Regent Power Ltd.(Barabkundu 22MW)SIPP	Gas	153,206,160
Malancha	Gas	133,693,824
Venture Energy Resources Ltd.(Bhola 32MW)	Gas	45,023,630
Ghorashal 45 MW (Aggreko)	HSD	110,000,000
	Gas	156,000,000
Aggreko Int.Ashugonj (80MW)	Gas	628,505,072
Ghorashal, 100 MW (Aggreko)	Gas	347,000,000
	HSD	266,000,000
Thakurgaon 50MW PS(RZ Power Ltd.)	HSD	76,948,309
Aggreko Int.Khulna RPP (40MW)	HSD	131,429,570
Khulna RPP 55 MW (Aggreko)	HSD	133,388,170
Bheramara RPP (Quantum)	HFO	257,386,483
KPCL(Khulna Power Company 115 MW)	HFO	609,008,483
Khanjahan Ali 40 MW	HFO	183,762,759
Quantum Noapara (105 MW)	HFO	152,412,600
Pagla DPA Power Generation Int.Ltd.	HSD	132,678,070
Desh Energy Shiddirganj,100 MW	HSD	254,576,568
Summit Power Co. Ltd Madangonj (100 MW)	HFO	413,851,725
IEL, Meghnaghat 100 MW	HFO	436,030,135
Shiddirganj Dutchbangla 100 MW	HFO	440,414,640
Energies Shikalbaha 55MW	HFO	84,845,280
Amnura, Chapainababganj	HFO	67,080,936
Power Pac mutiara Keranigonj	HFO	73,382,880
Julda,Acron Infra.Service Ltd.	HFO	74,135,370
Kata khali	HFO	36,854,994
TOTAL		**32,626,365,573**

(Source: Department of Environment)

As of February 2014, the high voltage transmission network in Bangladesh covers 9,322 km (230 kV and 132 kV lines), while the distribution network (33 kV and below) covers 34,827 km. Additionally, 54.70 km of 400 kV transmission line was constructed to support the addition of 500 MW electricity import capacity from India.



(Source: PGCB)

Figure 2.1-2 Electricity Transmission Network in Bangladesh (as of December 2013)

A summary of the main indicators of the power sector operation for the period 2006-2012 is provided in the following table.

Table 2.1-2 Main Indicators of the Power Sector

Items	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
A. Electricity						
Total Installed Capacity (MW)	5,202	5,201	5,719	5,823	7,264	8,716
Maximum Demand (MW)	3,718	4,130	4,162	4,606	4,890	6,060
Total Generation (GWh)	23,268	24,946	26,533	29,247	31,355	35,118
Total Sales (GWh)	21,181	22,622	23,937	24,860	26,652	29,974
Transmission Lines (km)	7,044	-	5,684	4,557	4,762	8,795
Distribution Lines (km) (35 kV and below)	271,144	-	29,174	31,362	33,366	33,879
Electrification (No.):						
a. Thana	443	443	221	236	236	236
b. Village	3,495	3,495	4,204	4,792	4,792	4,810
c. Deep/Shallow & Low lift pumps	21,020	21,020	26,572	29,626	30,405	30,933

Power shortage is still a major issue in the country, due to the lack of sufficient capacity to meet the peak demand. However, the increasing demand for electricity also requires further extension and strengthening of the existing transmission and distribution network and remains another significant issue for the sector's development.

2.2 Institutional Arrangements

2.2.1 Overall Power Sector Management

The institutional structure of the power sector in Bangladesh is summarized in the figure below.

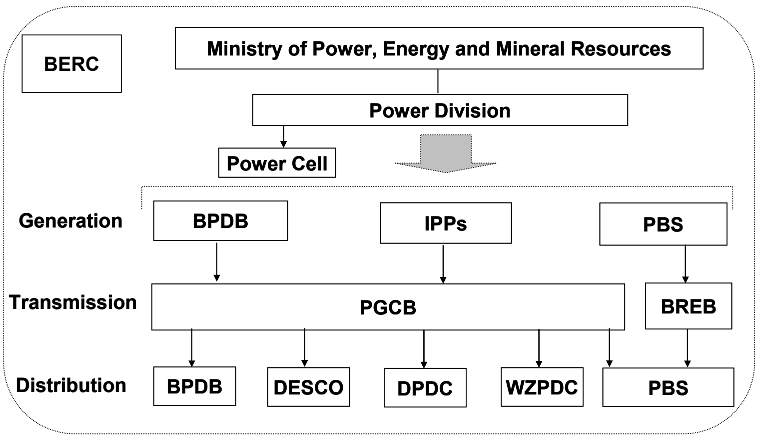


Figure 2.2-1 Institutional Structure of the Power Sector in Bangladesh

The sector is managed by the Power Division (PD) of the Ministry of Power, Energy and Mineral Resources (MPEMR). The main functions of the Power Divisions include:

- Management of all activities related to power generation, transmission and distribution;
- Management of all matters and policies related to the Power sector;
- Expansion, rehabilitation and modernization of the power generation, transmission and distribution services in line with the increasing national demand and preparation of action plans and programs accordingly;
- Encouragement of private and joint venture investment in the Power sector in addition to the government investment;

- Improvement of the standard of living of the rural poor through rural electrification and the introduction of renewable energy;
- Monitoring of revenue earnings and commercial activities of the utilities;
- Promotion of renewable energy and energy efficiency through formulation of policies/regulations, different incentive mechanisms and Research and Development (R&D).

Power Cell (PC) is a special entity under the PD created by the GOB to carry forward the power sector reform activities. The following activities are included in the PC mandate:

- Development of a reform program implementable plan;
- Implementation of specific programs to achieve desirable performance improvements, consumer satisfaction and viability of the sector;
- Provision of assistance to utilities in achieving accelerated development of the sector with optimum utilization of resources;
- Development of a strategy for corporatization of different entities in the power sector;
- Structuring of financial and business plans of the existing and emerging power entities;
- Development of a strategy for power distribution area demarcation and rationalization of the utilities;
- Development and implementation of centralized Management and Information System (MIS) and Information Technology (IT) system for the power sector;
- Development of in-house capacity for system efficiency improvement through formulation of tariff calculation and cash flow studies;
- Development of power sector master plan (M/P) incorporating updated data;
- Establishment of a communication system among the sector's utilities.

The power sector is regulated by the Bangladesh Electricity Regulatory Commission (BERC). The commission was established as an independent body in 2003 and took over the regulatory activities performed by other agencies up to then. BERC is a fully functional regulator in the area of electricity, and further regulates fuel markets.

The functions of BERC are stipulated in the Bangladesh Parliament Act of March 13, 2013 and cover the following items:

- Issue, cancel, amend and determine conditions of licenses, exemption of licenses and determine the conditions to be followed by such exempted persons.
- Help ensure efficient use, quality services, determine tariff and safety enhancement of electricity generation and transmission, marketing, supply, storage and distribution of energy.
- Approve schemes on the basis of the overall program of the licensee and make decisions taking into consideration the load forecast and financial status.
- Extend co-operation and advice to the Government, if necessary, regarding electricity generation, transmission, marketing, supply, distribution and storage of energy.
- Encourage the creation of a congenial atmosphere to promote competition amongst the licensees.
- Ensure control of environmental standards of energy under existing laws.
- Ensure appropriate remedy for consumer disputes, dishonest business practices or monopolies.
- Resolve disputes between licensees and between licensees and consumers, and refer to arbitration if necessary.
- Develop uniform methodology of accounting for all licensees to help ensure performance rating on a fair platform.
- Collect, review, maintain & publish statistics of energy.

- Frame codes and standards and make enforcement of these compulsory to ensure quality of services.
- Determine efficiency and standards of the machinery & appliances using energy and ensure through energy audit the verification, monitoring, and analysis of the energy data and economic use and enhancement of efficiency on use of energy.
- Perform any incidental functions if considered appropriate by the Commission for fulfilling objectives of the Act.

2.2.2 Generation, Transmission and Distribution

Generation, transmission and distribution of electricity in Bangladesh is provided by integrated utilities, such as the BPDP and its subsidiaries, as well as by Independent Power Producers (IPPs), and individual distribution companies.

Bangladesh Power Development Board (BPDB) is a statutory body created on May 1, 1972 to take over the development of the power sector after the independence of Bangladesh. Currently BPDB is in charge of a large share of the generation and distribution of electricity in the country. It also functions as a single buyer of electricity under the current electricity market model.

Generation Companies include BPDB and its subsidiaries, IPPs and small generation companies supplying electricity to the Rural Electrification Board (REB) network. BPDP and IPPs supply electricity to the high voltage transmission network of the PGCB, which is the sole operator of the transmission network in Bangladesh and is majority owned by BPDB.

PGCB supplies electricity to five distribution companies, namely BPDP – in the main provincial centers, Dhaka Power Distribution Company Limited (DPDC) – South Dhaka, Dhaka Electric Supply Company (DESCO) – North Dhaka, West Zone Power Distribution Company Limited (WZPDCL) – Khulna Area and the Bangladesh Rural Electricity Board (BREB).

The BREB is a statutory body in charge of rural electrification. The actual electricity distribution in individual rural areas, as well as small scale power generation, is controlled by cooperatives within the Pally Bidyut Samities (PBS), or Rural Electric Societies system.

2.2.3 Single Buyer Model

The electricity sector is operated under the Single Buyer Model, where BPDB functions as the single buyer. BPDB purchases all the generated electricity and collects the payments for the electricity sold by distribution companies. Based on that, it makes payments to the distribution companies, PGCB, and to the generation companies.

BPDP is also in charge of managing the payments for fuel supply in the energy sector. Power plants purchase fuel for their operation at tariffs determined by BERC. Fuel is supplied directly by the suppliers, for example, Petrobangla in the case of oil products; however, the actual payments are made by BPDB directly to the suppliers and subtracted from the payments due to the generation companies. (The only exceptions are some IPPs which directly import HFO or diesel from abroad.) Such a payment model guarantees smooth operation of the sector and avoids downstream or upstream payment delays. The payment flow is described in the next figure.

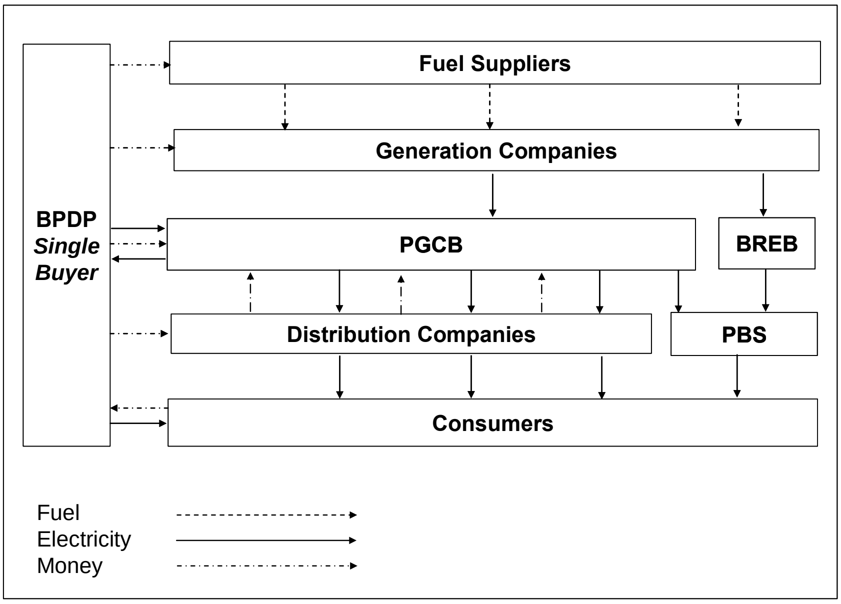


Figure 2.2-2 Operation of the Single Buyer Model

2.3 Power Supply and Demand in the Bangladesh National Grid

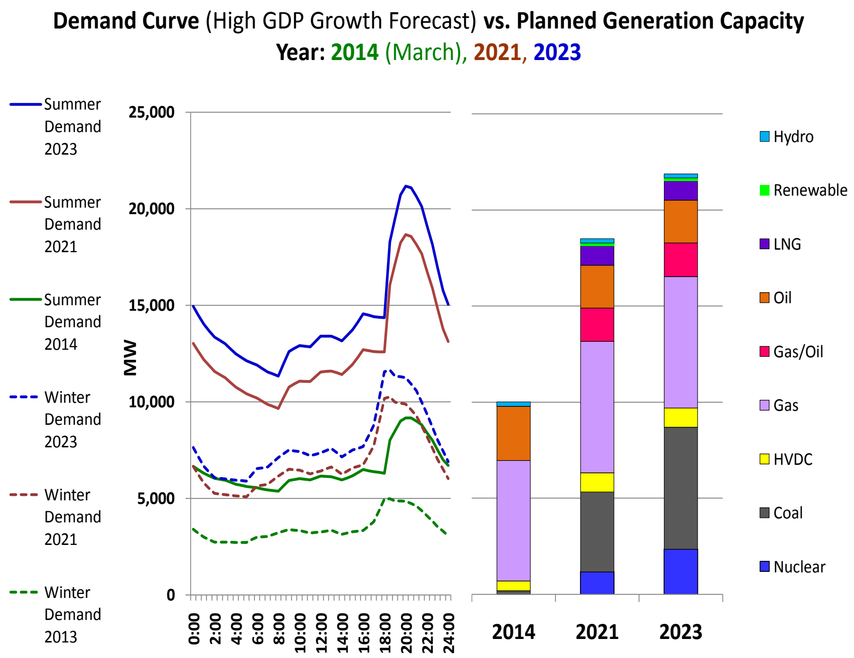
The power supply and demand data for the period 1997 – 2012 is summarized in the following table. The last column shows a growing gap over the years between the electricity demand and actual electricity generation capacity available, which needs to be addressed by further policy interventions and by attracting more investment into the power sector.

Table 2.3-1 Installed Capacity, Power Generation Demand and Load Shedding

Year	Installed Capacity (MW)	Installed Capacity (Derated) (MW)	Demand Forecast (MW)	Maximum Peak Generation (MW)	Maximum Load Shedding (MW)
1997-98	3,091	2,320	2,638	2,136	711
1998-99	3,603	2,850	2,881	2,449	774
1999-00	3,711	2,665	3,149	2,665	436
2000-01	4,005	3,033	3,394	3,033	663
2001-02	4,230	3,217	3,659	3,217	367
2002-03	4,680	3,428	3,947	3,428	468
2003-04	4,680	3,592	4,459	3,592	694
2004-05	4,995	3,721	4,597	3,721	770
2005-06	5,245	3,782	4,693	3,782	1,312
2006-07	5,202	3,718	5,112	3,718	1,345
2007-08	5,201	4,130	5,569	4,130	1,049
2008-09	5,719	5,166	6,066	4,162	1,269
2009-10	5,823	5,271	6,454	4,606	1,459
2010-11	7,264	6,639	6,765	4,890	1,335
2011-12	8,716	8,100	7,518	6,060	1,058

(Source: Statistical Yearbook of Bangladesh 2012, p. 192, Table: 6.02)

The projections for electricity supply and demand up to 2020, as well as the expected changes in the fuel mix are shown in the next figure.



(Source: PGCB)

Figure 2.3-1 Demand Projections and Changes in the Fuel Mix

Due to the expected decrease of domestic natural gas supply, a larger share of electricity is planned to be supplied by coal power plants towards 2023. Additionally, two nuclear power plants are expected to be put online in due course.

2.4 Energy Sector Policy

The main document guiding the energy policy in Bangladesh is the “Power System Master Plan 2010” (PSMP2010). The PSMP2010 promotes the attainment of a stable power supply through the achievement of Economic Growth, Energy Security and Environmental Protection, also called the 3Es. The PSMP2010 developed six value-up plans aimed at achieving specific targets.

Table 2.4-1 Summary of the Energy Sector Master Plan 2010

No.	Value-Up Plans	Targets	Actions
1	Actively develop domestic primary energy reSource:s	Maintain domestic primary energy supply over 50 %	1) Domestic natural gas development 2) Domestic coal development
2	Establish the power system portfolio by fuel diversification	Fuel mix by 2030: coal – 50 %, natural gas – 25 %, others – 25 %	1) Construction of imported coal power stations 2) Introduction of Liquefied Natural Gas (LNG) facilities 3) Construction of oil fired power stations 4) Import of electricity generated by hydro power from the neighboring countries or joint power plant development 5) Development of domestic renewable energy (wind and solar)
3	Realize a low carbon society by introducing highly efficient power supply and low Carbon Dioxide (CO_2) emission technologies	Improve thermal efficiency by 10 points on average	1) Higher efficiency gas power plants 2) Development of domestic coal power stations 3) Review of the O&M scheme 4) Energy conservation and demand side management
4	Build the infrastructure necessary for stable power supply under joint coordination of multiple sectors	Jointly build a deep sea port facility by the power, industry and commercial sectors	1) Construction of a deep sea port 2) Improvement of the power transmission system 3) Enhancement of gas transmission lines 4) Construction of fuel centers 5) Strengthening of domestic waterways 6) Strengthening of the railway system
5	Build efficient and effective mechanisms, organizations and regulations for stable power supply	- Establish an organization for long-term stable fuel supply - Formulate regulations for compulsory regular inspection of power stations under the leadership of the government - Revise tariff structure to recover maintenance costs and future investments for plants and equipment	1) Organization for coal procurement 1) Formulation of regulations for compulsory periodic inspection and repair of power stations 1) Introduction of a Power Development Surcharge into the power tariff 2) Promotion of private investment to realize the Master Plan 3) Creation of effective and efficient power market
6	Reduce poverty through social and economic growth	Promote local communities and mutual collaboration	1) Spread stable and sustainable power supply 2) Promote remote area electrification 3) Promote local industry, associated employment opportunities and income increase 4) Promote collaboration between power stations and local communities

(Source: Energy Sector Master Plan 2010)

Although the PSMP2010 is still the guiding document for the power sector policy, its actual implementation is strongly influenced by various factors, including fuel supply, funding availability and not least of all, the policy of the Bangladeshi government.

One major change that has occurred since the adoption of the master plan in 2011 is the change in fuel supply policy. For various social and environmental reasons, it was decided to terminate the further development of domestic coal reSources and switch completely to coal imports. Based on that, changes in the plans for the development of the transmission network are also required. This change is also expected to affect the plans for further expansion of the regional interconnection beyond what was projected in the PSMP2010.

The PSMP2010 is implemented under the guidance of the PD by each power sector entity. When a company wants to proceed with a particular project, it develops a Development Project Proforma/Proposal and submits it to the PD. The PD reviews the proposal and, if satisfactory, submits it to the Finance Division (FD). At the next step, the proposal is reviewed by the Executive Committee of the National Economic Council (ECNEC) and only if approved, it is added to the Annual Development Plan (ADP). Inclusion in the ADP is a prerequisite for the actual implementation of any project in the power sector.

2.5 Tariff System

BERC is the entity in charge of determining the electricity tariff for generation, transmission and distribution of electricity. Tariffs are set separately for different types of consumers and are based on the “required revenue” principle, i.e. they are operation cost-centered and do not include a proportion that covers the maintenance and power system expansion costs. The PSMP2010 clearly positions a reform of the tariff system as one of its value-up plans; however, this reform has not been implemented yet.

In determining the tariff, BERC sets a certain profitability target for the utilities. For example, for the power sector, all entities have to break even except for DESCO, which is allowed to have a 10% profit (due to its large market share).

There is no process of regular tariff update. Whenever utilities consider that there is any need for change in their tariff, they have to come up with a concrete and justified submission (proposal) which BERC thoroughly reviews. According to BERC, the system aims to be transparent and reflect the best international practices. All relevant stakeholders are included in the deliberation of any tariff changes, including through several stages of public hearings.

Since September 2008, tariffs have increased on average by 130% for power generation and by 78% for power distribution[1]. BERC reported that tariffs changed seven times over the same period.

2.5.1 Generation Tariffs

Generation tariffs are not publicly available and are determined for each generation company by BERC. The tariff includes two components, capacity availability payment and actual electricity generation payment. It is reported that many of the power plants constructed after 2010 under the program for dealing with power shortages received very attractive tariffs, which eventually put strong upward pressure on tariffs for final consumers.

2.5.2 Transmission Tariffs

PGCB is the only company in charge of the electricity transmission network (400 kV, 230 kV and 132 kV) in Bangladesh. PGCB does not buy or sell electricity, but receives wheeling payment from BPDB and other distribution companies. The current wheeling charges were last set in 2004 prior to the start of operation of BERC and have stayed unadjusted since.

[1] This information is based on interviews with BERC. Historical data was not made available to the study team.

Table 2.5-1 Wheeling Charges of PGCB

Transmission Line Type	Wheeling Charges [BDT/kilowatt-hours(kWh)]
230kV	0.2291
132kV	0.2268

(Source: BPGC)

As PGCB has undertaken a number of development projects in the past few years with the participation of foreign lenders and the repayment of the associated loans is due soon, the current tariff is considered insufficient to cover these expenses. This will be further discussed in the later chapters.

2.5.3 Distribution (Bulk Supply) Tariffs

Distribution companies pay the following tariffs to BPDB for the electricity they receive from the transmission network. (See the appendices for details)

Table 2.5-2 Electricity Tariffs for Distribution Companies

Serial no	Customer class	Agencies	Wholesale Electricity Tariff BDT/kWh
1	Class: G-1	Dhaka Power Distribution Company Limited (DPDC)	
		(a) 132 KV	5.325
		(b) 33 KV	5.405
2	Class: I-1	Rural Electricity Development Board (REB)	
		(a) 132 KV	5.325
		(b) 33 KV	4.0325
3	Class: I-2	Dhaka Electric Supply Company Limited (DESCO)	
		(a) 132 KV	5.325
		(b) 33 KV	5.405
4	Class: I-3	West Zone Power Distribution Company Limited	
		(a) 133 KV	5.325
		(b) 33 KV	4.43
5	Class: I-4	Bangladesh Electricity Development Board (PDB)	
		(a) 133 KV	5.325
		(b) 33 KV	4.9775
6	Class: I-5	North West Zone Power Distribution Company Limited	
		(a) 133 KV	5.325
		(b) 33 KV	4.9775
7	Class: I-6	Future constructed power distribution company	
		(a) 132 KV	5.325
		(b) 33 KV	4.9775

(Source: BERC)

A new tariff table for final consumers was approved in 2014. (Further details are provided to the appendices.) It is worth noting that BERC has introduced a lifeline tariff for the low-income households with consumption of less than 50kWh/month, in order to alleviate the pressure on the most disadvantaged social groups.

Chapter 3
Power Demand Forecast

Chapter 3 Power Demand Forecast

3.1 Record of Maximum Power Demand

The following table shows the total of the maximum loads of 132 kV substations in 2013 categorized by distribution companies.

Table 3.1-1 Total of the maximum loads of 132 kV substations in 2013

(Unit: Mega Watt (MW))

Area	Maximum Demand	Area	Maximum Demand
Comilla	1,028	Dhaka REB	1,760
Ctg	850	DESCO	852
Khulna	1,123	DPDC	1,296
Bogra	1,296	**Total**	**8,204**

The maximum power demand in the nation was 7,356 MW, recorded on 30th March, 2014. The reason why the maximum power demand in the nation was less than the total load shown in the above table 8,204 MW, is that the total load in the above table is the summation of the substations whose maximum loads appeared at different times. The following table shows the maximum power demand in each zone during March and April 2014.

Table 3.1-2 Demand Measurement in March-April, 2014

	Name of Zone	Day Peak (MW)	Evening Peak (MW)	Irrigation peak (MW)
Dhaka Division	Dhaka	2,645	2,784	2,486
	Mymensing	421	482	417
Chittagong Division	Chittagong	807	798	710
	Comilla	573	716	671
	Sylhet	179	285	231
	Rejshahi	668	793	582
	Rabgpur	379	431	284
	Khulna	654	871	719
	Barisal	118	173	124
Total		6,444	7,334	6,225

The maximum power demand in almost all the zones except for Chittagong was recorded as the night peak demand.

3.2 Power Demand Forecast

PGCB currently makes the power demand forecast as the maximum loads of 132 kV substations, and the nation-wide maximum power demand is deemed to be their total loads. The maximum loads of 132 kV substations are predicted in the following manners.

- The 132 kV substations are categorized into the following three groups.
  - ➢ Rural Area with electrification ratio of 40%
  - ➢ Industrial Area with electrification ratio of 80%
  - ➢ Urban Area with electrification ratio of 40%

- The growth ratios of the currently supplied loads are estimated by doing regression analysis of their past records.
- The power demand caused by rural electrification is added. Electrification ratio in 2021 was assumed as 100 % and currently, the national electrification ratio is 62 %.
- The large scale power consumption of newly developed industry is considered.
- Loads of new substations are also predicted by considering the possibility of switching medium voltage feeders to new 132 kV substations based on the information from the distribution utilities such as REB, DPDC and DESCO.

The power demand forecast for the study of 400 kV transmission lines is generally made as the regional power demand that is spread to an area at a certain degree (or the scale of the power demand supplied from 400 kV substations). However, in the power system analysis in this study, the maximum power demand forecast at 132 kV substations made by PGCB and their total amount of loads will be used, because no other power demand forecasts have been made so far for either nation-wide or region–wide, and the potential power demand is difficult to predict in the normal manner due to its scheduled outages as usual.

The total amount of the power demands at 132 kV substations in Bangladesh is predicted as shown in Figure 3.2-1 and, in each region, in Figure 3.2-2. The columns named 2013 indicate the maximum records of them recorded in 2013. Their total amount is expected to be 18,585 MW in 2020, that is, more than twice the current power consumptions. The maximum power demands at 132 kV substations are shown in Table 3.2-1 to Table 3.2-8 for each region. The growing ratio of the total amount of them in the Chittagong area is expected to be 13% for 2014, and 14% for 2015. The growing ratio of the regional total power demand would be more than 10% except for Dhaka north.

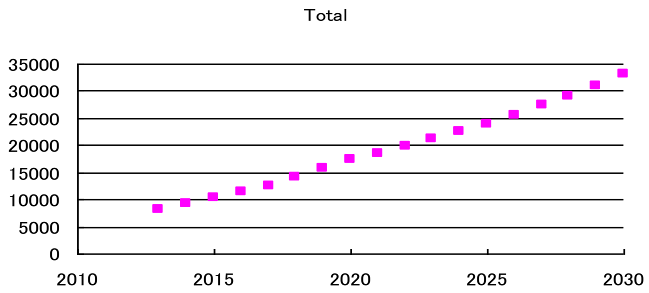


Figure 3.2-1 Total amount of Maximum Power Loads at 132 kV Substations in Bangladesh

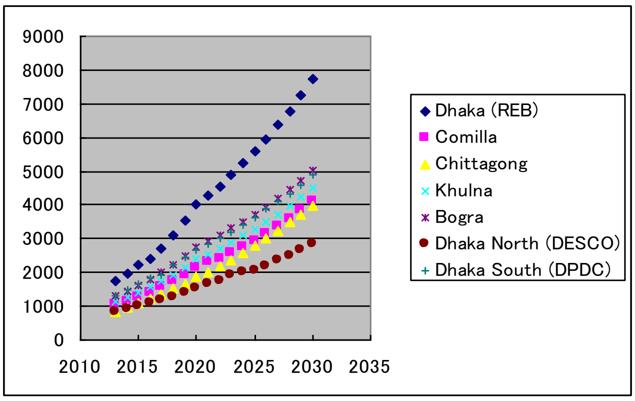


Figure 3.2-2 Total amount of Maximum Power Loads at 132 kV Substations in each region

Table 3.2-1 Maximum Power Demand Forecast (Region-Wide)

	Area	2013	2014	2015	2016	2017	2018	2019	2020	2021
Dhaka (REB)	**Max.Load**	1,760	1,973	2,214	2,419	2,721	3,111	3,547	4,003	4,276
	Incr. Ratio		12%	12%	9%	12%	14%	14%	13%	7%
Comilla	**Max.Load**	1,028	1,147	1,255	1,399	1,560	1,739	1,938	2,159	2,309
	Incr. Ratio		12%	9%	11%	12%	11%	11%	11%	7%
Chittagong	**Max.Load**	850	963	1,097	1,220	1,357	1,510	1,680	1,871	2,029
	Incr. Ratio		13%	14%	11%	11%	11%	11%	11%	8%
Khulna	**Max.Load**	1,123	1,251	1,395	1,554	1,732	1,944	2,151	2,397	2,555
	Incr. Ratio		11%	11%	11%	11%	12%	11%	11%	7%
Bogra	**Max.Load**	1,296	1,445	1,611	1,795	1,999	2,226	2,477	2,756	2,929
	Incr. Ratio		11%	11%	11%	11%	11%	11%	11%	6%
Dhaka North (DESCO)	**Max.Load**	852	899	986	1,081	1,189	1,273	1,400	1,540	1,640
	Incr. Ratio		6%	10%	10%	10%	7%	10%	10%	7%
Dhaka South (DPDC)	**Max.Load**	1,289	1,483	1,640	1,834	1,935	2,218	2,430	2,684	2,847
	Incr. Ratio		15%	11%	12%	6%	15%	10%	10%	6%
Total	**Max.Load**	8,197	9,162	10,197	11,302	12,494	14,020	15,623	17,410	18,585
	Incr. Ratio		12%	11%	11%	11%	12%	11%	11%	7%
	Area	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Dhaka (REB)	**Max.Load**	4,565	4,873	5,232	5,585	5,962	6,363	6,793	7,252	7,742
	Incr. Ratio	7%	7%	7%	7%	7%	7%	7%	7%	7%
Comilla	**Max.Load**	2,401	2,565	2,738	2,928	3,134	3,354	3,590	3,841	4,110
	Incr. Ratio	4%	7%	7%	7%	7%	7%	7%	7%	7%
Chittagong	**Max.Load**	2,189	2,371	2,568	2,778	2,995	3,230	3,484	3,699	3,962
	Incr. Ratio	8%	8%	8%	8%	8%	8%	8%	6%	7%
Khulna	**Max.Load**	2,724	2,904	3,086	3,284	3,500	3,731	3,975	4,237	4,516
	Incr. Ratio	7%	7%	6%	6%	7%	7%	7%	7%	7%
Bogra	**Max.Load**	3,113	3,308	3,505	3,719	3,950	4,196	4,455	4,732	5,026
	Incr. Ratio	6%	6%	6%	6%	6%	6%	6%	6%	6%
Dhaka North (DESCO)	**Max.Load**	1,746	1,902	1,997	2,067	2,201	2,344	2,496	2,657	2,829
	Incr. Ratio	7%	9%	5%	4%	6%	6%	6%	6%	6%
Dhaka South (DPDC)	**Max.Load**	3,020	3,204	3,399	3,647	3,869	4,090	4,340	4,605	4,888
	Incr. Ratio	6%	6%	6%	7%	6%	6%	6%	6%	6%
Total	**Max.Load**	19,757	21,127	22,524	24,007	25,611	27,307	29,133	31,024	33,072
	Incr. Ratio	6%	7%	7%	7%	7%	7%	7%	6%	7%

Table 3.2-2 Power Demand Forecast at 132 kV substations in Dhaka (REB)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Kabirpur	209	236	266	236	266	141	159	103	110	118	126	135	144	154	110	118	126	135
Safipur															95	102	109	116
Nabinagar						81	91	103	110	118	126	135	144	84	90	97	104	111
Dendabor														80	86	92	98	105
Dhaka EPZ								77	82	88	94	100	107	105	112	120	128	137
Ashulia						79	89	100	107	115	123	131	141	101	108	115	123	132
Akrain														80	86	92	98	105
Mirjapur				66	74	83	92	103	91	97	104	111	119	127	136	146	156	167
Deldwar									70	74	79	83	88	94	99	105	112	118
Kodda				52	66	80	69	85	91	97	104	111	119	127	96	103	110	117
Savar	90	102	115	97	110	124	94	106	113	121	129	138	148	128	137	147	127	136
Dhamrai				54	61	68	77	87	93	100	107	114	122	91	97	104	111	119
Hemayetpur							77	87	93	100	107	114	122	131	140	150	100	107
Hemayetpur-2																	90	96
Manikganj	79	87	97	87	96	60	67	74	79	85	91	97	104	86	92	98	105	113
Singair														65	70	74	80	85
Aricha						47	52	58	61	65	69	73	77	82	87	92	97	103
Joydevpur	184	208	235	106	119	72	82	92	99	106	113	67	72	77	82	88	94	101
BRRI												74	79	85	91	97	104	111
Sreepur				89	101	114	129	145	95	102	109	117	125	134	143	153	129	138
Sreepur-2									82	88	94	100	107	115	123	132	106	113
Barmibazar																	70	75
Rajendrapur						62	70	79	65	69	74	79	85	91	97	104	111	119
Boardbazar							65	74	79	85	91	97	104	111	119	127	136	145
Tongi	69	78	88	99	112	126	105	119	127	136	146	96	102	110	117	125	134	144
Tangail	120	133	148	131	145	112	125	138	97	102	109	115	92	97	103	109	116	123
Sakhipur													62	66	70	74	78	83
Ghatail						65	73	81	85	91	96	102	76	80	85	90	96	102
Jamalpur	104	75	83	93	103	80	89	99	105	111	118	100	106	112	87	92	98	104
Baksiganj												50	53	56	60	63	67	71
Sherpur		41	45	50	56	62	69	76	81	85	91	71	75	80	85	90	95	101
Dhanbari															72	76	81	86
Mymensingh	139	154	111	123	136	101	98	109	116	89	96	102	94	101	108	116	124	132
Ishwarganj										68	72	76	81	86	91	96	102	108
Bhaluka			60	68	77	87	98	111	119	127	136	145	95	102	109	117	125	134
Trisal													75	80	86	92	98	105
M.gacha						67	75	83	88	93	99	105	111	118	85	90	95	101
Phulpur							33	36	38	40	43	45	48	51	54	57	61	64
Netrokona	57	63	70	77	86	95	87	96	102	98	104	68	72	77	81	86	91	97
Purbadhala												42	45	47	50	53	56	60
Kishoreganj	52	58	64	71	79	60	66	74	78	60	63	67	71	76	80	85	90	95
Bajitpur						51	56	62	66	70	74	79	83	88	94	99	105	111
Ghorasal	80	89	98	109	68	69	77	86	91	96	102	108	84	90	95	101	107	113
Shibpur													81	87	93	99	106	114
Pubail					53	60	68	77	82	88	94	80	86	92	98	105	113	121
Norshingdi	84	94	106	120	136	112	126	143	90	96	102	110	106	114	122	130	139	149
Pachduna									63	67	72	77	83	88	95	101	108	116
Marjal						76	85	96	103	110	118	126	95	102	109	117	125	133
Bhulta	145	163	184	167	189	151	171	135	70	75	80	86	92	98	105	112	120	129
Kanchon									74	79	85	91	97	104	111	119	127	136
Rupshi				73	83	93	105	119	127	136	146	106	113	121	129	139	148	159
Rupshi-2												94	101	108	115	123	132	141
Araihazar						62	70	79	85	91	97	94	100	107	115	123	132	141
Madobdi								75	80	86	92	98	105	112	120	129	138	147
Haripur	85	96	108	89	101	114	96	108	116	124	133	108	115	123	117	125	134	143
Sonargaon	53	60	68	76	86	97	87	98	105	112	120	128	137	147	97	104	111	119
Sonargaon-2															88	94	101	108
Bandor							75	84	90	97	103	111	118	127	121	129	138	148
Munshiganj	59	65	72	80	72	80	89	99	106	113	121	68	73	78	83	89	95	102
Tongibari												62	66	70	74	78	83	88
Hasnabad	152	172	194	204	88	99	112	79	84	90	96	103	110	118	126	90	97	103
Abdullapur								48	51	54	58	62	67	71	76	82	87	93
Nawabganj					51	56	62	69	73	78	82	87	93	98	104	110	117	124
Keraniganj					59	66	75	84	90	97	103	111	118	127	136	100	107	115
Hasnabad-2																90	96	103
Sreenagar					51	56	62	69	74	79	85	91	97	104	111	119	127	136
Area Total	**1760**	**1973**	**2214**	**2419**	**2721**	**3111**	**3547**	**4003**	**4276**	**4565**	**4873**	**5232**	**5585**	**5962**	**6363**	**6793**	**7252**	**7742**

Table 3.2-3 Power Demand Forecast at 132 kV substations in Comilla

Substation Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Sylhet	147	165	159	106	120	84	94	106	116	126	68	74	80	88	96	104	114	124
Sylhet©											70	76	82	88	95	103	111	120
Beanibazar			33	36	40	45	50	55	59	63	68	72	70	75	80	86	92	98
Darbosto													60	64	69	74	79	84
Sylhet (N)						72	80	89	96	104	112	121	81	88	95	102	110	119
Sylhet (S)				83	94	85	95	107	116	125	70	76	82	88	95	103	111	120
Biswnath											60	64	67	71	76	80	85	90
Chhatak	42	47	22	24	27	30	33	37	39	41	44	47	49	52	55	59	62	66
Sunamganj			30	33	37	41	46	51	54	57	60	64	68	72	76	81	86	91
Fenchuganj	54	41	40	33	37	41	46	51	54	57	60	64	68	72	76	81	86	75
Kulaura		31	34	38	42	47	52	58	61	65	69	73	77	82	87	92	97	60
Molovibazar																		55
Srimongal	42	36	40	44	49	45	50	56	60	64	68	73	78	84	90	96	102	110
Shahajibazar	56	62	68	76	84	56	62	68	73	77	81	86	92	97	60	64	67	71
Madovpur															50	53	56	60
Nabiganj						47	52	58	61	65	69	73	77	82	75	80	84	89
B.baria	61	68	75	83	93	75	83	92	98	60	64	67	71	76	80	85	90	96
Nabinagar										63	67	71	75	80	84	89	95	100
Ashuganj	62	69	77	85	94	55	61	67	72	57	61	65	70	75	80	86	92	98
Comilla (N)	58	64	71	79	88	86	95	106	113	100	107	114	90	96	103	110	118	126
Maynamoti													80	87	95	104	113	123
Muradnagar						79	87	97	103	60	64	67	71	76	80	85	90	96
Comilla (S)	148	166	123	139	157	110	124	140	100	109	119	130	90	98	107	87	94	103
Lalmai									60	64	69	74	79	84	90	96	103	110
Miarbazar																70	76	82
Chaddugram			64	71	79	62	69	76	81	87	93	100	107	114	122	91	97	104
Daudkandi	68	76	86	97	109	75	84	93	99	106	114	72	77	82	88	94	100	107
Homna												50	54	57	61	66	70	75
Gazaria						48	54	61	68	76	85	96	107	120	78	87	98	110
Jamaldi															60	67	75	84
Chandpur	79	87	82	52	57	64	71	78	83	88	93	99	105	111	118	125	80	85
Matlob																	50	53
Kachua				39	44	49	54	60	64	67	71	76	80	85	90	96	101	107
Ramganj			57	64	71	79	87	97	103	109	115	60	64	68	72	76	81	85
Laxmipur												62	66	70	74	78	83	88
Chowmuhani	107	118	89	99	110	69	77	85	91	98	104	112	120	68	73	78	83	89
Sonaimuri														60	64	67	71	76
Sonapur						52	58	65	68	73	77	81	86	92	97	103	109	116
Feni	105	117	105	116	129	143	87	96	104	112	121	76	82	88	95	103	111	120
Feni-3												70	75	80	86	92	98	105
Feni-2							73	81	85	91	96	80	85	90	95	101	107	113
Chandina						51	58	65	60	64	69	74	79	84	90	96	103	110
Laksham						52	58	65	68	73	77	81	86	92	97	103	109	116
Area Total	**1028**	**1147**	**1255**	**1399**	**1560**	**1739**	**1938**	**2159**	**2309**	**2401**	**2565**	**2738**	**2928**	**3134**	**3354**	**3590**	**3841**	**4110**

Table 3.2-4 Power Demand Forecast at 132 kV substations in Chittagong

Substation Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Hathazari	77	86	59	66	75	85	95	107	115	123	82	87	93	100	107	114	122	51
Fatikchari											50	53	56	60	63	67	71	75
Raozan																		80
Khagrachari			27	30	34	37	42	46	49	52	55	58	62	65	69	73	78	83
Baroirhat			41	46	51	56	62	69	74	79	85	91	97	104	111	119	97	104
Mirsharai																	60	65
Baroaulia	95	107	104	72	82	92	83	93	103	113	124	86	95	105	115	127	94	104
Kumira												80	88	97	106	117	94	103
Batiari																	80	88
Sitakundu				45	51	58	65	74	81	89	98	78	86	95	104	115	96	106
Khulsi	163	178	127	96	105	114	88	96	104	112	121	80	86	92	98	105	112	120
Nasirabad												80	86	92	98	105	112	120
Agrabad			68	74	81	89	97	106	113	121	90	95	101	107	114	120	90	95
Agrabad-2											80	85	90	95	101	107	113	120
Rampur				78	86	94	102	112	120	128	90	95	101	107	114	120	100	106
Halishahar	122	138	155	118	134	89	100	113	124	80	88	97	104	111	119	127	105	112
Halishahar-2																	80	85
Patenga										65	70	76	82	88	96	103	111	120
F.hat							59	66	72	80	88	96	103	110	118	126	100	107
Newmooring						62	70	79	86	70	76	83	89	95	102	109	100	107
Sholoshahar				50	55	60	65	71	77	83	90	67	72	78	84	91	98	106
Bakulia	105	115	125	60	65	71	78	85	93	101	110	120	81	87	93	99	106	114
Kalurghat				49	55	62	70	79	86	94	103	112	85	91	97	104	111	119
Bakulia-2													70	75	80	86	92	98
Madunaghat	32	36	40	44	49	54	60	67	72	77	82	88	94	100	107	115	123	100
Chandraghona	37	41	29	32	35	39	44	48	51	54	58	61	65	69	73	77	82	87
Rangamati			27	30	34	37	42	46	49	52	55	58	62	65	69	73	78	83
Sikalbaha	47	54	60	68	77	74	83	94	104	114	125	70	77	85	93	102	100	110
Bhoalkhali												70	76	83	91	99	108	117
Shahmirpur	6	25	28	32	36	41	46	52	57	63	69	76	83	92	101	111	100	110
Juldah	21	24	27	31	35	39	44	50	55	61	67	73	81	89	98	108	90	99
Sikalbaha-2																	70	77
Dohazari	64	71	79	88	98	79	87	97	104	111	119	127	95	102	109	116	85	91
Baskhali													45	48	51	54	57	60
Bandarban																	40	42
Patiya						43	48	53	58	64	71	70	76	83	91	99	108	117
Kaptai	16	17	19	21	24	26	29	32	34	36	38	41	43	46	49	51	55	58
Cox'bazar	64	71	79	55	61	67	75	83	90	97	105	113	112	76	82	89	96	103
Teknaf														45	49	52	57	61
Chakaria													52	57.2	63	69	76	84
Moheskhali													57	66	75	87	100	115
Matarbari				33	37	41	46	51	58	70	84	101	33	37	41	46	52	58
Area Total	**850**	**963**	**1097**	**1220**	**1357**	**1510**	**1680**	**1871**	**2029**	**2189**	**2371**	**2568**	**2778**	**2995**	**3230**	**3484**	**3699**	**3962**

Table 3.2-5 Power Demand Forecast at 132 kV substations in Khulna

Substation Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Barisal (N)			66	74	84	94	88	99	106	113	121	79	85	91	97	104	111	119
Gournadi												70	75	80	86	92	98	105
Gangni						60	66	74	78	83	88	83	88	93	99	105	111	118
Barisal	95	107	69	77	87	98	86	97	104	111	119	77	82	88	94	101	108	116
Bakerganj												50	53	56	60	63	67	71
Madaripur	73	81	50	55	62	68	76	84	89	95	100	81	86	91	97	103	109	115
Jalokati							44	48	51	54	58	61	65	69	73	77	82	87
Shariotpur			26	29	32	36	39	44	46	49	52	55	59	62	66	70	74	78
Patuakhali	68	75	53	59	66	49	54	60	64	67	71	76	80	85	90	96	101	107
Bhola			30	33	37	41	46	51	54	57	60	64	68	72	76	81	86	91
Kalapara						36	39	44	46	49	52	55	59	62	66	70	74	78
Bandharia	31	34	38	43	47	41	46	51	54	57	60	64	68	72	76	81	86	91
Faridpur	75	84	93	103	89	65	73	81	85	91	96	102	108	114	80	85	90	96
Boalmari															55	58	62	66
Rajbari					49	54	60	67	71	75	80	84	89	95	100	107	113	120
Gopalganj	38	42	46	52	57	52	58	65	68	73	77	81	86	92	83	88	93	99
Bangha						45	50	55	59	62	66	70	74	78	83	88	93	99
Kustia	91	101	112	124	115	80	89	99	106	113	121	90	96	103	110	118	94	101
Mirpur												67	71	75	80	85	90	95
Bheramara	38	42	46	52	57	64	71	78	83	88	93	82	87	92	98	103	110	116
Chuadanga	37	41	45	50	56	62	54	60	64	67	71	76	80	85	90	96	101	107
Islamic Univ.																	62	66
Jhenaidah	58	64	71	79	88	97	66	74	78	83	88	93	99	105	111	118	95	100
Kaliganj							62	69	73	78	82	72	77	81	86	91	97	103
Magura	26	28	31	35	39	43	48	53	56	60	63	67	71	75	80	84	90	95
Jessore	123	137	114	126	123	99	89	99	106	113	121	85	91	97	104	81	87	93
Churamonkati												55	58	62	66	69	74	78
Benapole			38	43	47	52	58	65	68	73	77	81	86	92	97	103	109	116
Narail					44	49	54	60	64	67	71	76	80	85	90	96	101	107
Noapara	53	59	66	73	54	60	66	74	79	84	90	97	103	111	118	95	101	108
Rupdia																61	65	69
Kesabpur						56	62	69	73	78	82	87	93	98	104	90	96	101
Satkhira	50	55	62	68	76	65	73	81	85	91	96	102	108	114	121	89	94	100
Assasuni																59	63	66
Khulna (C)	88	99	112	127	143	120	94	106	114	124	83	90	97	105	114	86	92	100
Goalpara	47	52	57	64	71	79	68	76	82	89	76	82	73	79	86	92	100	108
Sonadanga											70	76	82	88	95	103	111	120
Gallamari	47	54	60	68	77	87	98	111	120	65	70	76	82	88	96	103	111	120
Lobanchura										64	69	75	81	87	94	102	110	118
Rupsha						69	77	85	92	99	107	116	75	81	88	95	102	111
Terokhada													60	65	70	76	82	88
Phultola							61	69	74	80	86	93	101	109	118	92	99	107
Fhulpur																72	78	84
Bagerhat	56	62	68	76	84	65	73	81	85	91	96	102	108	114	121	93	98	104
Pirojpur																76	81	85
Mongla	30	34	39	44	50	56	63	71	76	82	87	93	100	107	114	82	88	94
Area Total	**1123**	**1251**	**1395**	**1554**	**1732**	**1944**	**2151**	**2397**	**2555**	**2724**	**2904**	**3086**	**3284**	**3500**	**3731**	**3975**	**4237**	**4516**

Table 3.2-6 Power Demand Forecast at 132 kV substations in Bogra

Substation Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Pirganj						65	73	81	85	91	96	102	108	114	83	88	94	99
Puthia						51	56	62	66	70	74	79	83	88	94	99	105	111
Bera						56	62	69	73	78	82	87	93	98	104	110	117	94
Panchagarh	31	34	38	43	47	52	58	65	68	73	77	81	86	92	87	92	98	104
Thakurgaon	64	71	79	88	98	71	79	88	93	98	104	111	117	124	82	87	92	97
Thakurgaon-2															60	64	67	71
Purbasadipur	78	86	96	106	118	103	114	69	73	78	82	87	93	98	84	89	94	100
Birganj															58	61	65	69
Dinajpur								58	61	65	69	73	77	82	87	92	97	103
Saidpur	78	86	62	68	76	84	93	76	81	85	91	96	102	108	114	85	90	96
Parbatipur																55	58	62
Jaldhaka			34	38	42	47	52	58	61	65	69	73	77	82	87	92	97	103
Barapukuria	38	42	46	52	57	64	71	78	83	88	93	99	105	111	88	93	99	105
Hakimpur															67	71	75	80
Rangpur	88	99	112	126	95	107	120	94	101	108	115	123	82	88	94	100	107	115
Pirgacha													70	74	79	83	88	94
Mithapukur					57	64	71	78	83	88	93	99	80	85	90	95	101	107
Paglapir								69	73	78	82	87	93	98	104	90	95	101
Palashbari	56	62	68	76	74	82	91	62	66	70	74	79	83	88	89	94	100	106
Gaibandah								39	42	44	47	49	52	56	59	62	66	70
Lalmonirhat	50	55	62	30	34	37	42	46	49	52	55	58	62	65	69	73	78	83
Kurigram				38	42	47	52	58	61	65	69	73	77	82	87	92	97	103
Bogra	167	188	154	113	128	78	88	100	108	116	66	71	76	83	89	96	104	112
Dupchachia											60	64	67	71	76	80	85	90
Mahastanghar			57	64	71	79	87	97	103	109	115	122	60	63	67	71	75	80
Matdali													70	74	79	83	88	94
Sherpur(Bogra)				61	67	75	83	92	99	106	113	121	129	138	98	104	110	117
Bogra (New)						65	73	81	86	92	99	106	113	121	100	106	114	122
Sultanganj															80	86	92	98
Naogaon	78	86	96	106	118	79	87	97	103	109	115	122	90	95	101	107	113	120
Atrai													55	58	62	66	69	74
Joypurhat	39	43	48	53	59	65	73	81	85	91	96	102	108	114	89	94	100	106
Niamotpur	56	62	68	76	84	77	85	94	100	106	113	119	126	94	100	106	112	119
Mahadevpur														70	74	79	83	88
Patnitola						69	77	85	90	96	102	108	114	91	96	102	108	115
Sirajganj	62	69	77	85	94	71	79	88	94	100	107	115	68	73	78	83	89	95
Belkuchi													55	59	63	67	72	77
Ullapara						34	37	41	44	47	49	52	56	59	62	66	70	74
Natore	73	81	90	100	111	94	66	74	78	83	88	93	84	89	94	100	106	112
Bonpara							37	41	44	47	49	52	56	59	62	66	70	74
Shahajadpur	54	60	67	74	83	51	56	62	66	70	74	79	83	88	94	99	105	111
Pabna	67	74	82	91	67	60	66	74	78	83	88	93	99	105	111	118	125	99
Madhupur																		63
Bangura					34	37	42	46	49	52	55	58	62	65	69	73	78	83
Ishurdi	36	39	44	49	54	60	66	74	78	83	88	68	72	77	81	86	91	97
Bagha												65	69	73	77	82	87	92
Rajshahi	96	108	65	73	83	80	90	101	109	116	124	78	83	89	96	102	109	117
Rajshahi (N)			58	65	73	76	86	97	103	111	118	77	82	88	94	101	108	115
Tanore												70	75	80	86	92	98	105
Chapai	88	59	66	73	81	90	100	65	68	73	77	81	86	92	97	103	109	116
Chowdala								46	49	52	55	58	62	65	69	73	78	83
Amnura		38	42	47	52	58	64	71	76	80	85	75	80	84	90	95	101	107
Area Total	**1296**	**1445**	**1611**	**1795**	**1999**	**2226**	**2477**	**2756**	**2929**	**3113**	**3308**	**3505**	**3719**	**3950**	**4196**	**4455**	**4732**	**5026**

Table 3.2-7 Power Demand Forecast at 132 kV substations in Dhaka North (DESCO)

Substation Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Mirpur	149	102	112	92	101	88	97	106	111	116	122	128	135	142	149	106	111	117
Pallabi																98	103	108
Gulshan	153	137	150	106	116	92	100	109	115	121	127	133	95	99	104	110	115	121
Gulshan-2													94	99	104	109	114	120
Bashundhara	175	191	209	99	109	96	105	114	122	131	140	150	85	91	98	105	112	120
Bashundhara-2													75	80	86	92	98	105
Uttara-VI														90	96	103	110	118
Uttara	113	123	134	125	137	109	94	103	111	118	127	135	145	105	112	120	129	138
Tongi New	78	88	99	112	127	115	100	113	120	129	138	118	126	135	144	154	165	176
Kallayanpur	185	95	104	113	124	95	104	114	122	131	140	149	100	107	114	122	131	140
Agargaon		72	79	86	94	78	85	93	98	102	108	113	119	124	131	137	144	151
Dhamal Koat		90	98	68	74	81	88	96	103	110	118	126	135	145	155	118	126	135
Uttara-3rd Phase				52	57	62	68	74	79	85	91	97	104	111	119	128	136	146
Dumni				54	59	65	71	77	82	88	94	101	108	106	113	121	129	138
Purbachal				35	40	45	50	57	61	65	70	75	80	85	91	98	105	112
Purbachol-2											42	45	48	51	55	59	63	67
Aftabnagar				58	65	74	83	94	101	108	115	124	132	141	81	87	93	100
Badda															70	75	80	86
Banani				80	87	96	104	114	122	131	140	150	111	119	127	136	146	156
Mirpur-II						62	68	75	78	82	86	91	95	100	105	110	116	122
Airport						68	75	82	88	94	100	107	115	93	99	106	114	122
United City						48	53	58	62	66	71	76	81	87	93	99	106	114
Uttarkhan							55	60	65	69	74	79	85	91	97	104	111	119
Area Total	852	899	986	1081	1189	1273	1400	1540	1640	1746	1902	1997	2067	2201	2344	2496	2657	2829

Table 3.2-8 Power Demand Forecast at 132 kV substations in Dhaka South (DPDC)

Substation Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Ullon	142	115	126	138	91	99	108	118	124	130	137	144	151	103	109	114	120	126
Banasree														80	84	88	93	97
Maghbazar	149	162	178	194	124	86	94	102	107	113	119	124	111	116	122	128	135	141
Md.pur													100	105	110	116	122	128
Maniknagar	79	66	72	59	64	70	77	84	90	96	103	110	118	126	135	114	122	131
Konapra																76	81	87
Dhanmondi	161	176	192	82	89	98	107	117	123	129	135	142	149	106	112	117	123	129
Azimpur														85	89	94	98	103
Kamrangirchar	139	77	84	92	100	109	80	87	93	100	107	114	122	131	140	150	100	107
Hazaribagh																	60	64
Narinda	96	105	115	71	77	84	92	101	106	111	117	122	129	135	142	109	114	120
Bangsal																90	95	99
Shyampur	145	163	184	99	112	86	97	110	117	126	135	144	154	140	150	112	120	128
Rayerbazar														95	102	109	116	125
Pagla																88	94	101
Bangabhaban	61	67	73	40	44	48	52	57	60	63	66	69	73	76	80	84	88	93
Matuail	54	61	69	78	88	69	78	88	95	101	108	116	124	133	142	112	120	128
Sitalakhya	97	110	124	100	113	82	93	105	112	120	128	137	147	107	115	123	131	140
Sitalakhya-2														85	91	97	104	111
Siddirganj	99	112	127	113	78	88	99	112	119	128	137	146	157	100	108	115	123	132
Godnail														90	96	103	110	118
Madanganj		84	95	60	67	76	67	75	81	86	92	99	106	113	106	113	121	130
Satmasjit		70	77	84	91	100	79	87	93	99	106	113	101	109	116	124	133	142
Madertek	34	60	66	72	60	66	72	79	84	90	97	103	111	118	127	119	128	137
Lalbagh	34	55	60	66	72	78	86	94	98	103	109	114	120	111	116	122	128	135
Charsaidpur				48	54	61	69	78	83	89	95	102	109	116	124	133	143	152
Fatullah				78	88	74	84	95	102	109	116	124	133	107	115	123	132	141
Kazla				80	87	96	104	114	122	131	140	150	160	131	141	120	129	138
Postogola				81	89	97	106	116	121	127	134	141	148	125	131	138	145	152
Motijheel				60	66	72	78	86	90	94	99	104	109	115	120	127	133	139
New Ramna				74	81	88	97	106	111	116	122	128	135	142	149	106	111	117
Zigatola				68	74	81	89	97	102	107	112	118	124	110	116	121	127	134
Panthapath						70	77	84	88	93	98	102	108	113	119	124	131	137
Ctg Road						70	77	84	90	96	103	110	118	126	135	145	155	166
Khilgaon					76	83	91	100	105	111	116	122	128	109	115	121	127	133
Basila							70	77	82	88	94	101	88	94	100	107	115	123
Khanpur						70	79	89	95	102	109	117	125	111	119	127	136	145
Tejgaon						60	66	72	75	79	83	87	91	96	101	106	111	117
Demra					50	56	64	72	77	82	88	94	101	108	116	124	132	142
Area Total	1289	1483	1640	1834	1935	2218	2430	2684	2847	3020	3204	3399	3647	3869	4090	4340	4605	4888

Chapter 4
Power Development Plan

Chapter 4 Power Development Plan

4.1 Existing Power Stations

Table 4.1-1 and Table 4.1-2 show the list of existing power stations. The total available capacity, called de-rated capacity, is 9,508 MW; however, part of the available capacity is actually limited to a certain degree due to their periodic inspections, outages by deterioration and constraints of the power flow of transmission lines. Some power plants listed are expected to be retired within the next few years. The total de-rated capacity of power plants in Chittagong District is 710 MW, as shown in the following table. The maximum power demand in Chittagong is around 850 MW; thus, the remaining required capacity needs to be supplied from other areas, especially from Dhaka. If a unit of power generators is dropped out, power flow of around 200 to 300 MW would be expected through the transmission lines from the northern district to Chittagong.

Table 4.1-1 Derated Capacity in Chittagong District

Name of Power Station	Unit	Derated Capacity
Chittagong Raozan ST 1	ST-1	210
Chittagong Raozan ST 2	ST-2	210
Raozan 25 MW	25 MW	25
Sikalbaha ST	ST	40
Sikalbaha GT	GT	150
Sikalbaha	Energis	53
Barabkunda		22
		710

Table 4.1-2 Existing Power Stations (1/2)

Power Station Name	Unit		District	Installed Capacity	Derated Capacity MW	Fuel	Grid Connected Voltage	Modified Commissioning Date	Commissioning Date	Entity	Producer
Ghorasal ST 1 & 2	ST 1	Dhaka	Norshingdi	55	39	Gas	132 kV	16-Jun-74	16-06-1974	Public	BPDB
Ghorasal ST 1 & 2	ST 2	Dhaka	Norshingdi	55	39		132 kV	13-Feb-76	13-02-1976	Public	BPDB
Ghorasal ST 4	ST 4	Dhaka	Norshingdi	210	210	Gas	230 kV	14-Sep-86	14-09-1986	Public	BPDB
Ghorasal ST 3	ST 3	Dhaka	Norshingdi	210	210	Gas	230 kV	18-Mar-89	18-03-1989	Public	BPDB
Ghorashal 100 MW	100 MW	Dhaka	Norshingdi	100	100	Gas	132 kV	28-Feb-12	28/02/2012	Private	Aggreko
Ghorasal ST 5	ST 5	Dhaka	Norshingdi	210	210	Gas	230 kV	15-Sep-94	15-09-1994	Public	BPDB
Ghorasal ST 6	ST 6	Dhaka	Norshingdi	210	210	Gas	230 kV	31-Jan-99	31-01-1999	Public	BPDB
Ghorashal 45 MW	45 MW	Dhaka	Norshingdi	45	45	Gas	33 kV	28-Feb-12	28/02/2012	Private	Aggreko
Ghorashal MAX	Ghorashal MAX	Dhaka	Norshingdi	78	78	Gas	132 kV	27-May-11	27/05/2011	Private	Max Power
Haripur SBU GT 1, 2 & 3	GT-1	Dhaka	Narayanganj	32	20	Gas	132 kV	31-Oct-87	31-10-1987	Public	BPDB
Haripur SBU GT 1, 2 & 3	GT-2	Dhaka	Narayanganj	32	20	Gas	132 kV	15-Nov-87	15-11-1987	Public	BPDB
Haripur SBU GT 1, 2 & 3	GT-3	Dhaka	Narayanganj	32	20	Gas	132 kV	2-Dec-87	02-12-1987	Public	BPDB
Haripur NEPC	1 - 8	Dhaka	Narayanganj	110	85	HFO	132 kV	30-Jun-99	30-06-1999	Private	Pendekar
Haripur P. Ltd CCPP	GT	Dhaka	Narayanganj	240	240	Gas	132 kV	23-May-01		Private	Pendekar
Haripur P. Ltd CCPP	Steam	Dhaka	Narayanganj	120	120		132 kV	23-May-01		Private	Pendekar
Haripur EGCB 360 MW	360 MW	Dhaka	Narayanganj	412	412	Gas	230 kV		01-12-2001	Public	EGCB
Meghnaghat P.Ltd CCPP	CCPP (3)	Dhaka	Narayanganj	450	450	Gas	230 kV	26-Nov-02	26-11-2002	Private	Pendekar
Meghnaghat IEL		Dhaka	Narayanganj	100	100	HFO	132 kV	8-May-11	2011/8/5	Private	IEL
Meghnaghat Summit		Dhaka	Narayanganj	350	335	HSD		On test		Private	
Madanganj 102 MW		Dhaka	Narayanganj	102	102	HFO	132 kV	1-Apr-11	2011/1/4	Private	Summit Power
Keraniganj	100 MW	Dhaka	Dhaka	100	100	HFO	132 kV	27-Mar-12	27/03/2012	Private	Power Pac
Narshingdi	22	Dhaka	Norshingdi	22	22	Gas	33 kV	21-Dec-08	21-12-2008	Private	RPCL
Siddhirgonj ST	ST	Dhaka	Narayanganj	210	150	Gas	230 kV	3-Sep-04	03-09 2004	Public	BPDB
Siddhirgonj GT-1, 2	GT 1,2	Dhaka	Narayanganj	210	210	Gas	132 kV	5-Feb-12	2012/5/2	Public	EGCB
Siddhirganj 100MW	100 MW	Dhaka	Narayanganj	100	96	HSD	132 kV	17-Feb-11	17/02/2011	Private	Desh Energy
Dutch Bangla 100 MW	100 MW	Dhaka	Narayanganj	100	100	HFO	132 kV	21-Jul-11	21/07/2011	Private	Dutch Bangla
DPA Power 50MW	50 MW	Dhaka	Narayanganj	50	49	HSD	33 kV	24-Nov-10	24/11/2010	Private	Primordial Energy Ltd.
Summit Power (Dhaka)		Dhaka	Dhaka	150	146	Gas	33 kV	9-Jun-09	Rupganj: 9 - 6-2009 Mawna: 12/5/2009	Private	Summit Power
Gazipur RPCL		Dhaka	Gazipur	50	50	HFO	33 kV	12-Jul-12		Private	RPCL
Tongi GT	GT	Dhaka	Dhaka	105	105	Gas	132 kV	28-Mar-05	28-03-2005	Public	BPDB
Chittagong Raozan ST 1	ST-1	Chittagong	Chittagong	210	210	Gas	230 kV	28-Mar-93	28-03-1993	Public	BPDB
Chittagong Raozan ST 2	ST-2	Chittagong	Chittagong	210	210	Gas	230 kV	21-Sep-97	21-09-1997	Public	BPDB
Raozan 25 MW	25 MW	Chittagong	Chittagong	25	25	HFO	33 kV	3-May-13	2013/3/5	Private	RPCL
Kaptai Hydro unit 1,2,3,4 &	1	Chittagong	Rangamati	46	220	0	132 kV	26-Feb-62	26-02-1962	Public	BPDB
Kaptai Hydro unit 1,2,3,4 &	2	Chittagong	Rangamati	46			132 kV	8-Jan-62	08-01-1962	Public	BPDB
Kaptai Hydro unit 1,2,3,4 &	3	Chittagong	Rangamati	50			132 kV	8-Jan-82	08-01-1982	Public	BPDB
Kaptai Hydro unit 1,2,3,4 &	4	Chittagong	Rangamati	50			132 kV	11-Jan-88	11-01-1988	Public	BPDB
Kaptai Hydro unit 1,2,3,4 &	5	Chittagong	Rangamati	50			132 kV	11-Jan-88	11-01-1988	Public	BPDB
Sikalbaha ST	ST	Chittagong	Chittagong	60	40	Gas	132 kV	24-Apr-84	24-04-1984	Public	BPDB
Sikalbaha GT	GT	Chittagong	Chittagong	150	150	Gas	132 kV	18-Aug-10	18-08-2010	Public	BPDB
Sikalbaha	Energis	Chittagong	Chittagong	60	53	HFO	132 kV	6-Jun-11	2011	Public	Energis
Hathazari	100 MW	Chittagong	Chittagong	100	0	HFO	132 kV	23-Dec-11	23-12-2011	Public	BPDB
Dohazari	102 MW	Chittagong	Chittagong	102	0	HFO	132 kV	1-Jan-12	2012/1/1	Public	BPDB
Juldah		Chittagong	Chittagong	100	0	HFO	132 kV	26-Mar-12	26/03/2012	Private	Acorn Infra Service Ltd
Malancha,Ctg EPZ		Chittagong	Chittagong	40	0	Gas	33 kV			Private	United Power
Barabkunda		Chittagong	Chittagong	22	22	Gas	33 kV	23-May-09	23-05-2009	Private	Regent
Ashuganj ST 1 & 2	1	Chittagong	Brahmanbaria	64	128	Gas	132 kV	17-Jul-70	17-07-1970	Public	APCL
	2	Chittagong	Brahmanbaria	64		Gas	132 kV	8-Jul-70	08-07-1970	Public	APCL
Ashuganj ST 3	3	Chittagong	Brahmanbaria	150	390	Gas	230 kV	17-Dec-86	17-12-1986	Public	APCL
Ashuganj ST 4	4	Chittagong	Brahmanbaria	150		Gas	230 kV	4-May-87	04-05-1987	Public	APCL
Ashuganj ST 5	5	Chittagong	Brahmanbaria	150		Gas	230 kV	21-Mar-88	21-03-1988	Public	APCL
Ashuganj CCPP	CCPP-146MW	Chittagong	Brahmanbaria	146	91	Gas	132 kV	15-Nov-86	28-03-1984	Public	APCL
Ashuganj 50 MW TSK	50 MW	Chittagong	Brahmanbaria	50	53	Gas	132 kV	30-Apr-11	30-04-2011	Public	APCL
Ashuganj Precision	Precision	Chittagong	Brahmanbaria	55	55	Gas	132 kV	7-Apr-10	07/04/10	Private	Precision
Ashuganj Aggrekko	Aggreko	Chittagong	Brahmanbaria	80	80	Gas	132 kV	31-May-11	31/05/2011	Private	Aggreko
Ashuganj UP-53 MW	Up-53 MW	Chittagong	Brahmanbaria	53	53	Gas	132 kV	22-Jun-11	22/06/2011	Private	United Power
Ashuganj Midland		Chittagong	Brahmanbaria			Gas				Private	Midland Power
Brahmanbaria 70MW		Chittagong	Brahmanbaria	68	68	Gas	132 kV	6-Mar-11	2011/6/3	Private	Aggreko
Daudkandi 50 MW		Chittagong	Comilla	50	52	FO	132 kV	29-Oct-11	29-10-2011	Public	BPDB
Chandpur CCPP	CCPP	Chittagong	Chandpur	150	0	Gas	132 kV	1-Jul-12	July-12	Public	BPDB

Table 4.1-3 Existing Power Stations (2/2)

Power Station Name	Unit		District	Installe d Gapacit	Derated Capacit y MW	Fuel	Grid Connecte d Voltage	Modified Commissioning Date	Commissioning Date	Entity	Producer
Feni		Chittagong	Feni	20	22	Gas	33 kV	16-Feb-09	16-02-2009	Private	Doreen
Mahipal,Feni		Chittagong	Feni	10	11	Gas	33 kV	22-Apr-09	22-4-2009	Private	Doreen
Jangalia		Chittagong	Comilla	34	33	Gas	33 kV	25-Jun-09	25-06-2009	Private	Summit Power
Summit Power (Comilla)		Chittagong	Comilla	25	25	Gas	33 kV	2-Jun-01		Private	Summit Power
RPCL CCPP,Mymensingh	1 - 4	Dhaka	Mymensingh	210	185	Gas	132 kV	20-Nov-99	, Jan 00Oct. 00,Dec.00J	Private	RPCL
Tangail		Dhaka	Tangail	20	22	Gas	33 kV	12-Nov-08	39793	Private	Doreen
Fenchugonj CCPP (old)	GT-1	Sylhet	Sylhet	30	30	Gas	132 kV	24-Dec-94	24-12-1994	Public	
Fenchugonj CCPP (old)	GT-2	Sylhet	Sylhet	30	30	Gas	132 kV	31-Jan-95	31-01-1995	Public	
Fenchugonj CCPP (old)	Steam	Sylhet	Sylhet	30	30	Gas	132 kV	8-Jun-95	08-06-1995	Public	
Fenchugonj CCPP (new)	CCPP-2(New)	Sylhet	Sylhet	104	104	Gas	132 kV	26-Oct-11	26-10-2011	Public	
Fenchugonj BEDL	51 MW	Sylhet	Sylhet	51	51	Gas	132 kV	18-Oct-09	18-10-2009	Private	BEDL
Fenchuganj Prima 50 MW	50 MW	Sylhet	Sylhet	50	0	Gas	132 kV	15-Feb-12	15-02-2012	Private	Energyprima
Hobiganj		Sylhet	Habiganj	11	11	Gas	33 kV	10-Jan-09	10/01/09	Private	Saiham Power Plant Ltd
Shahjibazar GT 8,9	Unit-8,9	Sylhet	Habiganj	66	66	Gas	132 kV	28-Mar-00	25-10-2000	Public	
Shahjibazar 86 MW	86 MW	Sylhet	Habiganj	86	86	Gas	132 kV	9-Feb-09	09-2- -2009	Private	hahjibazar Power Co. Ltd
Shahjibazar 50 MW	50 MW	Sylhet	Habiganj	50	50	Gas	132 kV	39765	13-11-2008	Private	Energyprima
Sylhet 150 MW	150 MW	Sylhet	Sylhet	150	150	Gas	132 kV	28-Mar-12	28-03-2012	Public	
Sylhet GT	GT(Gas)	Sylhet	Sylhet	20	20	Gas	132 kV	13-Dec-86	13-12-1986	Public	
Sylhet 50MW	50 MW	Sylhet	Sylhet	50	50	Gas	132 kV	23-Jul-08	23-07-08	Private	Energyprima
Sylhet 11 MW	11 MW	Sylhet	Sylhet	11	10	Gas	33 kV	15-Mar-09	15-03-2009	Private	Desh Energy
Shahjahanulla 25MW		Sylhet	Sylhet			Gas				Private	
Bheramara GT 1, 2 & 3	GT-1	Khulna	Kushtia	20	46	HSD	132 kV	28-Jul-76	28-07-1976	Public	
Bheramara GT 1, 2 & 3	GT-2	Khulna	Kushtia	20			132 kV	27-Apr-76	27-04-1976	Public	
Bheramara GT 1, 2 & 3	GT-3	Khulna	Kushtia	20			132 kV	19-Jan-80	19-01-1980	Public	
Bheramara	105 MW	Khulna	Kushtia	105	105	HSD	132 kV	31-Dec-10	31-12-2010	Private	Quantum Power
HVDC C/B Interconnector		Khulna	Kushtia			0	230 kV			Private	
Khulna ST 110MW	ST 110 MW	Khulna	Khulna	110	55	FO	132 kV	25-May-73	25-05-1973	Public	
Khulna ST 60MW	ST 60MW	Khulna	Khulna	60	30	FO	132 kV	7-Jul-84	07-07-1984	Public	
Khulna 40 MW	40 MW	Khulna	Khulna	40	40	HSD	33 kV	12-Jun-08	12-06-2008	Private	
Khulna 55 MW	55 MW	Khulna	Khulna	55	55	HSD	33 kV	10-Aug-10	10-08-2010	Private	Aggreko
KPCL ,Khulna.		Khulna	Khulna	110	110	HFO	132 kV	12-Oct-98	12-10-1998	Private	Summit Power
KPCL ,Khulna.(new)		Khulna	Khulna	115	115	HFO	132 kV	1-Jun-11	40549	Private	Summit Power
Khulna 150MW		Khulna	Khulna			HSD	132 kV			Private	
Faridpur		Dhaka	Faripur	54	54	FO	132 kV	4-Nov-11	40644	Public	BPDB
Gopalganj 110 MW		Dhaka	Gopalganj	110	109	HFO	132 kV	16-Nov-11	16-11-2011	Public	BPDB
Noapara (105 MW) Quanta	105 MW	Khulna	Jessore	105	101	HFO	132 kV	26-Aug-11	26-08-2011	Private	Quantum Power
Noapara (40 MW),KZA	40 MW	Khulna	Jessore	40	40	HFO	33 kV	29-May-11	29-05-2011	Private	han Jahan Ali Company Lt
Barisal Diesel	HSD	Barisal	Barisal	2	2		132 kV			Public	
Barisal GT 1 & 2	GT 1&2	Barisal	Barisal	40	32	HSD	132 kV	5-Aug-87	)5-08-198404-10-1987	Public	
Bhola		Barisal	Bhola	33	33	Gas	33 kV	12-Jul-09	40154	Private	Sinha Power
Baghabari GT 1	GT 1	Rajshahi	Sirajganj	71	71	Gas	132 kV	4-Jun-91	04-06-1991	Public	
Baghabari GT 2	GT 2	Rajshahi	Sirajganj	100	100	Gas	132 kV	25-Nov-01	25-11-2001	Public	
Baghabari 50 MW	50 MW	Rajshahi	Sirajganj	50	52	HFO	132 kV	29-Aug-11	29-08-2011	Public	
Baghabari Westmont	Westmont	Rajshahi	Sirajganj	70	70	Gas	132 kV	26-Jun-99	26-06-1999	Private	
Bera 70 MW		Rajshahi	Pabna	70	71	HFO	132 kV	28-Oct-11	28-10-2011	Public	
Amnura 50 MW		Rajshahi	Nawabganj	50	0	HFO	132 kV	13-Jan-12	13-01-2012	Private	Sinha Power
Katakhali NPS 50 MW		Rajshahi	Rajshahi	50	0	HFO	132 kV	22-May-12	22-05-2012	Private	NPSL
Katakhali PPP 50 MW		Rajshahi	Rajshahi	50	50	HFO	132 kV	1-Dec-12	December , 2012	Public	
Sirajganj 150 MW		Rajshahi	Sirajganj	150	150	Gas	132 kV	3-Feb-13		Public	BPDB
Santahar 50 MW		Rajshahi	Naogaon	50	50	HFO	132 kV	1-Dec-12	December , 2012	Public	
Bogra GBB		Rajshahi	Bogra	21	21	Gas	33 kV	11-Apr-08	11-04-2008	Private	GBB Power Ltd.
Barapukuria ST 1	ST 1	Rajshahi	Bogra	125	125	Coal	230 kV	31-Jan-06	31-01-2006	Public	
Barapukuria ST 2	ST 2	Rajshahi	Bogra	125	125	Coal	230 kV	31-Jan-06	31-01-2006	Public	
Bogra 20MW		Rajshahi	Bogra	20	20	Gas	33 kV	12-Nov-11	12-11-2011	Private	Energyprima
Summit Power (Ullapara)		Rajshahi	Sirajganj	11	11	Gas	33 kV	2-Mar-09	02-03-2009	Private	Summit Power
Rangpur GT		Rangpur	Rangpur	20	20	HSD	132 kV	16-Aug-88	16-08-1988	Public	
Sayadpur GT		Rangpur	Nilphamari	20	20	HSD	132 kV	17-Sep-87	17-09-1987	Public	
Thakurgaon		Rangpur	Thakurgaon	47	47	HSD	132 kV	2-Aug-10	2-08-2010	Private	RZPL
Rajlanka 52 MW		Rajshahi	Natore	52	52	FO				Private	RLPCL
Total				6691	9508						

4.2 Power Generation Plan between Dhaka and Chittagong

Table 4.2-1 and Table 4.2-2 list the existing and the future power stations to be operated in 2023. The power plants that are scheduled to be retired are removed from the list. The large scaled power plants located in south Chittagong related to the Project are listed in the following table.

Table 4.2-1 Large Scaled Power Plants Located in South Chittagong Related to the Project

Name of Power Station	Type of Fuel	Commercial Operation Date(COD)	Installed Capacity
Sikalbaha 225 MW CCPP	Gas/ F. Oil	1-Mar-2017	225
Anowara, Chittagong 1000 MW CCPP	LNG	1-Dec-2019	1000
Matarbari 1200 MW Coal Power Plant (CPGCBL)	Imp. Coal	1-Jun-2021	1200
Moheskhali 1200 MW Coal Power Plant	Imp. Coal	1-Jun-2022	1200
Moheskhali G-to-G 1000 MW Coal Power Plant	Imp. Coal	1-Jun-2022	1000

(Source: PGCB)

Table 4.2-2 Existing Generation Capacity to be Operated in 2023

Existing Generation Capacity

SL No.	Name of Power Station/ Location	Ownership	Grid	Type of Fuel	COD Date (DD/MM/YY)	Voltage Level KV	Installed Capacity (MW)	Derated Capacity (MW)	Area
1	Karnaphuli Hydro 2	Public	East	Hydro	8-Jan-1962	132	40	40	Chittagong
2	Karnaphuli Hydro 1	Public	East	Hydro	26-Feb-1962	132	40	30	Chittagong
3	Karnaphuli Hydro 3	Public	East	Hydro	8-Jan-1982	132	50	50	Chittagong
4	Karnaphuli Hydro 4	Public	East	Hydro	11-Jan-1988	132	50	50	Chittagong
5	Karnaphuli Hydro 5	Public	East	Hydro	11-Jan-1988	132	50	50	Chittagong
6	Ghorasal (Polash, Norshindi) 210 MW ST3	Public	East	Gas	14-Sep-1986	230	210	180	Dhaka
7	Ghorasal (Polash, Norshindi) 210 MW ST4	Public	East	Gas	18-Mar-1989	230	210	180	Dhaka
8	Raozan (Chittagong) (210 MW) 1	Public	East	Gas	28-Mar-1993	230	210	180	Chittagong
9	Ghorasal (Polash, Norshindi) 210 MW ST5	Public	East	Gas	15-Sep-1994	230	210	190	Dhaka
10	Raozan (Chittagong) (210 MW) 2	Public	East	Gas	21-Sep-1997	230	210	180	Chittagong
11	Ghorasal (Polash, Norshindi) 210 MW ST6	Public	East	Gas	31-Jan-1999	230	210	190	Dhaka
12	RPCL (Mymenshing) (210 MW)	Private	East	Gas	20-Nov-1999	132	210	197	Dhaka
13	Haripur Power Ltd. (360 MW CC)	Private	East	Gas	23-May-2001	230	360	360	Dhaka
14	Meghnaghat power Ltd. (450 MW) (Norshindhi)	Private	East	Gas	26-Nov-2002	230	450	450	Dhaka
15	Siddhirganj (210 MW) ST	Public	East	Gas	3-Sep-2004	230	210	150	Dhaka
16	Tongi (105 MW) (Dhaka)	Public	East	Gas	28-Mar-2005	132	105	105	Dhaka
17	Summit Power (REB)	Private	East	Gas	16-Dec-2006	33	105	105	
18	Tangail SIPP (Doreen)	Private	East	Gas	12-Nov-2008	33	22	22	Dhaka
19	Narsindi SIPP (REB) (Doreen)	Private	East	Gas	21-Dec-2008	33	22	22	Dhaka
20	Hobiganj SIPP (REB) (Confi-Energypac)	Private	East	Gas	10-Jan-2009	33	11	11	
21	Shahjibazar 15 Yrs RPP	Private	East	Gas	9-Feb-2009	132	86	86	Comilla
22	Feni SIPP (Doreen)	Private	East	Gas	16-Feb-2009	33	22	22	Comilla
23	Ullapara SIPP (REB) (Summit)	Private	West	Gas	2-Mar-2009	33	11	11	Bogra
24	Kumkargoan, Sylhet 15 Years RPP (Desh Energy)	Private	East	Gas	15-Mar-2009	33	10	10	
25	Mahipal, Feni SIPP (REB)	Private	East	Gas	22-Apr-2009	33	11	11	Comilla
26	Mouna, Gazipur SIPP (REB)	Private	East	Gas	12-May-2009	33	33	33	Dhaka
27	Barobkundo SIPP (Regent Power)	Private	East	Gas	23-May-2009	33	22	22	
28	Rupganj , Narayanganj SIPP (REB)	Private	East	Gas	9-Jun-2009	33	33	33	Dhaka
29	Jangalia, Comilla SIPP (Summit)	Private	East	Gas	25-Jun-2009	33	33	33	Comilla
30	Bhola, SIPP (Venture)	Private	West	Gas	12-Jul-2009	33	33	33	
31	Fenchuganj 15 Years RPP (Barakatullah)	Private	East	Gas	18-Oct-2009	132	51	51	Comilla
32	Shikalbaha 150 MW Peaking PP	Public	East	Gas	18-Aug-2010	132	150	150	Chittagong
33	SIDDHIRGANJ 2x120 MW #2 EGCB	Public	East	Gas	14-Oct-2010	132	105	105	
34	Ashugonj 50 MW	Public	East	Gas	30-Apr-2011	132	53	51	Comilla
35	Baghabari 50 MW Peaking PP	Public	West	F.Oil	29-Aug-2011	132	52	52	Bogra
36	FENCHUGANJ CC (104 MW) 2 nd Unit	Public	East	Gas	26-Oct-2011	132	104	104	Bogra
37	Bera 70 MW Peaking PP	Public	West	F.Oil	28-Oct-2011	132	71	71	Bogra
38	Titas, Doudkandi 50 MW Peaking PP	Public	East	F.Oil	29-Oct-2011	132	52	52	Comilla
39	Faridpur 50 MW Peaking PP	Public	West	F.Oil	4-Nov-2011	132	54	54	
40	Gopalgonj 100 MW Peaking PP	Public	West	F.Oil	16-Nov-2011	132	109	109	
41	SIDDHIRGANJ 2x120 MW #1 EGCB	Public	East	Gas	1-Dec-2011	132	105	105	
42	Hathazari 100 MW Peaking PP	Public	East	F.Oil	23-Dec-2011	132	98	98	Chittagong
43	Sangu, Dohazari 100 MW Peaking PP	Public	East	F.Oil	1-Jan-2012	132	102	102	Chittagong
44	Sylhet 150 MW Power Plant	Public	East	Gas	28-Mar-2012	132	142	142	Comilla
45	Gazipur 50 MW Power Plant RPCL	Public	East	F.Oil	1-Jul-2012	132	52	52	Dhaka
46	Chandpur 150 MW CCPP	Public	East	Gas	1-Jul-2012	132	163	163	Comilla
47	Sirajganj 150 MW GT (China Mechinaries EXIMCO)	Public	West	Gas/ HSD	1-Sep-2012	132	150	150	Bogra
48	Santahar 50 MW Peaking Power Plant	Public	West	F.Oil	1-Dec-2012	132	50	50	Bogra
49	Katakhali 50 MW Peaking Power Plant	Public	West	F.Oil	1-Dec-2012	132	50	50	Bogra
50	Raozan 25 MW Peaking PP	Private	East	F.Oil	3-May-2013	33	25	25	Chittagong
51	Haripur 360 MW CCPP	Public	East	Gas	Test Run	132	412	412	Dhaka
52	Khulna 150 MW GT	Public	West	HSD	23-Sep-2013	132	150	150	Khulna
53	Ashugonj 51 MW (Midland) PP	Private	East	Gas	6-Dec-2013	132	51	51	Comilla
54	Shajahanullah Power Com. Ltd.	Private	East	Gas	1-Nov-2013	33	25	25	
55	Power IMPORT from India	Public	West		1-Nov-2013	400	500	500	
56	Natore 52 MW Power Plant (Raj Lanka Power)	Private	West	F.Oil	24-Jan-2014	132	52	52	Bogra
								5962	

Table 4.2-3 Future Generation Capacity to be Operated in 2023

Generation Capacity installed from May-2014 to the end of 2023									
SL No.	Name of Power Station/ Location	Ownership	Grid	Type of Fuel	COD Date (DD/MM/YY)	Voltage Level KV	Installed Capacity (MW)	Derated Capacity (MW)	Area
57	Sirajgonj 150 MW PP Conversion (NWPGC)	Public	West	Gas/ HSD	1-May-2014		75	75	Bogra
58	Ghorashal, Narsingdi 100 MW PP	Private	East	Gas	1-May-2014		108	108	Dhaka
59	Baraka-Patanga, Chittagong 50 MW PP	Private	East	F.Oil	1-May-2014		50	50	Chittagong
60	Gogonnagar, Narayangonj 100 MW PP	Private	East	F.Oil	1-May-2014		102	102	Dhaka
61	Potiya, Chittagong 100 MW Power Plant	Private	East	F.Oil	1-May-2014		108	108	Chittagong
62	Kathpotti, Munshigonj 50 MW Power Plant	Private	East	F.Oil	1-Jun-2014		53	53	Dhaka
63	Meghnaghat 300-450 MW CCPP (2nd Unit)	Private	East	Gas/ F.Oil	1-Oct-2014		335	335	Dhaka
64	Alir Tak, Narayangonj 50 MW Power Plant	Private	East	F.Oil	1-Dec-2014		53	53	Dhaka
65	Nababgonj 55 MW PP	Private	East	F.Oil	1-Dec-2014		55	55	Dhaka
66	Bosila, Keranigonj 108 MW PP (CLC Power)	Private	East	F.Oil	1-Dec-2014		108	108	Dhaka
67	Manikganj 55 MW PP	Private	East	F.Oil	1-Mar-2015		55	55	Dhaka
68	Jangalia, Comilla 52 MW PP	Private	East	Gas/ F.Oil	1-Mar-2015		52	52	Comilla
69	Ashugonj 225 CCPP	Public	East	Gas	1-Jun-2015		225	225	Dhaka
70	Ashuganj (South) 450 MW CCPP	Public	East	Gas	1-Jun-2015		373	373	Dhaka
71	Keranigonj 100 MW Power Plant (Relocate from Khulna)	Private	East	F.Oil	1-Jun-2015		100	100	Dhaka
72	Bosila, Keranigonj, (Dhaka West) 108 MW PP	Private	East	F.Oil	1-Jun-2015		108	108	Dhaka
73	Jamalpur 100 MW Power Plant	Private	West	Gas/ F.Oil	1-Jun-2015		95	95	Dhaka
74	Gabtoli, Dhaka 108 MW PP	Private	East	F.Oil	1-Jun-2015		108	108	Dhaka
75	Ashugonj 195 MW Modular PP	Public	East	Gas	1-Jun-2015		195	195	Dhaka
76	Fenchugonj 50 MW Power Plant	Private	East	Gas	1-Jun-2015		50	50	Dhaka
77	Bhairab, Kishorgonj 50 MW PP	Private	East	F.Oil	1-Aug-2015		50	50	Dhaka
78	Kodda, Gazipur 150 MW Power Plant	Public	East	F.Oil/ Gas	1-Sep-2015		150	150	Dhaka
79	Sylhet 150 MW PP Conversion	Public	East	Gas	1-Sep-2015		75	75	Comilla
80	Up gradation of Khulna 150 MW to 225 MW (NWPGCL)	Public	West	Gas/ HSD	1-Sep-2015		75	75	Khulna
81	Siddirganj 335 MW CCPP	Public	East	Gas	1-Dec-2015		335	335	Dhaka
82	Bhola 225 MW CCPP	Public	West	Gas	1-Dec-2015		195	195	Khulna
83	Kaptai Solar	Public	East	Solar	1-Dec-2015		8	8	Chittagong
84	Hatiya Hybride	Public	East	F.Oil/ Solar	1-Dec-2015		7	7	
85	Madangonj 50 MW Peaking Plant(Re. from Shantahar)	Private	East	F.Oil	1-Dec-2015		50	50	Dhaka
86	Barisal 100 MW PP (Re. from Syedpur)	Private	West	F.Oil	1-Dec-2015		100	100	Khulna
87	Sorishabari 3 MW Solar	Private	West	Solar	1-Dec-2015		3	3	
88	Dhorola 30 MW Solar Park	Private	West	Solar	1-Dec-2015		30	30	Bogra
89	Bibiana 300-450 MW CCPP (2nd Unit)	Private	East	Gas	1-Jan-2016		341	341	Dhaka
90	Munshigonj 50 MW PP	Private	East	F.Oil	1-Jun-2016		50	50	Dhaka
91	Satkhira 50 MW PP	Private	West	F.Oil	1-Jun-2016		50	50	Khulna
92	Fenchugonj 163 MW CCPP	Private	East	Gas	1-Jun-2016		163	163	Dhaka
93	Chapai Nababganj 104 MW PP	Public	West	F.Oil	1-Jun-2016		104	104	Bogra
94	Bagabari 100 MW PP Conversion	Public	West	Gas	1-Jun-2016		50	50	Bogra
95	Shajibazar 70 MW PP Conversion	Public	East	Gas	1-Jun-2016		35	35	Comilla
96	Bibiana #3 CCPP	Public	East	Gas	1-Dec-2016		400	400	Dhaka
97	Shajibazar CCPP	Public	East	Gas	1-Dec-2016		332	332	Comilla
98	Chittagong 65-85 MW CCPP	Private	East	Naphtha/ Gas	1-Dec-2016		65	65	Chittagong
99	Wind	Private	East	Wind	1-Dec-2016		100	100	Chittagong
100	Ashugonj (North) CCPP	Public	East	Gas	1-Jan-2017		381	381	Dhaka
101	Ghorasal 3rd Unit Repowering (Capacity Addition)	Public	East	Gas	1-Jan-2017		206	206	Dhaka
102	Bheramara 360 MW CCPP (NWPGC)	Public	West	Gas	1-Jan-2017		360	360	Khulna
103	Ghorasal 363 MW CCPP	Public	East	Gas	1-Mar-2017		363	363	Dhaka
104	Shikalbaha 225 MW CCPP	Public	East	Gas/ F.Oil	1-Mar-2017		225	225	Chittagong
105	Sirajganj 300-450 MW CCPP	Private	West	Gas/ HSD	1-Mar-2017		367	367	Bogra
106	Sirajganj 225 MW CCPP (2nd Unit):(NWPGC)	Public	West	Gas/ HSD	1-Apr-2017		220	220	Bogra
107	Barapukuria 275 MW (3rd Unit)	Public	West	Coal	1-Jun-2017		274	274	Bogra
108	Ghorasal 6th Unit Repowering (Capacity Addition)	Public	East	Gas	1-Sep-2017		206	206	Dhaka
109	Bibiana South 300-450 MW CCPP	Public	East	Gas	1-Dec-2017		450	450	Comilla
110	Sirajgonj 150-225 MW CCPP (LANKO)	Private	West	Gas	1-Dec-2017		218	218	Bogra
111	Maowa, Munshiganj 522 MW Coal Fired Power Project (Orion)	Private	East	Imp. Coal	1-Dec-2017		522	522	Dhaka
112	Khulna 630 MW Coal Fired PP (Orion)	Private	West	Imp. Coal	1-Jan-2018		630	630	
113	Ghorasal 4th Unit Repowering (Capacity Addition)	Public	East	Gas	1-Jun-2018		206	206	
114	BIFPCL, Rampal, Khulna 1300 MW Coal Fired Power Project	Public	West	Imp. Coal	1-Dec-2018		1320	1320	
115	Anowara, Chittagong 1000 MW CCPP	Public	East	LNG	1-Dec-2019		1000	1000	Chittagong
116	Power import	Public	West	Import	1-Dec-2020		500	500	
117	Matarbari 1200 MW Coal Power Plant (CPGCL)	Public	East	Imp. Coal	1-Jun-2021		1200	1200	Chittagong
118	Ruppur Nuclear 1000 MW (BAEC) 1st Unit	Public	West	Nuclear	1-Dec-2021		1180	1180	Khulna
119	Moheskhali 1200 MW Coal Power Plant	Public	East	Imp. Coal	1-Jun-2022		1200	1200	Chittagong
120	Moheskhali G-to-G 1000 MW Coal Power Plant	Public	East	Imp. Coal	1-Jun-2022		1000	1000	Chittagong
120	Ruppur Nuclear 1000 MW (BAEC) 2nd Unit	Public	West	Nuclear	1-Dec-2023		1180	1180	Khulna
								18384	

The list of power plants assumed to be retired up to 2023 is shown below.

Table 4.2-4 Power Plants to be Retired up to 2023

Name of Power Station/ Location	Ownership	Grid	Type of Fuel	COD Date (DD/MM/YY)	Voltage Level KV	Installed Capacity (MW)	Area
Barapukuria ST 1	Public	West	Coal	31-Jan-06	230 kV	125	Bogra
Barapukuria ST 2	Public	West	Coal	31-Jan-06	230 kV	125	Bogra
Bogra 20MW	Private	West	Gas	12-Nov-11	33 kV	20	Bogra
Bogra GBB	Private	West	Gas	11-Apr-08	33 kV	21	Bogra
Amnura 50 MW	Private	West	HFO	13-Jan-12	132 kV	50	Bogra
Rajlanka 52 MW	Private	West	FO			52	Bogra
Katakhali NPS 50 MW	Private	West	HFO	22-May-12	132 kV	50	Bogra
Baghabari GT 1	Public	West	Gas	4-Jun-91	132 kV	71	Bogra
Baghabari GT 2	Public	West	Gas	25-Nov-01	132 kV	100	Bogra
Baghabari Westmont	Private	West	Gas	26-Jun-99	132 kV	70	Bogra
Sayadpur GT	Public	West	HSD	17-Sep-87	132 kV	20	Bogra
Rangpur GT	Public	West	HSD	16-Aug-88	132 kV	20	Bogra
Thakurgaon	Private	West	HSD	2-Aug-10	132 kV	47	Bogra
Juldah	Private	East	HFO	26-Mar-12	132 kV	100	Chittagong
Malancha,Ctg EPZ	Private	East	Gas		33 kV	40	Chittagong
Raozan 25 MW	Private	East	HFO	3-May-13	33 kV	25	Chittagong
Sikalbaha	Public	East	HFO	6-Jun-11	132 kV	60	Chittagong
Sikalbaha ST	Public	East	Gas	24-Apr-84	132 kV	60	Chittagong
Ashuganj Precision	Private	East	Gas	7-Apr-10	132 kV	55	Comilla
Ashuganj Aggrekko	Private	East	Gas	31-May-11	132 kV	80	Comilla
Ashuganj CCPP	Public	East	Gas	15-Nov-86	132 kV	146	Comilla
Ashuganj ST 1	Public	East	Gas	17-Jul-70	132 kV	64	Comilla
Ashuganj ST 2	Public	East	Gas	8-Jul-70	132 kV	64	Comilla
Ashuganj ST 3	Public	East	Gas	17-Dec-86	230 kV	150	Comilla
Ashuganj ST 4	Public	East	Gas	4-May-87	230 kV	150	Comilla
Ashuganj ST 5	Public	East	Gas	21-Mar-88	230 kV	150	Comilla
Ashuganj UP-53 MW	Private	East	Gas	22-Jun-11	132 kV	53	Comilla
Brahmanbaria 70MW	Private	East	Gas	6-Mar-11	132 kV	68	Comilla
Summit Power (Comilla)	Private	East	Gas	2-Jun-01	33 kV	25	Comilla
Shahjibazar 50 MW	Private	East	Gas	13-Nov-08	132 kV	50	Comilla
Shahjibazar GT 8,9	Public	East	Gas	28-Mar-00	132 kV	66	Comilla
Fenchuganj Prima 50 MW	Private	East	Gas	15-Feb-12	132 kV	50	Comilla
Fenchugonj CCPP (old)	Public	East	Gas	24-Dec-94	132 kV	30	Comilla
Fenchugonj CCPP (old)	Public	East	Gas	31-Jan-95	132 kV	30	Comilla
Fenchugonj CCPP (old)	Public	East	Gas	8-Jun-95	132 kV	30	Comilla
Sylhet 50MW	Private	East	Gas	23-Jul-08	132 kV	50	Comilla
Sylhet GT	Public	East	Gas	13-Dec-86	132 kV	20	Comilla
Keraniganj	Private	East	HFO	27-Mar-12	132 kV	100	Dhaka
DPA Power 50MW	Private	East	HSD	24-Nov-10	33 kV	50	Dhaka
Dutch Bangla 100 MW	Private	East	HFO	21-Jul-11	132 kV	100	Dhaka
Haripur NEPC	Private	East	HFO	30-Jun-99	132 kV	110	Dhaka
Haripur SBU GT 1, 2 & 3	Public	East	Gas	31-Oct-87	132 kV	32	Dhaka
Haripur SBU GT 1, 2 & 3	Public	East	Gas	15-Nov-87	132 kV	32	Dhaka
Haripur SBU GT 1, 2 & 3	Public	East	Gas	2-Dec-87	132 kV	32	Dhaka
Madanganj 102 MW	Private	East	HFO	1-Apr-11	132 kV	102	Dhaka
Meghnaghat IEL	Private	East	HFO	8-May-11	132 kV	100	Dhaka
Meghnaghat Summit	Private	East	HSD	On test		350	Dhaka
Siddhirganj 100MW	Private	East	HSD	17-Feb-11	132 kV	100	Dhaka
Ghorasal ST 1 & 2	Public	East	Gas	16-Jun-74	132 kV	55	Dhaka
Ghorasal ST 1 & 2	Public	East		13-Feb-76	132 kV	55	Dhaka
Ghorashal 100 MW	Private	East	Gas	28-Feb-12	132 kV	100	Dhaka
Ghorashal 45 MW	Private	East	Gas	28-Feb-12	33 kV	45	Dhaka
Ghorashal MAX	Private	East	Gas	27-May-11	132 kV	78	Dhaka
Barisal Diesel	Public	West			132 kV	2	Khulna
Barisal GT 1 & 2	Public	West	HSD	5-Aug-87	132 kV	40	Khulna
Noapara (105 MW) Quantam	Private	West	HFO	26-Aug-11	132 kV	105	Khulna
Noapara (40 MW),KZA	Private	West	HFO	29-May-11	33 kV	40	Khulna
Khulna 40 MW	Private	West	HSD	12-Jun-08	33 kV	40	Khulna
Khulna 55 MW	Private	West	HSD	10-Aug-10	33 kV	55	Khulna
Khulna ST 110MW	Public	West	FO	25-May-73	132 kV	110	Khulna
Khulna ST 60MW	Public	West	FO	7-Jul-84	132 kV	60	Khulna
KPCL ,Khulna.	Private	West	HFO	12-Oct-98	132 kV	110	Khulna
KPCL ,Khulna.(new)	Private	West	HFO	1-Jun-11	132 kV	115	Khulna
Bheramara	Private	West	HSD	31-Dec-10	132 kV	105	Khulna
Bheramara GT 1, 2 & 3	Public	West		27-Apr-76	132 kV	20	Khulna
Bheramara GT 1, 2 & 3	Public	West	HSD	28-Jul-76	132 kV	20	Khulna
Bheramara GT 1, 2 & 3	Public	West		19-Jan-80	132 kV	20	Khulna
Total						4670	

Chapter 5
Existing Dhaka – Chittagong Power System

Chapter 5 Existing Dhaka – Chittagong Power System

5.1 Power Network System Configuration between Dhaka and Chittagong

Figure 5.1-1 shows the existing 230 and 132 kV grid network of Bangladesh. Although some of the transmission lines are designed for operation at 400 kV, such as Meghnaghat – Aminbazar, the highest operation voltage of the current grid is 230 kV, indicated by red lines.

Figure 5.1-2 shows the 400 kV, 230 kV and 132 kV grid network plan of Bangladesh up to around 2021. One of the items in the Project scope is the 400 kV double circuit transmission line from Meghnaghat substation to Madunaghat substation located in the Chittagong district, whose length is around 210 km, illustrated surrounded by an orange ellipse. This figure illustrates just the double circuit transmission line from Meghnaghat to Madunaghat with Matarbari, Moheskhali and Anowara power stations; however, it was found out that more circuit seems to be required in this interval to transmit the power from those three power stations, according to the rough stability study described in a later section. Further study will be needed to identify adequate plans for this.

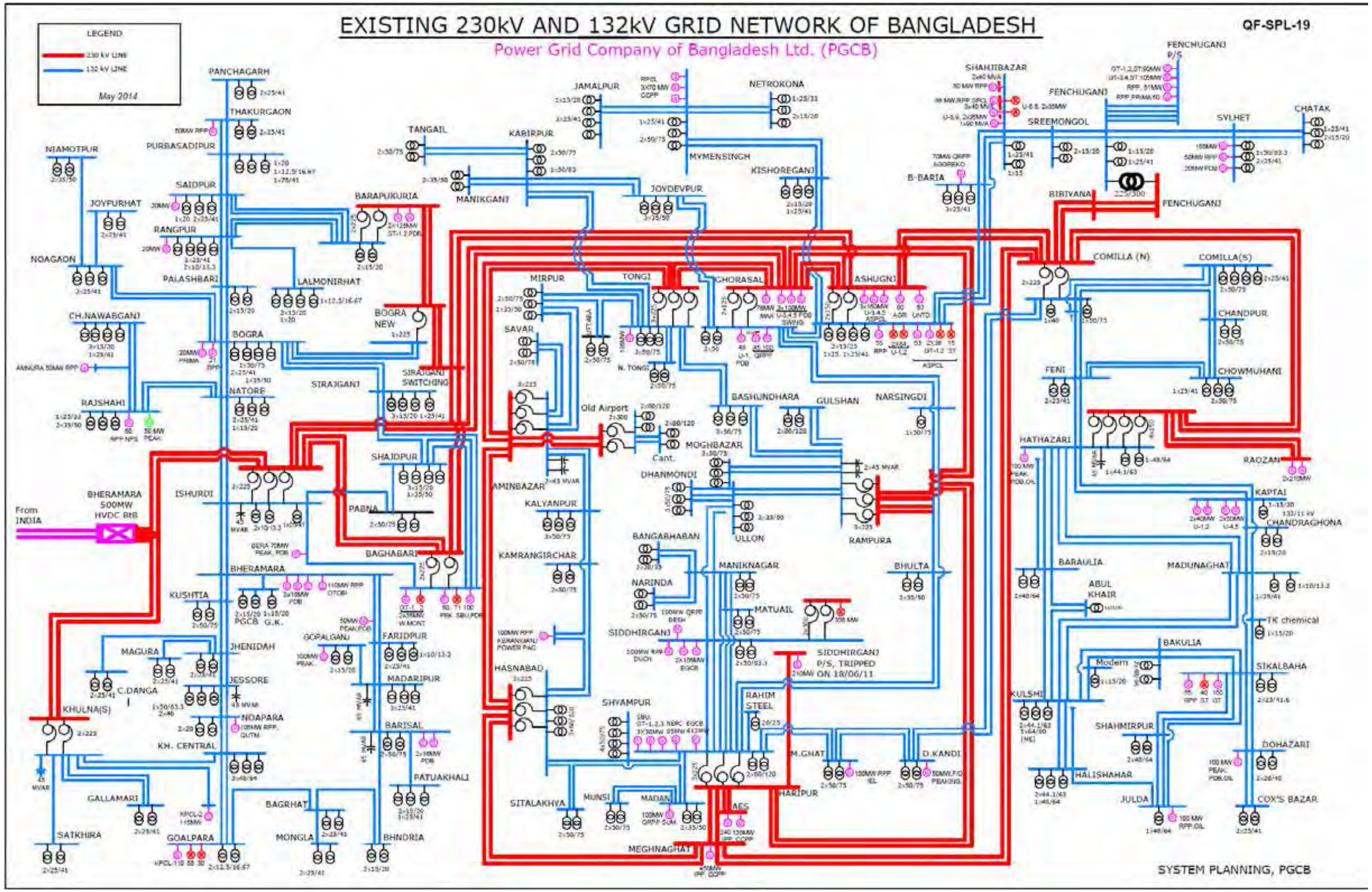
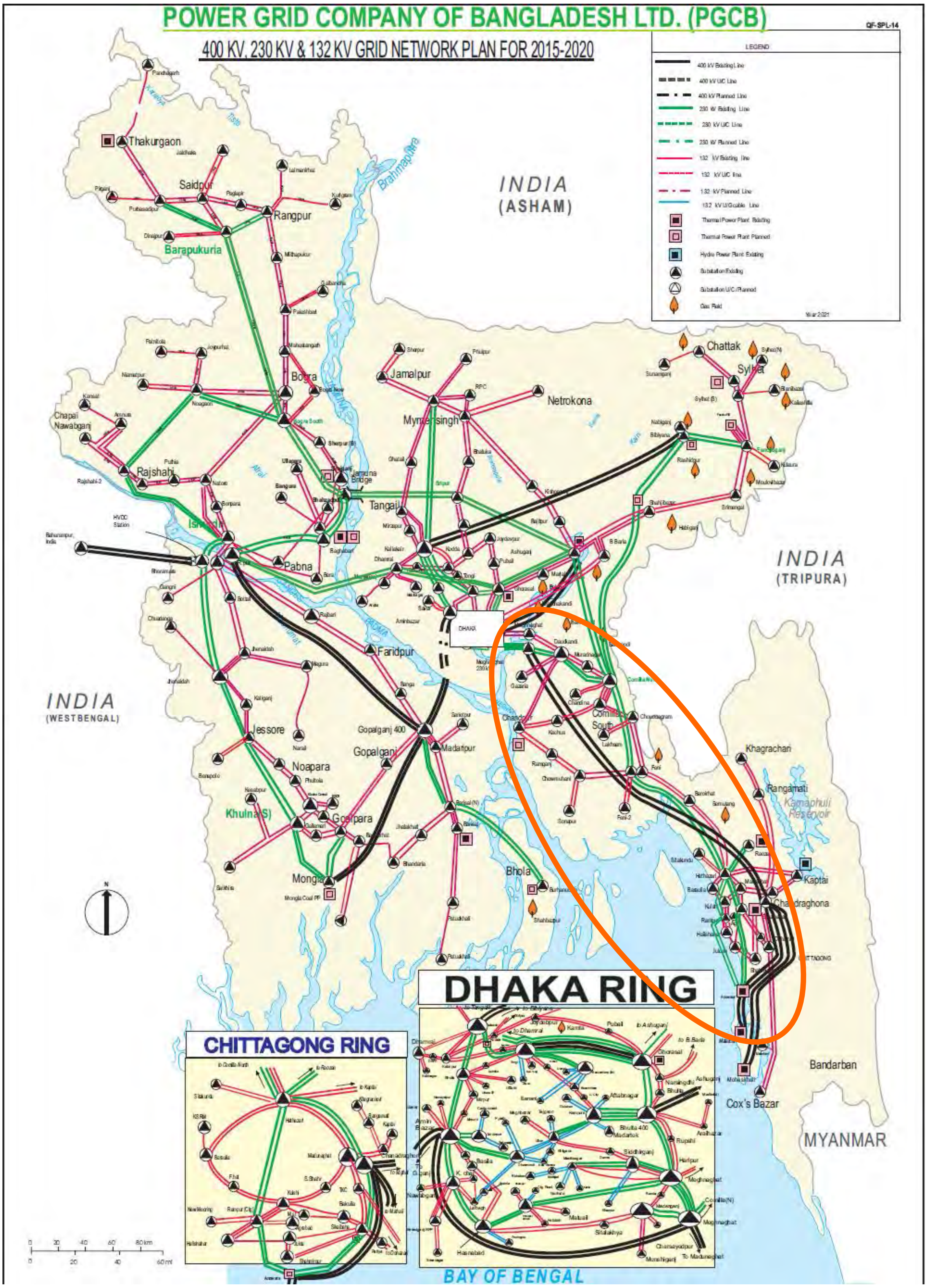


Figure 5.1-1 Existing 230 and 132 kV grid network of Bangladesh (Source: PGCB System Planning)



(Source: PGCB)

Figure 5.1-2 400, 230 & 132 kV Grid Network (Existing, Under Construction & Planned)

5.2 Power Supply-Demand Balance in Chittagong Area

5.2.1 Power Supply Demand Balance in and around Chittagong

Although some gas thermal power plants such as Raozan or Sikalbaha in Chittagong are now operated, as well as Kaptai hydropower station, the power demand in Chittagong is partially supplied from the northern part of Bangladesh, such as Dhaka, through the double circuit 230 kV transmission line and 132 kV transmission lines. Rapid growth of power demand is predicted in Chittagong and the power transmission capacity from the northern part of Bangladesh to Chittagong will be insufficient for the future power supply in Chittagong unless large power plants in its south area, such as Matarbari, are commissioned, or there is more power transmission capacity from the northern part of Bangladesh to Chittagong.

Figure 5.2-1 shows the current power system configuration from Dhaka to Chittagong.

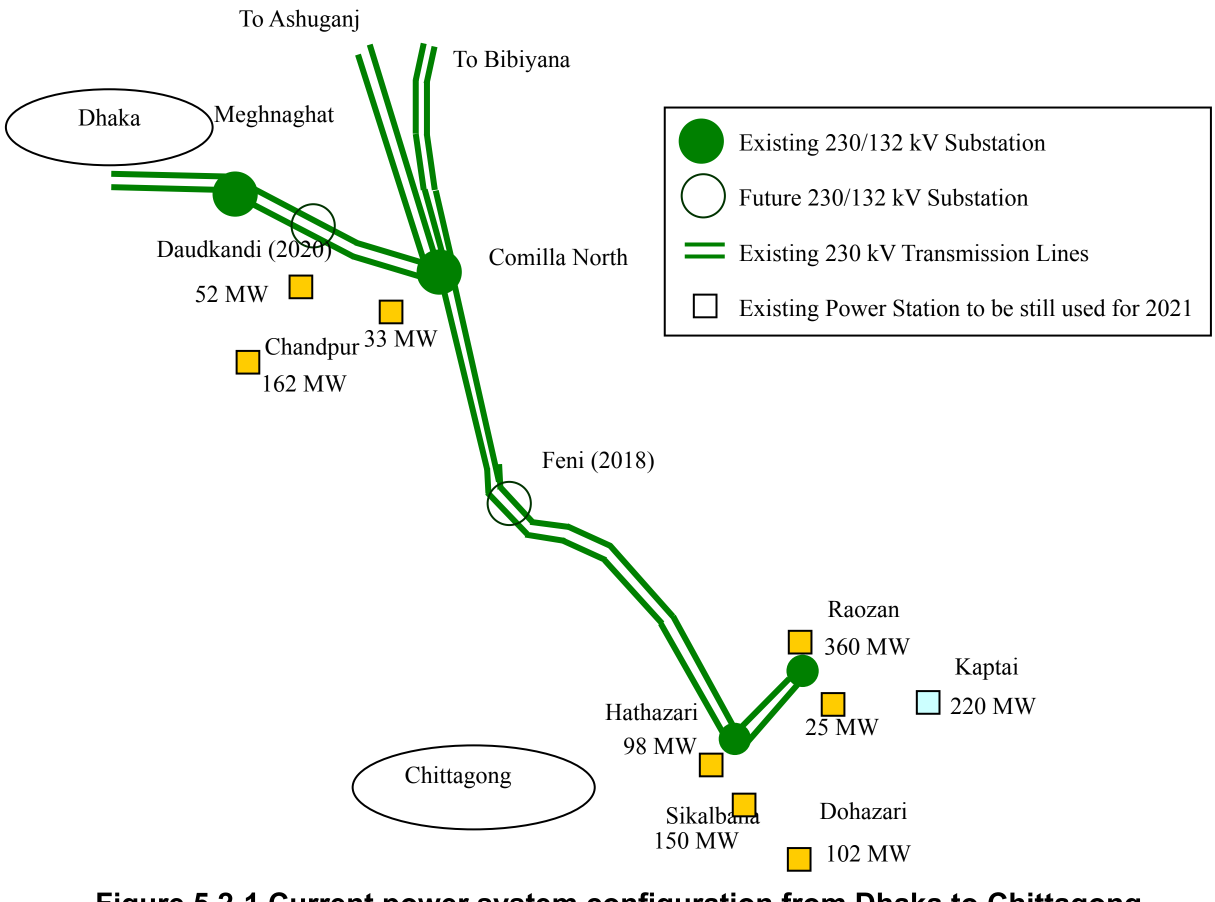


Figure 5.2-1 Current power system configuration from Dhaka to Chittagong

The situations of power supply demand balance in and around the Dhaka and Chittagong areas up to 2023 were examined by comparing the amount of the loads supplied to the 132kV system and the power output from the generators connected to the system above 132 kV. The power output was estimated on the assumption that Kaptai hydropower station was operated at 40% of its normal capacity supposed in the dry season and gas thermal power stations in Chittagong were not operated due to fuel shortages except for Sikalbaha, generating 50 MW from its normal capacity of 150 MW. The wind turbines in Chittagong were assumed to be operated at 100 MW. The power outputs of the existing power stations expected to be abolished up to 2023 were gradually decreased to 0 year by year. The power units must be planned so as to make some reserve margin. To see the regional power deficit (or regional required amount of power) in actual operation during the peak demand period of time, we compared the maximum power demand and the "counted" power supply capacity without margin. Here, its margin was assumed 8%. The estimated demand supply balance is shown in the below tables.

The maximum power demand in the Chittagong area already exceeds the total amount of power generation in the area and its insufficient power will reach 500 to 600 MW in around 2015 to 2018.

On the other hand, the transmission lines coming to the Chittagong area from other areas are only a double circuit 230 kV line between Comilla North and Hathazari and a double circuit 132 kV line with capacities of 143.8 Mega Volt-Ampere (MVA) x 2 and 346.2 MVA x 2 respectively. In consideration of a fault of N-1 contingency and line voltage drops, the allowable power flow from other areas to Chittagong is estimated at less than 500 – 600 MW. It seems difficult to compensate for the insufficient power from other areas in around 2015 to 2018 without any system reinforcement.

The power supply and demand will be balanced from the year 2019 because Anowara power station, with 1,000 MW, will be operated at that time; however, its development is currently uncertain. If Anowara is delayed, power insufficiency in the Chittagong area would become larger up to 2021, when Matarbari power station will be operated. Thus, more power transmission from Dhaka to Chittagong or urgent installation of power plants in Chittagong would be required up to 2021.

Table 5.2-1 Estimated Power Demand Supply Balance

Derated capacity is over 132 kV power supplier

Bogra		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Max. demand at 132kV	1296	1445	1611	1795	1999	2226	2477	2756	2929	3113	3308
	Derated Cap. Total *0.92	870	934	882	971	1911	1858	1805	1752	1700	1647	1594
	Existing operated in 2023	373	373	373	373	373	373	373	373	373	373	373
	Existing not operated in 202	573	515	458	401	344	286	229	172	115	57	0
	New Cap.	0	127	30	154	1079	0	0	0	0	0	0
	Accumlation new Cap.	0	127	157	311	1390	1390	1390	1390	1390	1390	1390
	Supply Cap - Max. Dem	(426)	(511)	(730)	(825)	(89)	(368)	(672)	(1004)	(1229)	(1466)	(1714)

Chittagong		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Max. demand at 132kV	850	963	1097	1220	1357	1510	1680	1871	2029	2189	2371
	Derated Cap. Total *0.92	441	573	560	699	893	880	1787	1774	2865	4876	4863
	Existing operated in 2023	340	340	339	339	339	339	339	339	338	338	338
	Existing not operated in 202	139	125	111	97	83	70	56	42	28	14	0
	New Cap.	0	158	0	165	225	0	1000	0	1200	2200	0
	Accumlation new Cap.	0	158	158	323	548	548	1548	1548	2748	4948	4948
	Supply Cap - Max. Dem	(409)	(390)	(537)	(521)	(464)	(630)	107	(97)	836	2687	2492

Comilla		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Max. demand at 132kV	1028	1147	1255	1399	1560	1739	1938	2159	2309	2401	2565
	Derated Cap. Total *0.92	1596	1501	1522	2446	2765	2670	2575	2480	2385	2289	2194
	Existing operated in 2023	646	647	647	647	647	648	648	648	648	649	649
	Existing not operated in 202	1037	934	830	726	622	519	415	311	207	104	0
	New Cap.	51	0	127	1108	450	0	0	0	0	0	0
	Accumlation new Cap.	51	51	178	1286	1736	1736	1736	1736	1736	1736	1736
	Supply Cap - Max. Dem	568	354	267	1047	1205	931	637	321	76	(111)	(371)

Dhaka		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Max. demand at 132kV	3900	4356	4840	5333	5845	6602	7377	8227	8762	9331	9979
	Derated Cap. Total *0.92	3674	4317	5953	6043	7480	7564	7457	7351	7245	7139	7032
	Existing operated in 2023	2872	2868	2865	2862	2859	2855	2852	2849	2846	2842	2839
	Existing not operated in 202	1122	1010	897	785	673	561	449	337	224	112	0
	New Cap.	0	814	1894	213	1678	206	0	0	0	0	0
	Accumlation new Cap.	0	814	2708	2921	4599	4805	4805	4805	4805	4805	4805
	Supply Cap - Max. Dem	(226)	(39)	1113	709	1635	962	80	(876)	(1517)	(2192)	(2946)

Khulna		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Max. demand at 132kV	1123	1251	1395	1554	1732	1944	2151	2397	2555	2724	2904
	Derated Cap. Total *0.92	1096	1047	1337	1333	1615	3359	3309	3719	4755	4705	5741
	Existing operated in 2023	0	0	0	0	0	0	0	0	0	0	0
	Existing not operated in 202	542	488	433	379	325	271	217	163	108	54	0
	New Cap.	650	0	370	50	360	1950	0	500	1180	0	1180
	Accumlation new Cap.	650	650	1020	1070	1430	3380	3380	3880	5060	5060	6240
	Supply Cap - Max. Dem	(27)	(205)	(58)	(220)	(117)	1415	1157	1322	2200	1981	2837

Total		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Max. demand at 132kV	8197	9162	10197	11302	12494	14020	15623	17410	18585	19757	21127
	Derated Cap. Total *0.92	7677	8371	10254	11492	14664	16330	16933	17076	18949	20656	21425
	Existing operated in 2023	4231	4228	4224	4221	4218	4215	4212	4209	4205	4202	4199
	Existing not operated in 202	3413	3071	2730	2389	2048	1706	1365	1024	683	341	0
	New Cap.	701	1099	2421	1690	3792	2156	1000	500	2380	2200	1180
	Accumlation new Cap.	701	1800	4221	5911	9703	11859	12859	13359	15739	17939	19119
	Supply Cap - Max. Dem	(520)	(791)	57	190	2170	2310	1310	(333)	364	899	298
		-7%	-9%	1%	2%	15%	14%	8%	-2%	2%	4%	1%

Here, we have compared the methodologies of power compensation to the Chittagong area; the first one was power transmission from Dhaka and the second one was the urgent installation of power plants in Chittagong up to 2021.

5.2.2 Analysis on the Best Method to Supply Power Chittagong

The following two cases were set out. Only the capacity costs were compared, assuming that the total amounts of power generation capacities were the same and that there were no differences in the variable costs between cases, such as fuel and maintenance costs.

Case A: Pre-operation of Transmission Line from Dhaka to Chittagong
This was the case of power supply from Dhaka to Chittagong by operating a 400kV transmission line between Meghnaghat and Madunaghat at 230kV in 2017 in advance.

Case B: Emergency Rental Generators in Chittagong
This was the case of installation of emergency rental gas turbine plants in Chittagong instead of the power plants planned in the Dhaka or Comilla areas.

The power deficit of Chittagong would be 500 to 1,100 MW from 2017 to 2020 if Anowara Power station is not commissioned up to 2020, which is a likely consequence. The required amount of power to Chittagon from other areas was assumed as 300 MW on the average during that period except for power supply by the existing 230 kV and 132 kV transmission lines between Comilla North and Hathazari.

The type of power plants in the Dhaka or Comilla areas postponed in Case B was assumed as combined cycle because only combined cycle, repowering of the existing units were planned in Dhaka and Comilla as shown in the following table. The capital cost of the postponed plants was assumed as 917 United States Dollar (USD)/KW*1) - the cost of the general combined cycle power plant using natural gas.

The capital cost of emergency gas turbine units was assumed as 16.5 USD/KW-month - the average rental price per kW of quick rental power plants according to the latest information from PGCB.

*1) Source: Updated Capital Cost Estimates for Utility Scale Electricity Generating Plants, April 2013, Energy Information Administration, U.S. Department of Environment (DOE)

Table 5.2-2 Generation Plan in Comilla and Dhaka from 2017 to 2023

Name		Fuel	COD	Capacity(MW)	Area
Bibiyana South 300-450 MW CCPP	Public	Gas	1-Dec-2017	450	Comilla
Ashuganj (North) CCPP	Public	Gas	1-Jan-2017	381	Dhaka
Ghorasal 3rd Unit Repowering (Capacity Addition)	Public	Gas	1-Jan-2017	206	Dhaka
Ghorasal 363 MW CCPP	Public	Gas	1-Mar-2017	363	Dhaka
Ghorasal 6th Unit Repowering (Capacity Addition)	Public	Gas	1-Sep-2017	206	Dhaka
Ghorasal 4th Unit Repowering (Capacity Addition)	Public	Gas	1-Jun-2018	206	Dhaka

The results are shown in the following table. The capital cost of Case A is cheaper than Case B. The variable cost of Case A is deemed also to be cheaper than Case B. If the current generation plan is fixed, because its change is unrealistic, Case B would have an additional emergency gas turbine and require more cost than Case A. Thus, the total cost of Case A would become less than Case B and Case A can be considered the economical choice.

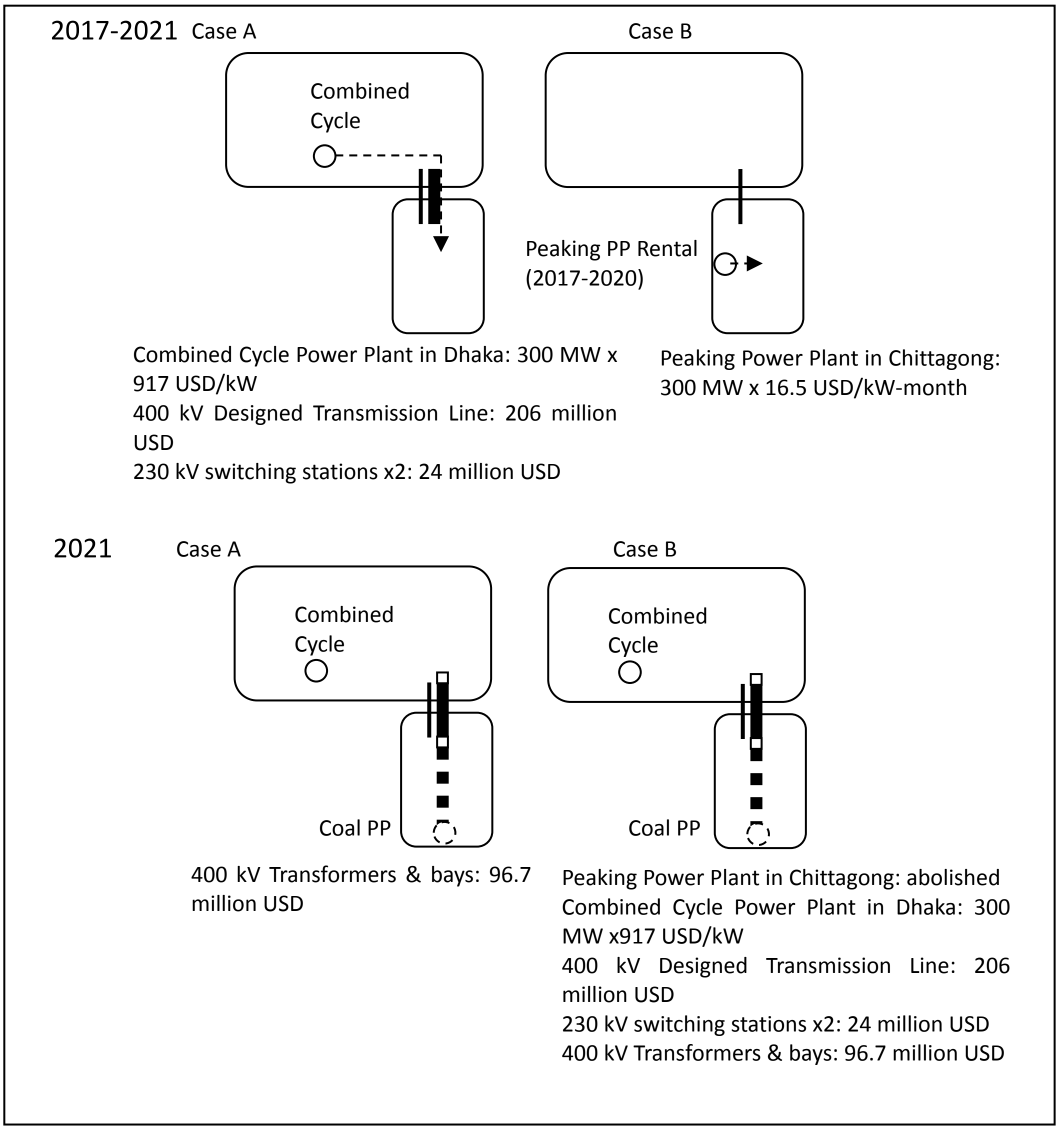


Figure 5.2-2 Cost Comparison Scenario between Cases of Transmission Line from Dhaka to Chittagong and Emergency Generator in Chittagong

Table 5.2-3 Results of the Cost Comparison between Cases of Transmission Line from Dhaka to Chittagong and Emergency Generator in Chittagong

Case A			
Year	Project	Capital Investment	Incremental Capacity
2017	Combined Cycle Power Plant in Dhaka: 300 MW x 917 USD/kW	275.1	300
	400 kV Designed Transmission Line: 206 million USD	206	
	230 kV switching stations x2: 24 million USD	24	
2018			
2019			
2020			
2021	400 kV Transformers & bays: 96.7 million USD	96.7	
	Total	601.8	300
	Net Present Value (Discount Rate 10%) Total	**571**	
Case B			
Year	Project	Capital Investment	Incremental Capacity
2017	Peaking Power Plant in Chittagong: 300 MW x 15 USD/kW-month	59.4	300
2018	Peaking Power Plant in Chittagong: 15 million USD/month	59.4	
2019	Peaking Power Plant in Chittagong: 15 million USD/month	59.4	
2020	Peaking Power Plant in Chittagong: 15 million USD/month	59.4	
2021	Peaking Power Plant in Chittagong: abolished		-300
	Combined Cycle Power Plant in Dhaka: 300 MW x 917 USD/kW	275.1	300
	400 kV Designed Transmission Line: 206 million USD	206	
	230 kV switching stations x2: 24 million USD	24	
	400 kV Transformers & bays: 96.7 million USD	96.7	
	Total	839.4	
	Net Present Value (Discount Rate 10%) Total	**618**	

5.3 Transmission Lines

The current transmission lines operated by PGCB are shown in the table below.
For Chittagon are, there are two sections of 230 kV Transmission lines, No.4 Raojan - Hathazari and No. 10 Commila North - Hathazari in the first table and some of 132 kV lines listed as No 8 - 18 in the second table.

Table 5.3-1 Existing Transmission Lines (T/L)

[400 kV T/Ls]

SN	Name of Lines	Length in Route km	Length in Ckt. Km	No. of Ckt.	Conductor		Date of Commissioning
					Name	Size	
1	HVDC Bheramara-Baharampur	27.35	54.70	Double	Twin Finch	1113 MCM	5th October 2013

[230 kV T/Ls]

SN	Name of Lines	Length in Route km	Length in Ckt. Km	No. of Ckt.	Conductor		Date of Commissioning
					Name	Size	
1	Ghorasal-Ishurdi (1st EWI)	178.00	356.00	Double	Mallard	795 MCM	
2	Tongi - Ghorasal	27.00	54.00	Double	Mallard	795 MCM	
3	Ghorasal - Ashuganj	44.00	88.00	Double	Mallard	795 MCM	
4	Raojan - Hathazari	22.50	45.00	Double	Twin 300 sq.mm		
5	Ashuganj - Comilla North	79.00	158.00	Double	Finch	1113 MCM	
6	Ghorasal - Rampura	50.00	100.00	Double	Twin Mallard	2x795 MCM	
7	Rampura - Haripur	28.00	56.00	Double	Twin Mallard	2x795 MCM	
8	Haripur - Meghnaghat	12.50	25.00	Double	Twin Mallard	2x795 MCM	
9	Meghnaghat - Hasnabad	26.00	52.00	Double	Twin Mallard	2x795 MCM	
10	Comilla North - Hathazari	150.00	300.00	Double	Finch	1113 MCM	
11	AES, Haripur - Haripur	2.40	4.80	Double	Finch	1113 MCM	
12	Comilla North - Meghnaghat	58.00	116.00	Double	Twin Mallard	2x795 MCM	
13	Hasnabad - Aminbazar - Tongi	46.50	93.00	Double	Twin AAAC	37/4.176 mm.	
14	Siddhirganj 210 MW P/S - Haripur	1.50	1.50	Single	ACSR	600 sq. mm.	
15	Ashuganj - Sirajganj (2nd EWI)	143.00	286.00	Double	Twin AAAC	37/4.176 mm.	23rd November 2007
16	Khulna - Ishurdi	185.00	370.00	Double	Twin AAAC	37/4.176 mm.	30th June 2008
17	Bogra-Barapukuria	106.00	212.00	Double	Twin AAAC	37/4.176 mm.	28th June 2008
18	Sirajganj-Bogra	72.00	144.00	Double	Twin AAAC	37/4.176 mm.	31st December 2008
19	Ishurdi-Baghabari	55.00	110.00	Double	Twin AAAC	37/4.176 mm.	
20	Baghabari-Sirajganj	38.00	76.00	Double	Twin AAAC	37/4.176 mm.	24th April 2009
21	Fenchuganj-Bibiyana	33.19	66.37	Double	Twin Mallard	2x795 MCM	05-10-2012 Single ckt. 31-08-2012 Single ckt.
22	Bibiyana-Comilla(N)	153.55	306.00	Double	Twin Mallard	2x795 MCM	24-10-2012 Single ckt.
23	HVDC Double Circuit LILO	4.50	9.00	Double	Twin AAAC	37/4.176 mm.	5th October 2013
24	Aminbazar-Old Airport (O/H)	3.58	7.15	Double			19-Nov-13
25	Aminbazar-Old Airport (U/G)	4.01	8.03	Double	XLPE	2000 sq. mm.	19-Nov-13

[132 kV T/Ls]

SN	Name of Lines	Length in Route km	Length in Ckt. Km	No. of Ckt.	Conductor		Date of Commissioning
					Name	Size	
1	Siddhirganj - Shahjibazar	138	276	Double	Grosbeak	636 MCM	
2	Shahjibazar - Chhatak	150	300	Double	Grosbeak	636 MCM	
3	Siddhirganj - Kaptai	273	546	Double	Grosbeak	636 MCM	
4	Kulshi - Halishahar	13	26	Double	Grosbeak	636 MCM	
5	Comilla South -Chandpur	61	122	Double	Linnet + Grosbeak	(336.4 + 636) MCM	
6	Comilla North -Comilla South	16	32	Double	Grosbeak	636 MCM	
7	Ashuganj - Jamalpur	166	332	Double	Grosbeak	636 MCM	
8	Madanhat - Sikalbaha	13	26	Double	Grosbeak	636 MCM	
9	Sikalbaha - Dohazari	35	70	Double	Grosbeak	636 MCM	
10	Sikalbaha - Julda	5	5	Single	AAAC	804 sq.mm	
11	Julda-Halisahar	8	8	Single	AAAC	804 sq.mm	
12	Kulshi - Baraulia	13	13	single	Grosbeak	636 MCM	
13	Khulshi-Abul Khair	9	9	single	Grosbeak	636 MCM	
14	Abul Khair-Baraulia	4	4	single	Grosbeak	636 MCM	
15	Madanhat - Kulshi	13	13	Single	Grosbeak	636 MCM	
16	Madanhat - Kulshi	13	13	Single	Grosbeak	636 MCM	
17	Kaptai - Baraulia	58	116	Double	Grosbeak	636 MCM	
18	Dohazari - Cox's Bazar	87	174	Double	Grosbeak	636 MCM	
19	Feni - Chowmuhani	32	64	Double	Grosbeak	636 MCM	
20	Baraulia - Kabir Steel	4	4	Single	Grosbeak	636 MCM	
21	Mymensingh - Netrokona	34	68	Double	Grosbeak	636 MCM	
22	Goalpara - Ishurdi	169	338	Double	AAAC	804 MCM	
23	Ishurdi - Bogra	103	206	Double	AAAC	804 MCM	
24	Bogra - Saidpur	140	280	Double	AAAC	804 MCM	
25	Saidpur - Thakurgaon	64	128	Double	AAAC	804 MCM	
26	Goalpara - Bagerhat	45	45	Single	AAAC	804 MCM	
27	Barisal - Bhandaria - Bagerhat	80	80	Single	HAWK	477 MCM	
28	Bagerhat - Mangla	31	31	Single	HAWK	477 MCM	
29	Barisal - Patuakhali	37	37	Single	Grosbeak	636 MCM	
30	Bheramara - Faridpur - Barisal	225	450	Double	HAWK	477 MCM	
31	Rajshahi - Natore	40	40	Single	HAWK	477 MCM	
32	Ishurdi - Baghabari - Shahjadpur	57	57	Single	HAWK	477 MCM	
33	Ishurdi - Pabna - Shahjadpur	56	56	Single	Grosbeak	636 MCM	
34	Bogra - Sirajganj	66	132	Double	Grosbeak	636 MCM	

35	Sirajganj-Shahjadpur	34	34	Single	Grosbeak	636 MCM	
36	Rajshahi - Nawabganj	47	94	Double	Grosbeak	636 MCM	
37	Rangpur - Lalmonirhat	38	38	Single	Grosbeak	636 MCM	
38	Bogra - Noagaon	52	104	Double	Grosbeak	636 MCM	
39	Kabirpur - Tangail	51	102	Double	Grosbeak	636 MCM	
40	Tongi - Mirpur - Kall.pur - Hasbad	49	98	Double	Grosbeak	636 MCM	
41	Tongi-New tongi	0.5	1	Double			
42	Hasnabad - Shyampur - Haripur	40	80	Double	Grosbeak	636 MCM	
43	Siddhirganj - Ullon	16	32	Double	Grosbeak	636 MCM	
44	Siddhirganj -Matuil- Maniknagar	10	10	Single	Grosbeak	636 MCM	
45	Siddhirganj - Maniknagar	10	10	Single	Grosbeak	636 MCM	
46	Maniknagar - Bangabhaban	3	6	Double	Cu.Cable	240 sq.mm	
47	Maniknagar - Narinda	5	10	Double	Cu.Cable	240 sq.mm	
48	Ullon - Dhanmondi	5.5	11	Double	Cu.Cable	240 sq.mm	
49	Ullon - Dhanmondi	5.5	11	Double	XLPE	800 sq.mm	
50	Tongi - Kabirpur - Manikganj	56	112	Double	Grosbeak	636 MCM	
51	Ullon - Rampura -Tongi	23	46	Double	Grosbeak	636 MCM	
52	Rampura-Mogbazar	4.5	9	Double	Grosbeak	636 MCM	
53	Ghorasal - Joydebpur	26	52	Double	Grosbeak	636 MCM	
54	Baghabari - Shahjadpur	7	14	Double	Grosbeak	636 MCM	
55	Chandpur - Chowmuhani	75	150	Double	Grosbeak	636 MCM	
56	Barapukuria-Rangpur	45	90	Double	Grosbeak	636 MCM	
57	Barapukuria-Saidpur	36	72	Double	Grosbeak	636 MCM	
58	Madaripur-Gopalganj	45	45	Single	AAAC	804 MCM	
59	Khulna(C)-Khulna(S)	9	18	Double	Twin AAAC	37/4.176 mm.	
60	Khulna(S)-Satkhira	56	56	Single	AAAC	804 MCM	
61	Rajshahi - Natore	40	40	Single	Grosbeak	636 MCM	
62	Matuail In-Out from Hari-Manik	5.5	11	Double	Grosbeak	636 MCM	
63	Rampura-Gulshan U/G Cable	3.3	6.6	Double	XLPE	800 sq.mm	
64	Sikalbaha-Bakulia	4	8	Double	Grosbeak	636 MCM	
65	Julda-Shahmirpur	7	14	Double	Grosbeak	636 MCM	
66	Kamrangirchar In-Out from Has-Kal	3	6	Double	Grosbeak	636 MCM	
67	Kulshi-Bakulia	15	30	Double	Grosbeak	636 MCM	
68	Haripur-Maniknagar	12	12	Single	Grosbeak	636 MCM	
69	Joydebpur-Kabirpur	15	30	Double	Grosbeak	636 MCM	
70	Sikalbaha-Shahmirpur	9	18	Double	Grosbeak	636 MCM	
71	Kulshi-Halishahar (Open at Kulshi)	13	13	Single	Grosbeak	636 MCM	
72	Bogra Old-Bogra New	3	6	Double	Twin AAAC	37/4.176 mm.	
73	Ashuganj-Shahjibazar Single Ckt.	53	53	Single	Grosbeak	636 MCM	31st August 2009
74	Khulna (S) - Gallamari	4.2	8.4	Double	Grosbeak	636 MCM	16th November 2009
75	Noagaon-Niamotpur	46	46	Single	AAAC	804 MCM	2nd January 2010
76	Aminbazar-Savar	15.8	31.6	Double	Grosbeak	636 MCM	23rd April 2010
77	Jhenaidah-Magura	26	26	Single	Grosbeak	636 MCM	11th June 2010
78	Jhenaidah-Chuadanga	39	39	Single	Grosbeak	636 MCM	15th October 2010
79	Naogaon-Joypurhat	46	46	Single	Grosbeak	636 MCM	9th November 2010
80	Thakurgoan-Panchagor	45	45	Single	AAAC	636 MCM	25th Dec 2010
81	Megnaghat S/S to Megnaghat Rental PP	5	10	Double	Grosbeak	636 MCM	15th March 2011
82	Shiddhirganj to Siddhirganj Dutch Bangla PP	2.4	2.4	sinlge	Grosbeak	636 MCM	26th June 2011
83	In-out at Ashuganj-Shahjibazar 132 kV line to B.Baria	11.1	44.4	Four	Grosbeak	636 MCM	11 th feb 2011
84	In-out at Haripur-Daudkandi 132 kV line to Meghnaghat	10.26	41.04	Four	AAAC	636 MCM	31th dec 2010
85	In-out at Megnaghat-Comilla(N) 132 kV line to Daudkandi	19.5	78	Four	AAAC	636 MCM	31th June Dec 2010
86	Goalpara-Khulna (c) 132 kV U/G Cable	2.4	2.4	single			22th march 2011
87	Noapara PP to Noapara Ss	1.6	1.6	single			30th Jan 2011
88	Daudkandi PP to Daudkandi ss	1.2	1.2	single			1st july 2011
89	Gopalganj PP to Gopalganj ss	1.2	1.2	single			25th july 2011
90	Shiddhirganj desh energy PP to Siddhirganj ss	2.5	2.5	single			26th july 2011
91	Faridpur pp to faridpur -bheramara 132 kV line.	1	1	single			9th july 2011
92	Bera pp to bagagari -ishridi line	4.5	4.5	single			8th july 2011
93	Amnura pp to Rajshahi-chapai	12.6	12.6	single			9th july 2011
94	In-out of Hasnabad-kallayanpur line to keraniganj pp	7.5	30	Four			15th july 2011
95	Madanganj-Munsiganj 132 kV line	4	8	Double			
96	Old Airport-Cantonment (U/G)	6.99	13.98	Double	XLPE	800 sq.mm	19-Nov-13

(Source: PGCB)

5.4 Substations

The substations currently owned by PGCB are shown in the table below. Most substations are air-insulated type due to its cost-effectiveness.

Table 5.4-1 Number of PGCB's Substations

Year	230/132 kV		132/33 kV		66/33/11 kV	
	Number	Total Capacity [MVA]	Number	Total Capacity [MVA]	Number	Total Capacity [MVA]
2006-07	10	5175	70	7219	2	25.6
2007-08	12	5850	71	7526	2	25.6
2008-09	13	6075	71	7399	-	-
2009-10	13	6300	75	7844	-	-
2010-11	13	6675	81	8437	-	-
2011-12	13	6675	83	8737	-	-
2012-13	15*	6975	84	9705	-	-

*15 in total (including two switching stations)

(Source: Annual Report 2012-2013)

In addition, the current data of substations in Dhaka and Chittagong area is as follows.

Table 5.4-2 Substation Data in Dhaka and Chittagong area

230/132 kV		132/33 kV		66/33/11 kV	
Number	Total Capacity [MVA]	Number	Total Capacity [MVA]	Number	Total Capacity [MVA]
12	5625	36	5249	-	-

(Source: Web Site of PGCB)

The summaries of the existing 230 kV Meghnaghat Switching Station and 132 kV Madunaghat SS are shown below with pictures.

[Existing Meghnaghat Switching Station]

- ✓ Voltage Class: 230kV Switching Station, two power plants are connected.
- ✓ 230kV Bus scheme: One and a half

(a) Existing 230 kV Air insulated switchgear

(b) Existing 230 kV Circuit Breaker

Figure 5.4-1 Pictures of existing Meghnaghat Switch Station

Notably, the current capacity of the 230 kV bus-bar is designed to 1800 A, and all circuit breakers for transmission feeders are rated as 1800 A as normal current and 40 kA as short-time withstand current. In case the project utilize this existing facilities for the future projects, these current capacities must be well considered, and replacement and/or expansion of 230 kV main circuit may be necessary, which will be studied in this project.

[Existing Madunaghat SS]

- ✓ Voltage Class: 132/33 kV Substation
- ✓ 132 kV Bus scheme: Ring bus

(a) Existing 132 kV Air insulated switchgear

(b) Existing 132kV Hathazari T/L tower on the premises

(c) Existing Remote Terminal Unit (RTU) Panel

(d) Existing Control Building

Figure 5.4-2 Pictures of existing Madunaghat SS

PGCB's substation design policy prioritizes Air Insulated Switchgear (AIS) over Gas Insulated Switchgear (GIS) due to AIS's cost efficiency. Regarding the secondary equipment, optical fiber composite overhead ground wire (OPGW) has already been adopted as a communication method for the protection relays and the transmission of information for NLDC. Notably, relay protection panels have been replaced with numerical types, although the main equipment is relatively old.

5.5 Telecommunication Facilities

At the present, the media used for the telecommunication system in PGCB are optical fiber and Power Line Communication (PLC). The telecommunication system provides telecommunication links for the following services.

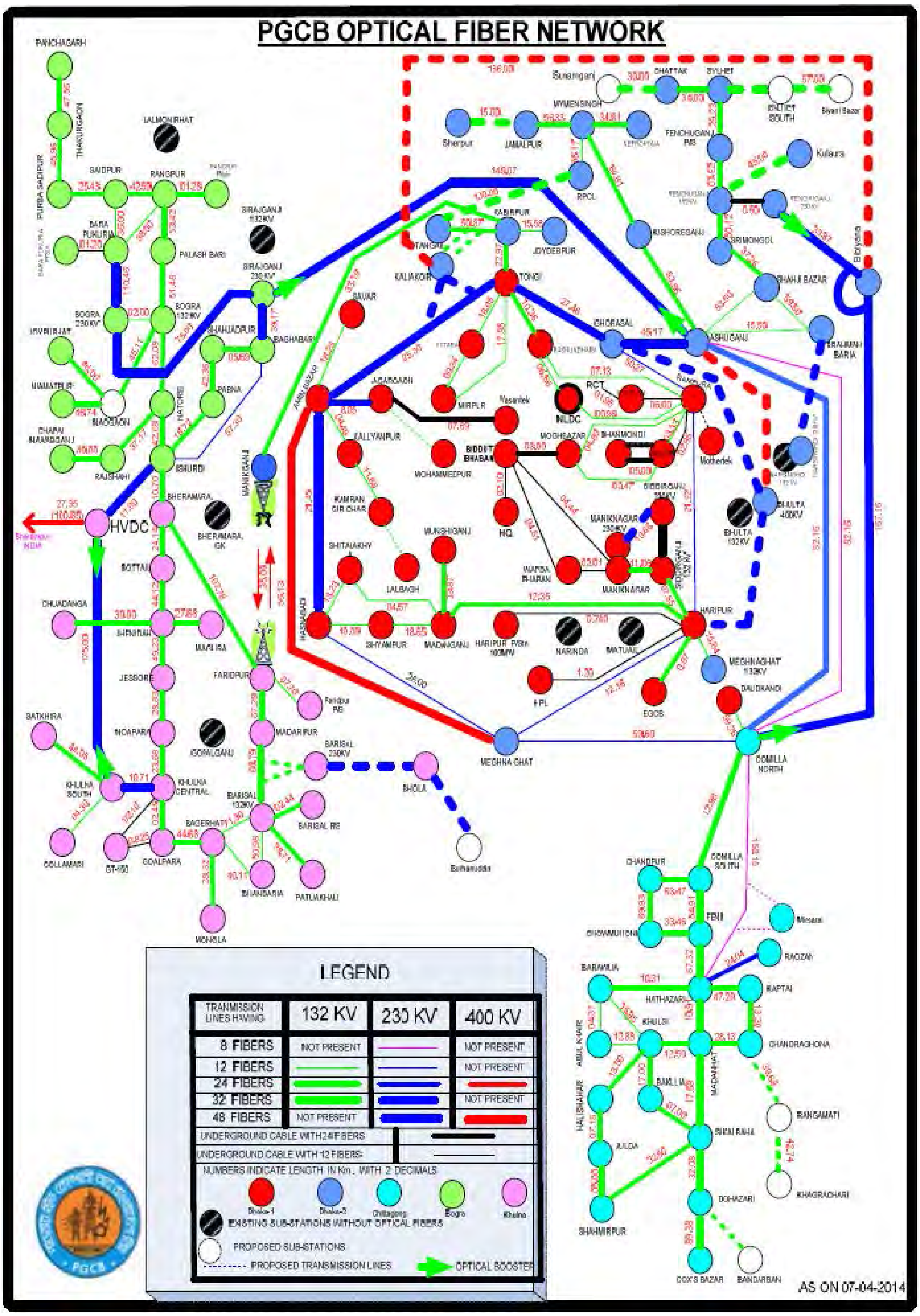
- Telephony (Voice)
- Data acquisition (Supervision)
- Tele-operation (Supervisory Control)
- Tele-protection (Communication Aided Protection)

Basically, the above services are provided by a private network. However, some substations utilize General Packet Radio Service (GPRS), which is a public mobile network, for Supervisory Control and Data Acuisition (SCADA).

(1) Optical Fiber Network

An Optical Fiber Transmission System was introduced at Tongi SS, Aminbazar SS, and Hasnabad SS in 2005. Most of the optical fiber cable is OPGW, covering most of the substations (except for Lalmonirhat SS, Sirajgnj 132kV SS, Bhulta 132kV SS, Gopalganj SS, Norshingdi SS and Matuail SS) and the current total length is 5,050 km.

The following diagram shows the optical fiber network of PGCB. The operational and maintenance area is divided into 5 zones (Khulna, Bogra, Dhaka-1, Dhaka-2, and Chittagong). The western zone (Borga and Khulna) has only one route OPGW for Dhaka and Chittagong. Therefore, the microwave radio system between Manikganj and Faridpur is used for a backup route.



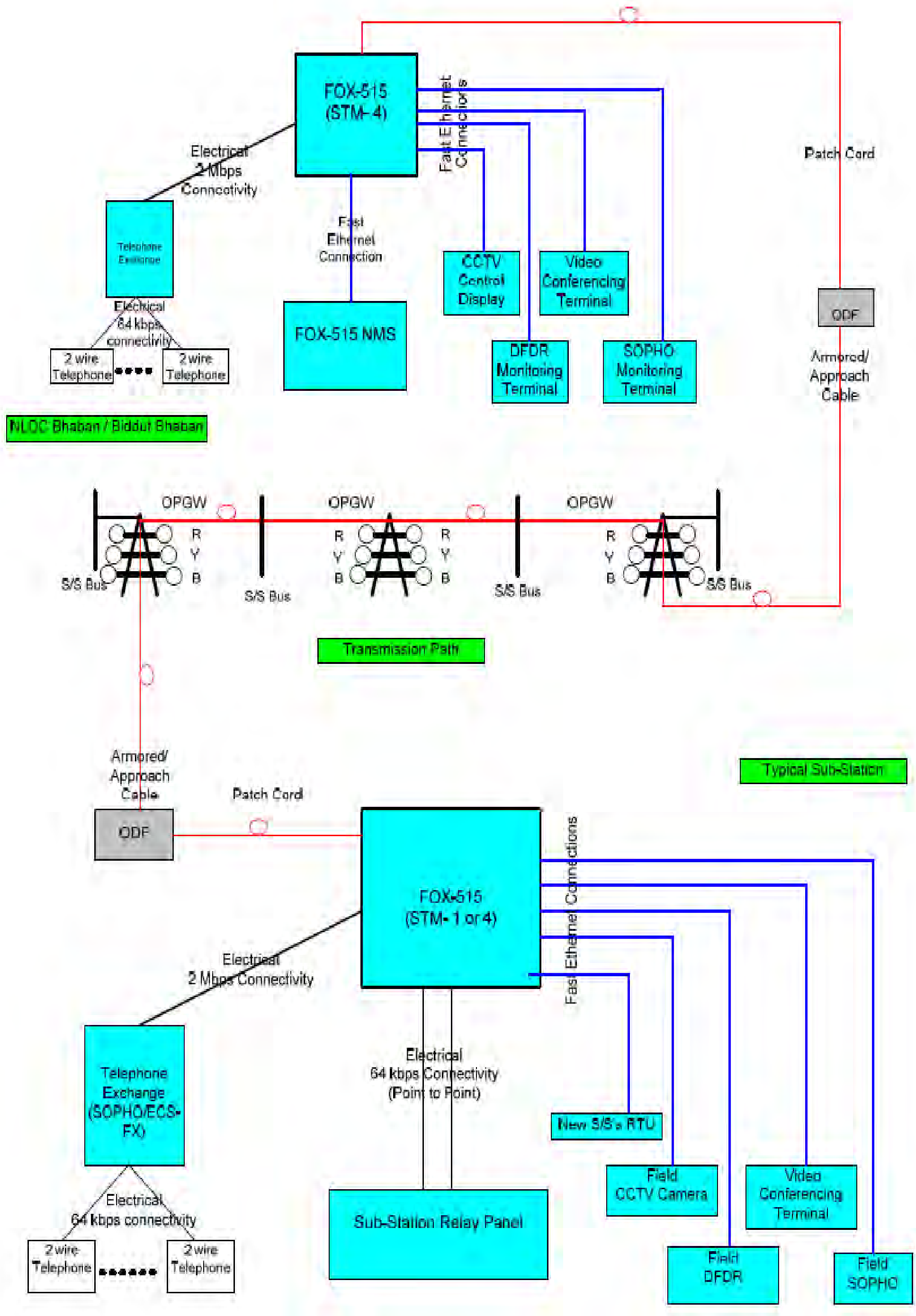
(Source: PGCB)

Figure 5.5-1 PGCB Optical Fiber Network

(2) Transmission System

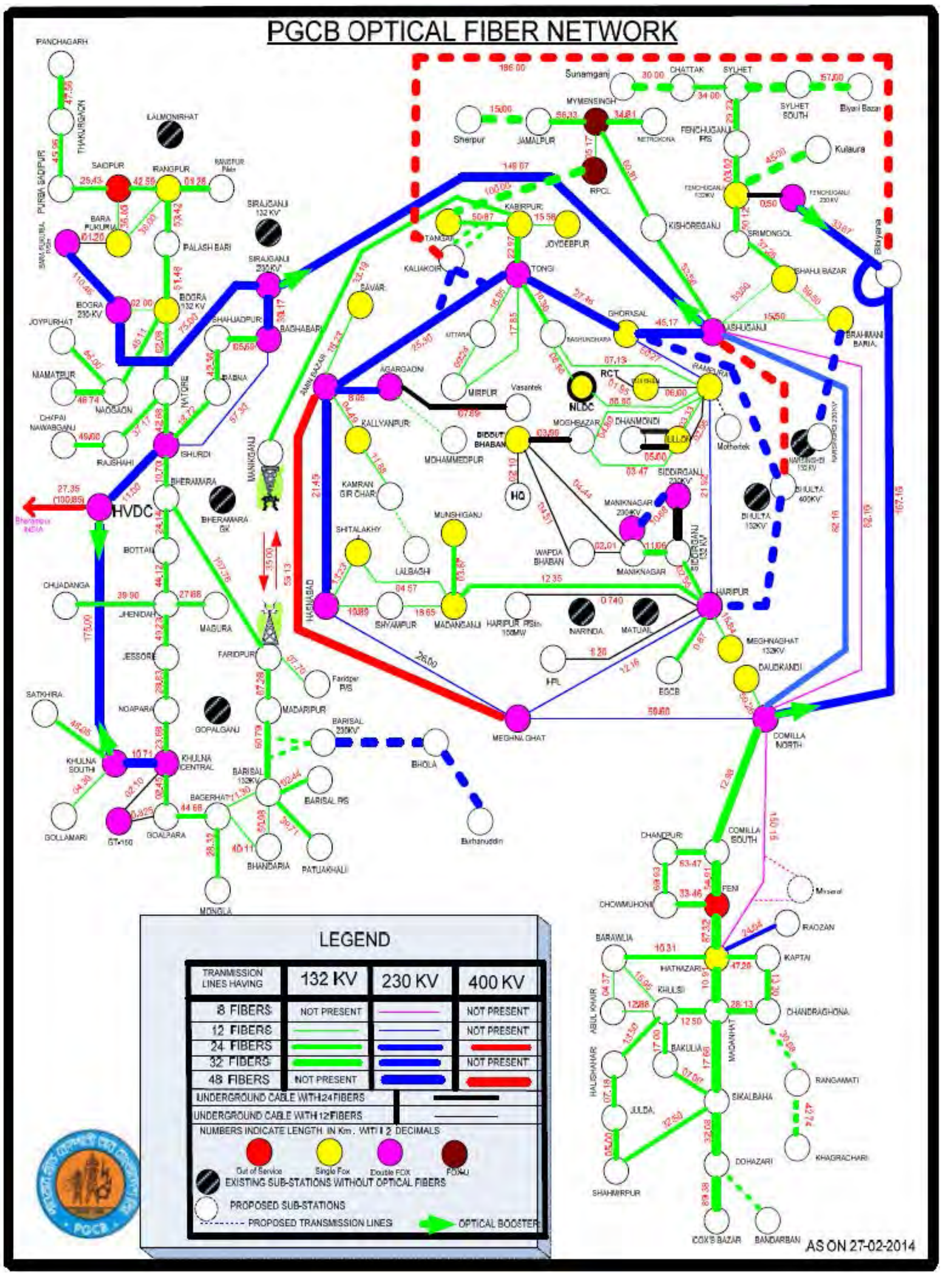
The transmission system mainly consists of two systems. One is a FOX Network that consists of FOX-515 (manufactured by ABB). The other one is an NLDC system that consists of Huawei equipment. The transport hierarchy between substations is Synchronous Transport Module (STM) -4 (622.080Mbit/s) of Synchronous Digital Hierarchy (SDH).

The following 4 diagrams show the system connection and network diagram of the FOX network and NLDC communication network respectively.



(Source: PGCB)

Figure 5.5-2 FOX-515 System Connection



(Source: PGCB)

Figure 5.5-3 FOX Network of PGCB

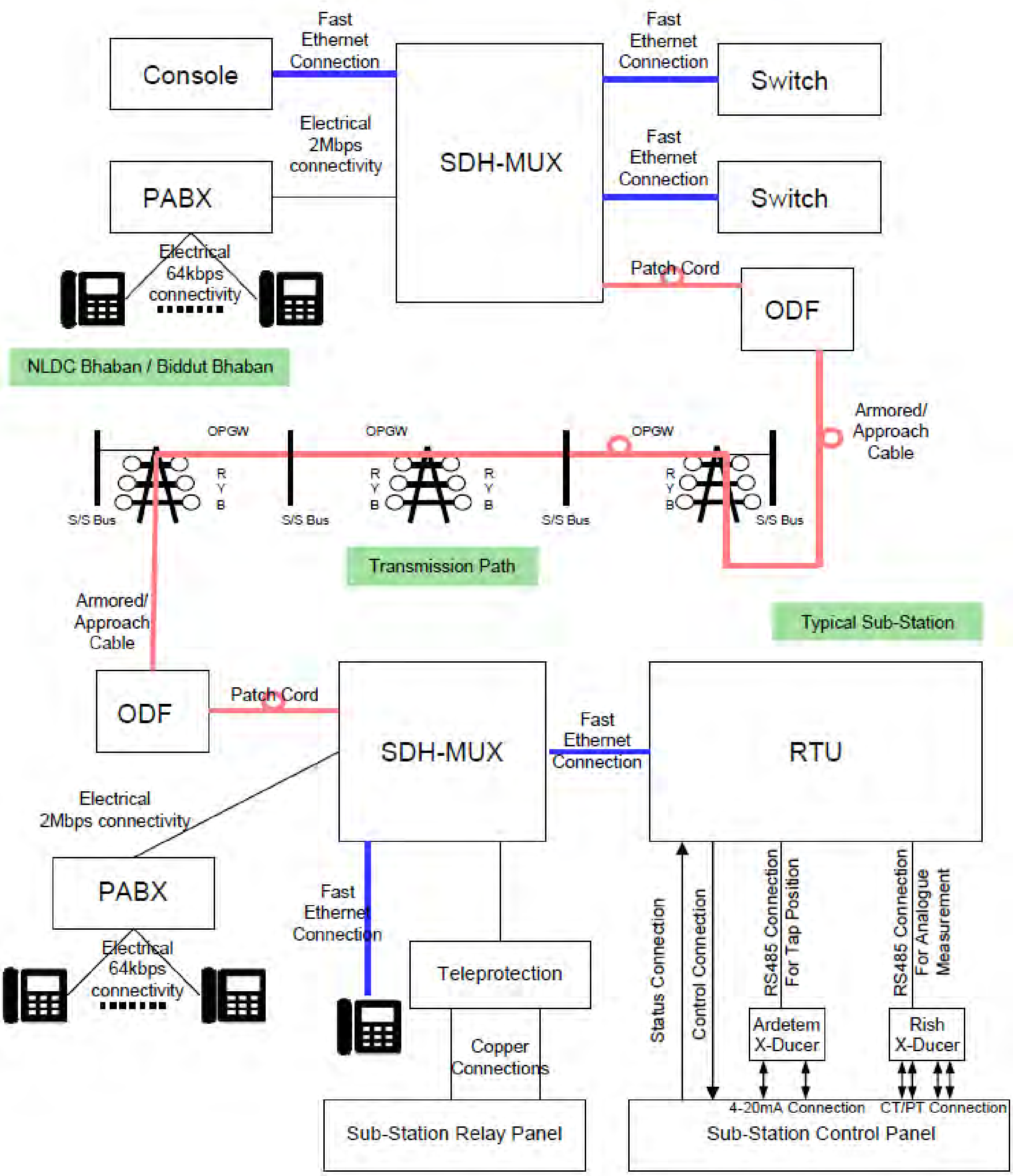
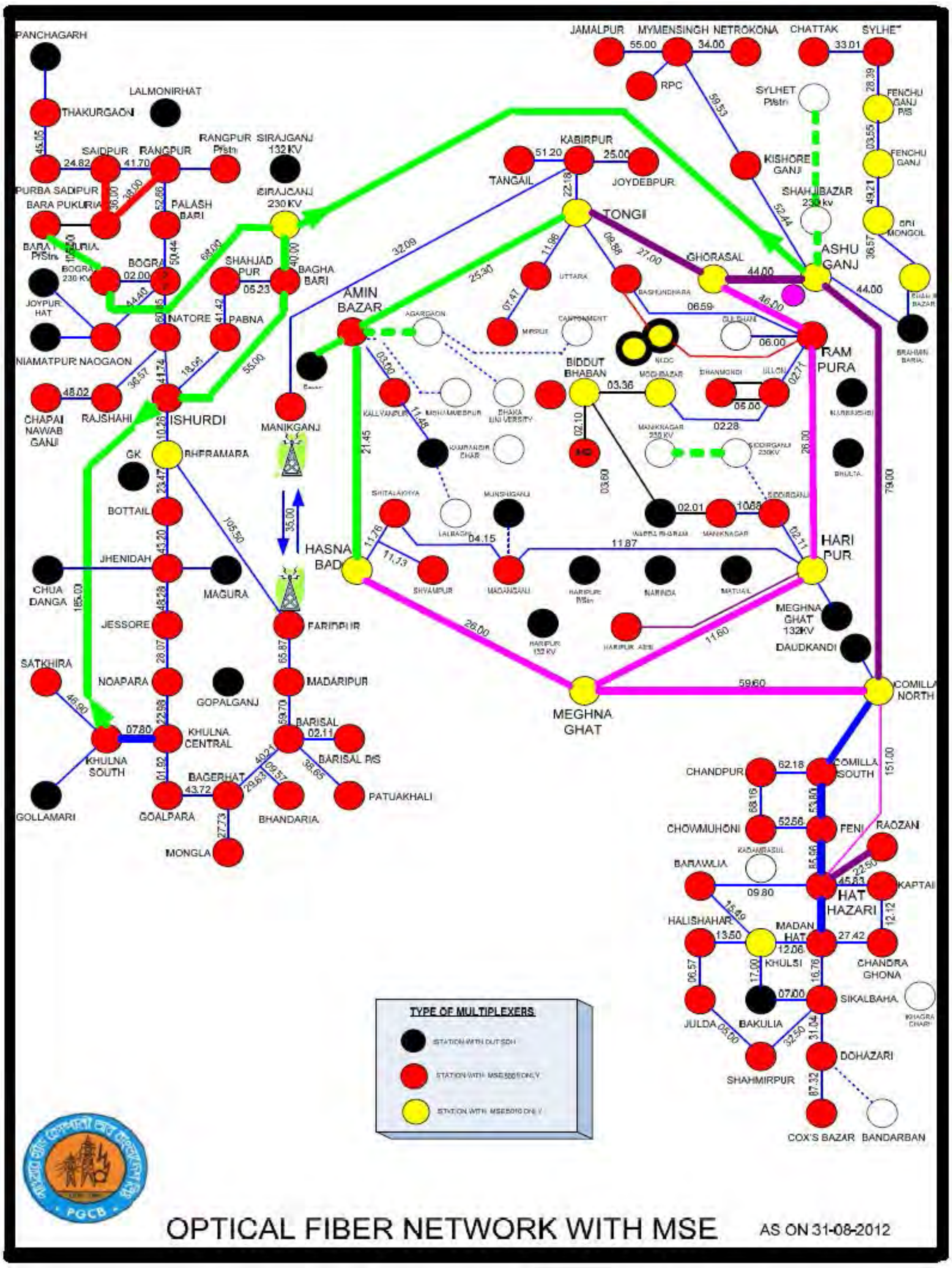


Figure 5.5-4 NLDC Communication System Connection



(Source: PGCB)

Figure 5.5-5 NLDC Communication System Network

(3) Microwave Radio Communication System

The microwave link (Manikganj SS-Faridpur SS) is the standby path (STM-1) for the Khulna & Bogra zones. It also creates a ring network for the Khulna and Bogra zone with the Dhaka zone. It is used for SCADA data transmission and telephony of the Khulna and Bogra zones if any fault has occurred in the Ashuganj – Sirajganj optical transmission System. The following table shows the specification of the microwave radio transmission system.

Table 5.5-1 Microwave Radio Transmission System Specification

Item	Description
Frequency	6GHertz(Hz) band (U6)
Bandwidth	40MHz
Channel	STM-1 (S1.1 optical interface)
Diversity	Space Diversity
Antenna	1.8m antenna
Tower	70m at both ends
Supervision	SNMP through the SNMPC network management software
Availability	99.99%
Polarization	Vertical (V)
Manufacturer	Harris

(Source: PGCB)

(4) Power Line Carrier System

The following diagram is a conceptual diagram of Power Line Carrier (PLC). PLC is not used by Japanese utilities currently. PGCB utilizes PLC for backup routes for the OPGW network in the most of substations. Most of the PLC equipment is manufactured by ABB. Recently, PGCB has been introducing the ABB ETL 600 series that can accommodate LAN.

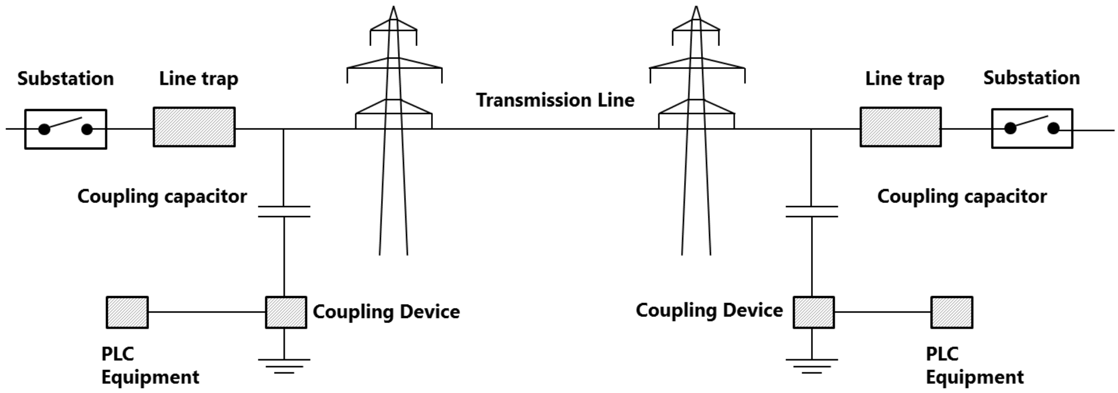
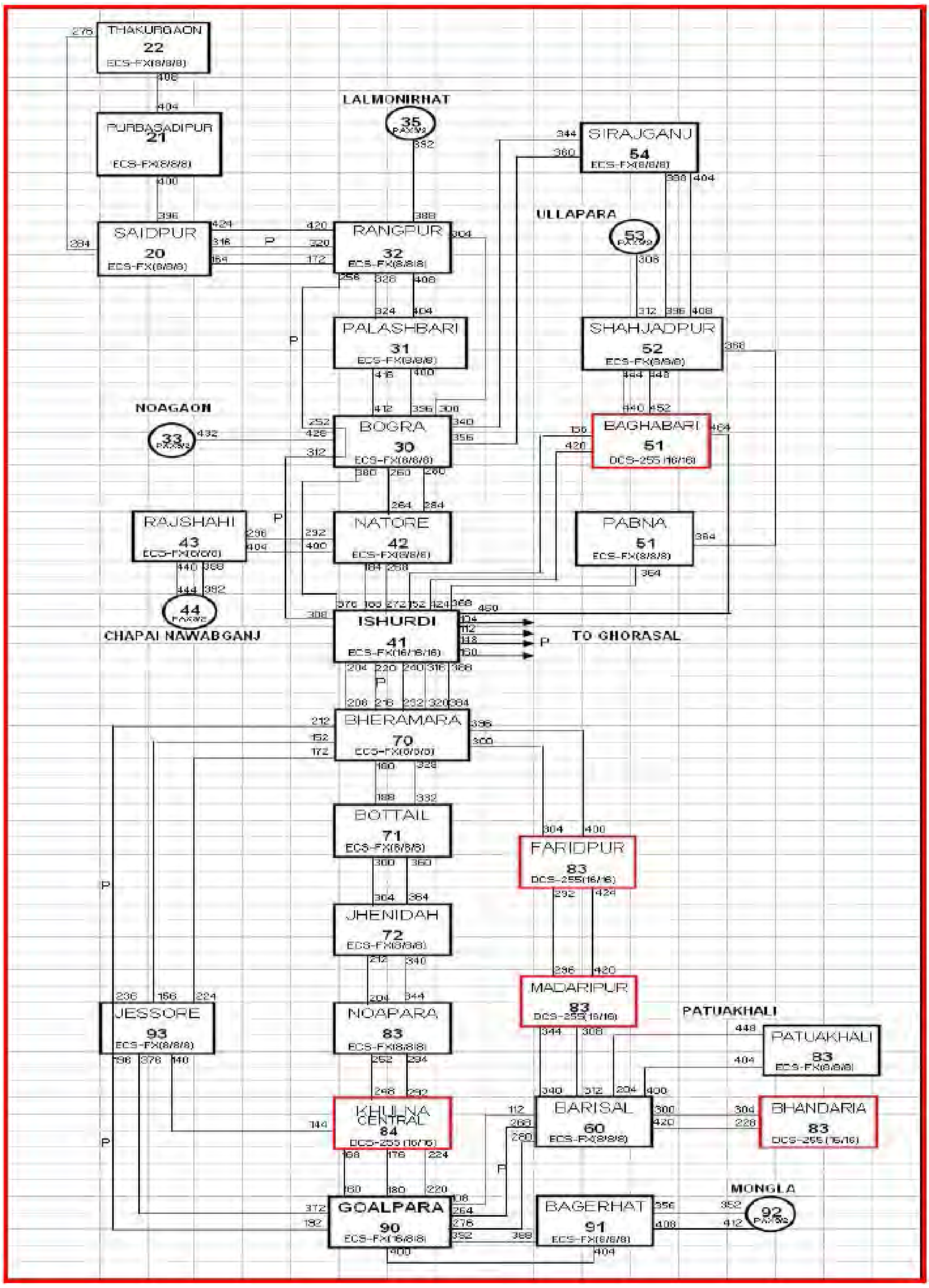


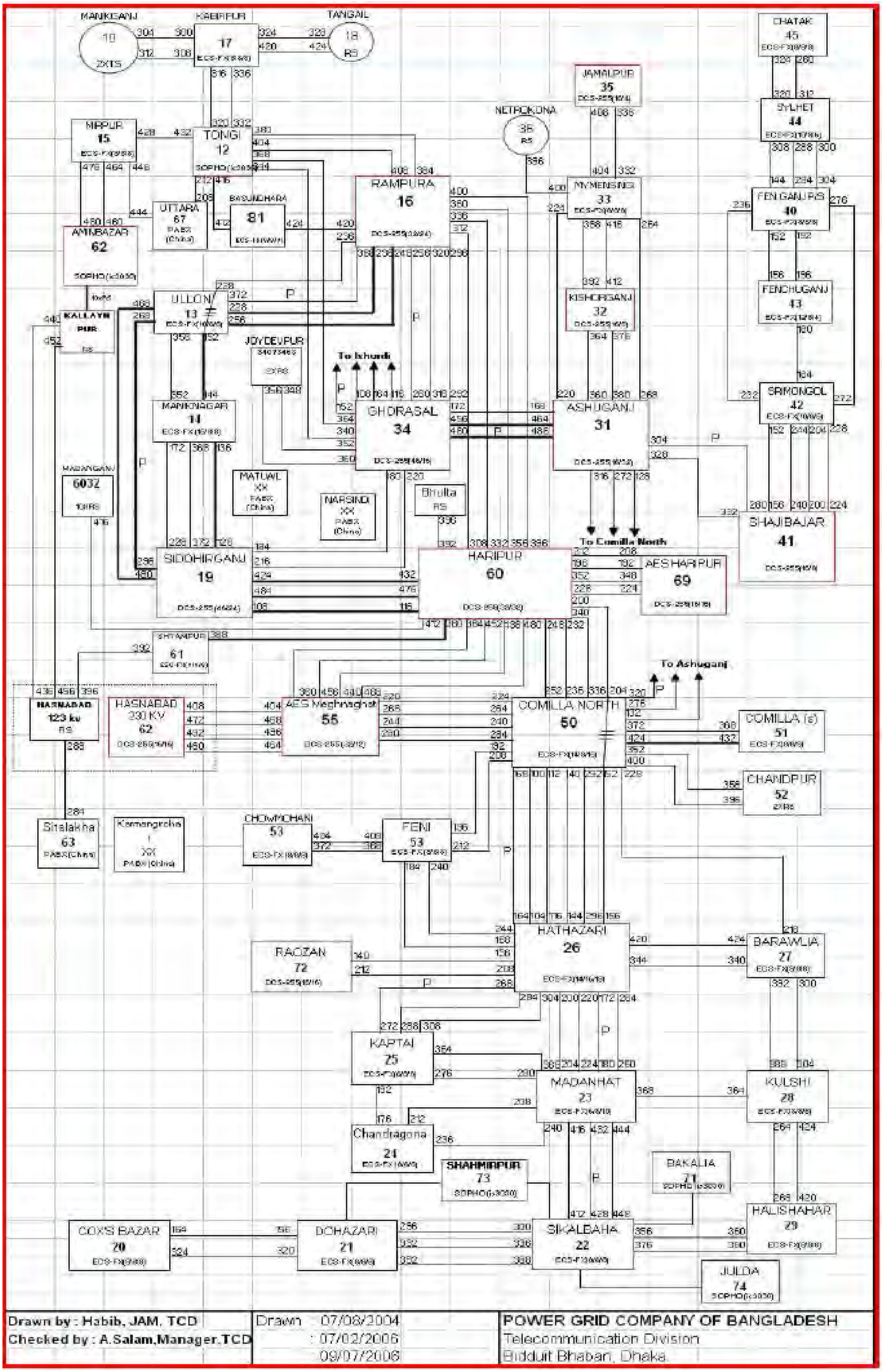
Figure 5.5-6 PLC system on transmission line

The following two diagrams show the PLC Network diagram of PGCB.



(Source: PGCB)

Figure 5.5-7 PLC Network (Western Area)

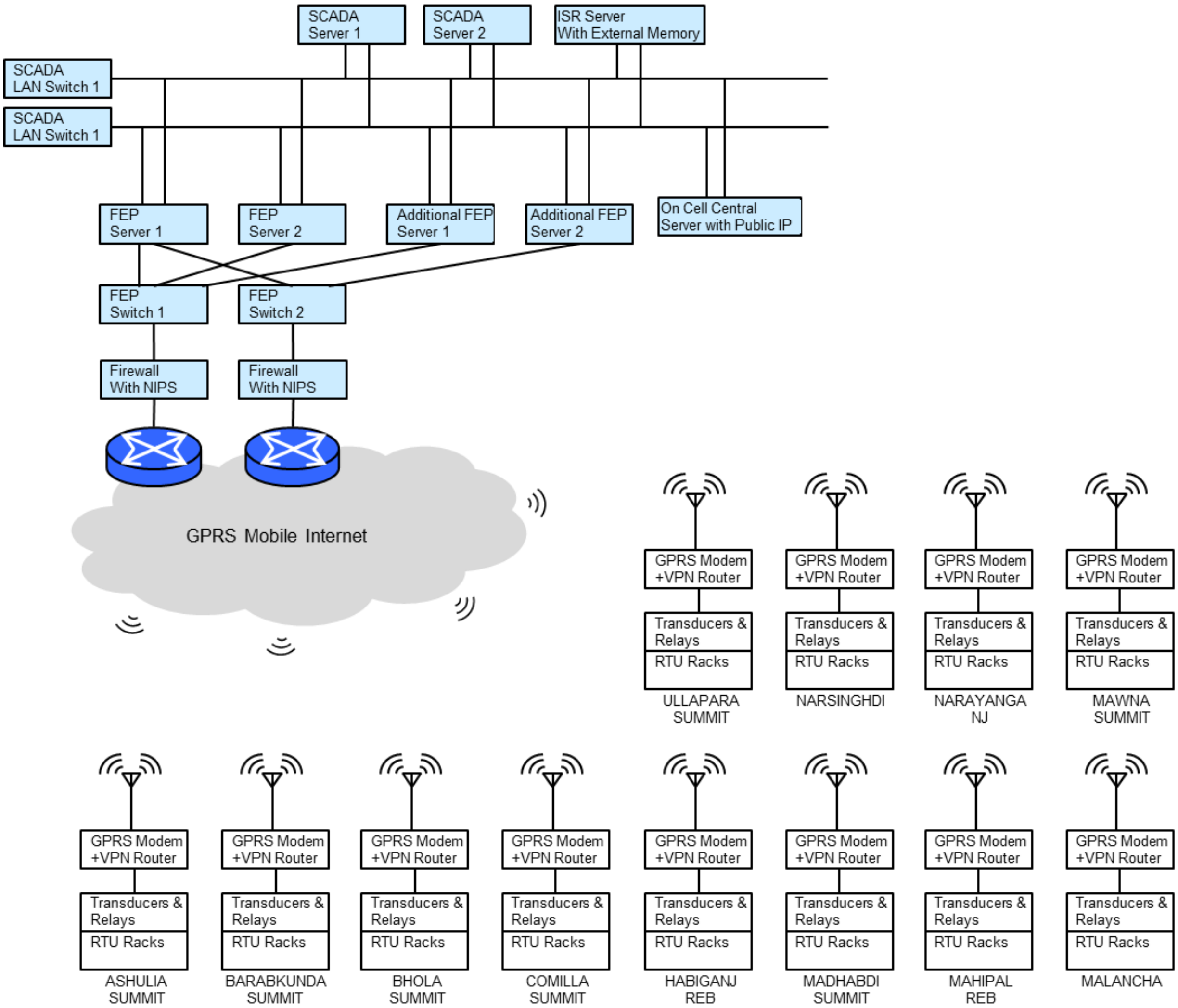


(Source: PGCB)

Figure 5.5-8 PLC Network (Eastern Area)

(5) General Packet Radio System

The following figure shows the GPRS telecommunication system in PGCB. In PGCB, 12 power stations are connected with the Virtual Private Network (VPN) through GPRS. However, GPRS is a public network that is shared with the public mobile telecommunication system. Therefore, this is a potential risk to network security.

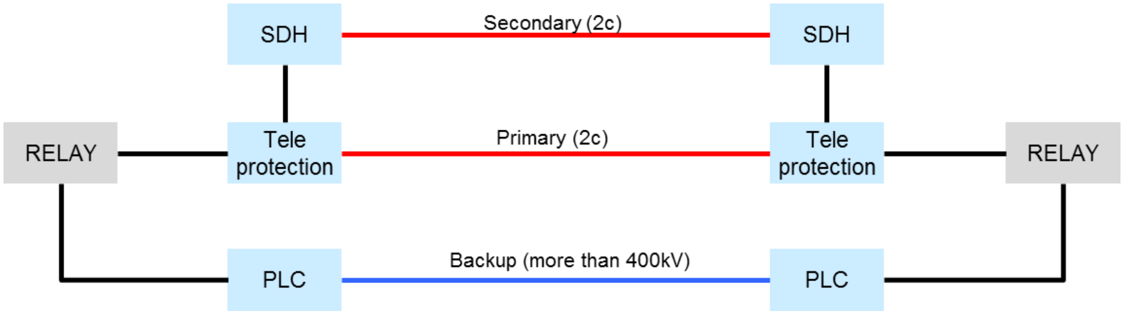


(Source: JICA Survey Team)

Figure 5.5-9 GPRS for Remote PS SCADA system

(6) Tele-protection

The tele-protection system is one of the most important systems due to its role in protecting transmission lines. Thus, the system needs redundant telecommunication lines. For less than a 230kV Transmission Line, the system needs two links, which are the primary line connected directly with optical fibers between tele-protection equipment and the secondary line through SDH. Especially, in the case of a more than 400kV Transmission Line, a third backup through PLC is needed. The following figure shows an outline of the telecommunication connections of a tele-protection system.

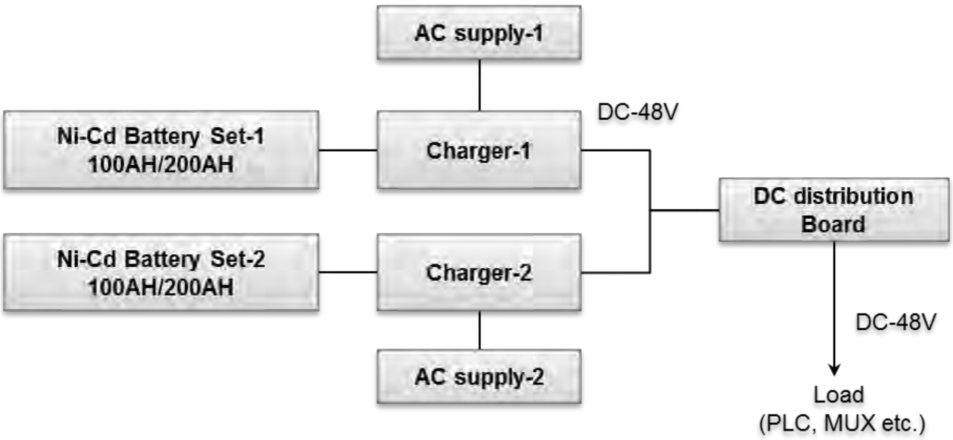


(Source: JICA Survey Team)

Figure 5.5-10 Communication System for Tele-protection

(7) Power Source: for Telecommunication Equipment

The following diagram shows the power supply system for telecommunication equipment in PGCB. Direct Current (DC) -48V is used for the power Source: of telecommunication equipment. The system consists of batteries, chargers, and DC distribution boards. Based on PGCB design philosophy, power Source: backup time for outages is 10 hours. Telecommunication equipment in a typical substation needs 100 Ampere hour(Ah) batteries. Battery capacity is changed in accordance with the power needed for telecommunication equipment.

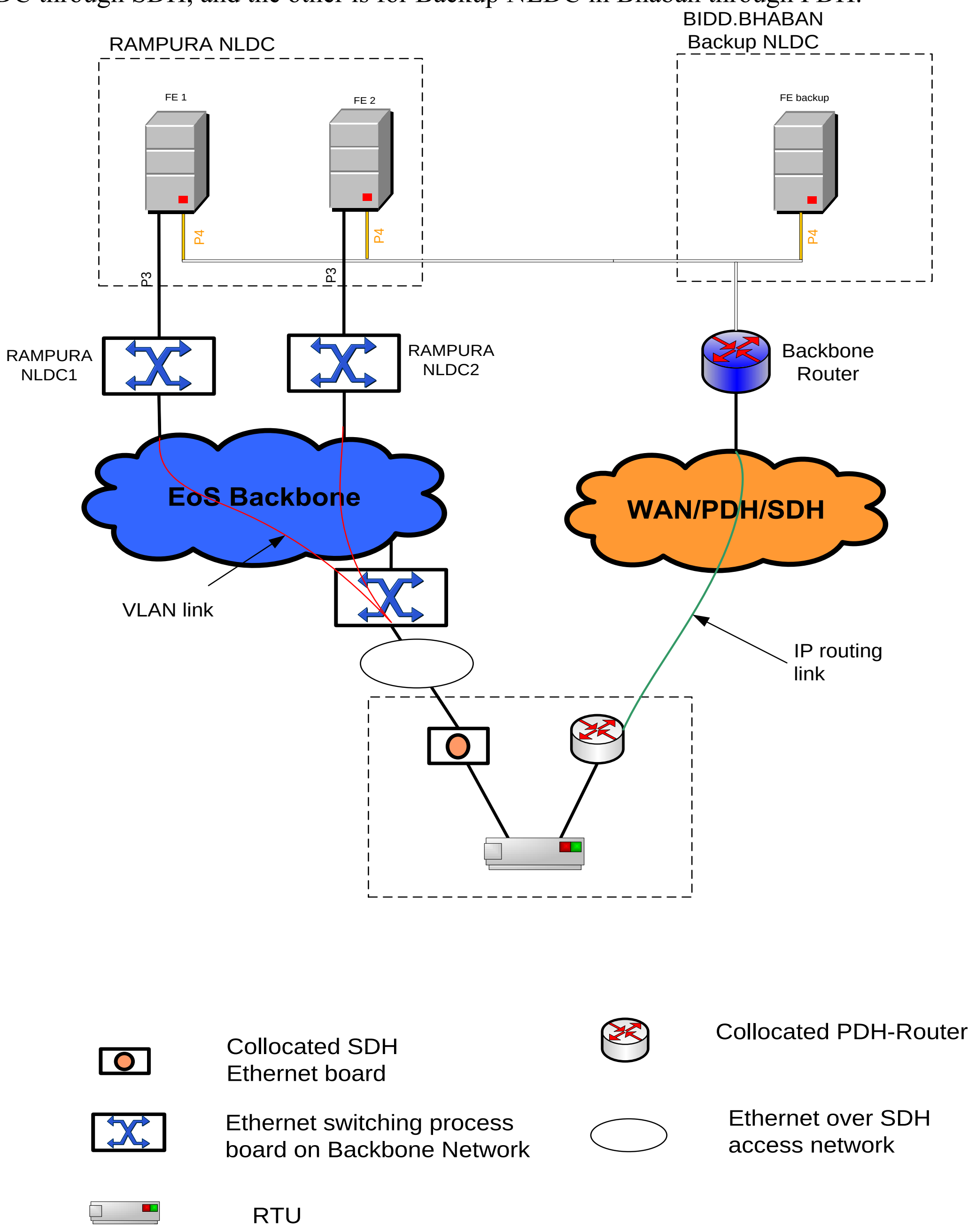


(Source: JICA Survey Team)

Figure 5.5-11 Power Supply System for Telecommunication Equipment

(8) SCADA

The following diagram shows the data flow of SCADA. There are two physical networks of SDH and Plesiochronous Digital Hierarchy (PDH), but PDH data mapped into SDH and optical transmission is only by SDH. RTUs have two communication modems, one is for RAMPURA NLDC through SDH, and the other is for Backup NLDC in Bhaban through PDH.



(Source: PGCB)

Figure 5.5-12 SCADA data flow

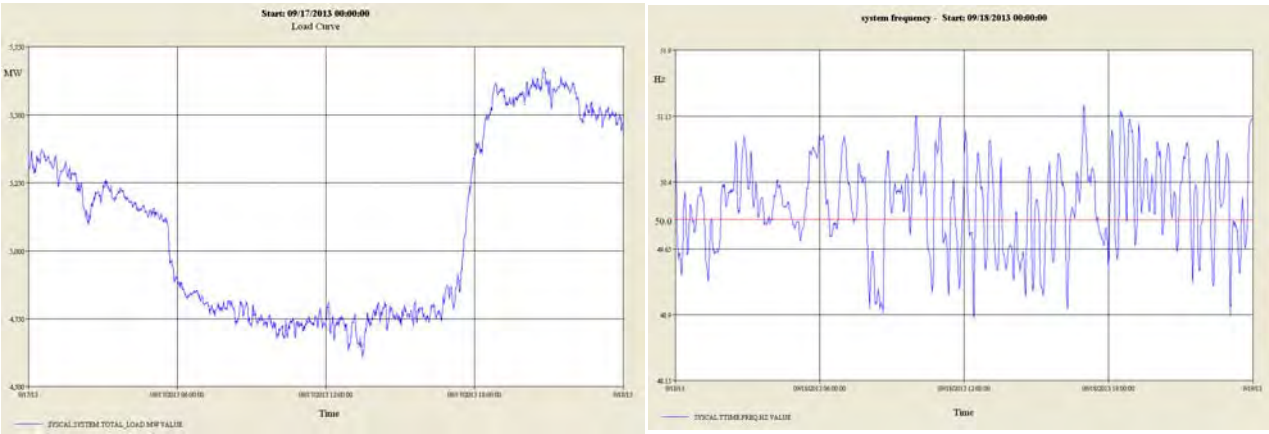
Chapter 6
Existing National Load Dispatching Center

Chapter 6 Existing National Load Dispatching Center

Bangladesh's NLDC monitors the entire Bangladesh power system and instructs generation of power plants. NLDC is now utilizing an Energy Management System (EMS)/SCADA System to stabilize the operation bulk power network, but frequent power system outages and subsequent load shedding still happening. The JICA studied the current power system operations, which could be significantly improved with proper technical supports both for the revision of operational governing rules and utilization of recent system operation technologies.

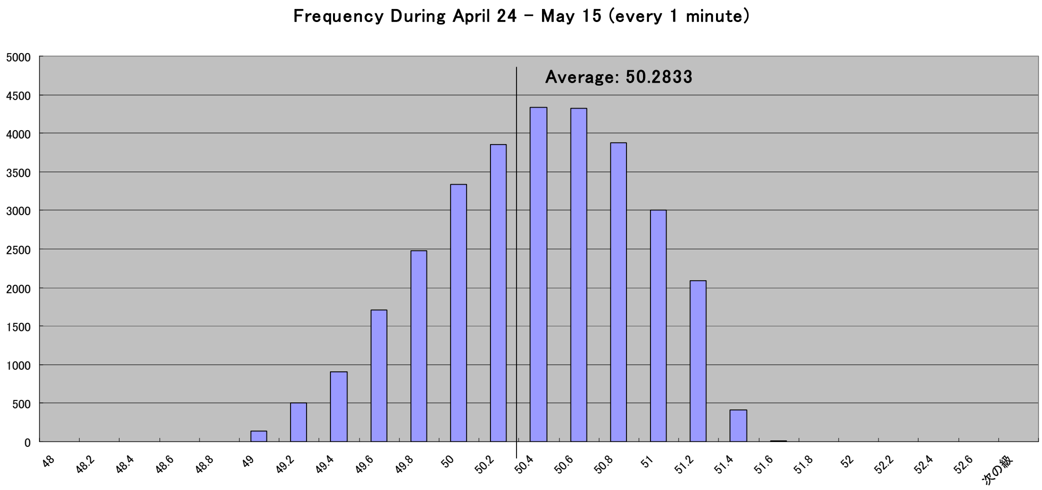
6.1 Study on the operation of Bangladesh's Power System

With scarce power generation and increasing demand, PGCB and NLDC have been suffering from unstable frequency deviation and supply voltage drop, both of which violate the Grid Code's power quality requirements.



(Source: NLDC's study document on Availability Based Tariff)

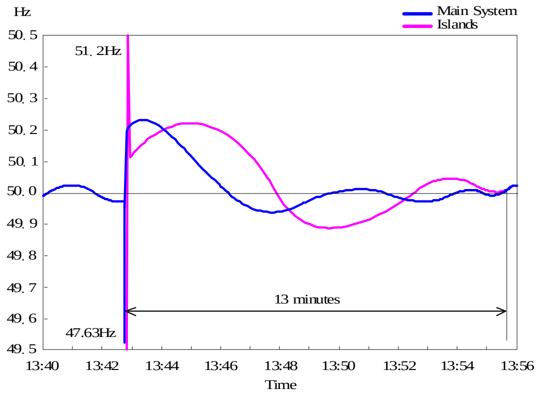
Figure 6.1-1 Frequency Change and Demand Curve

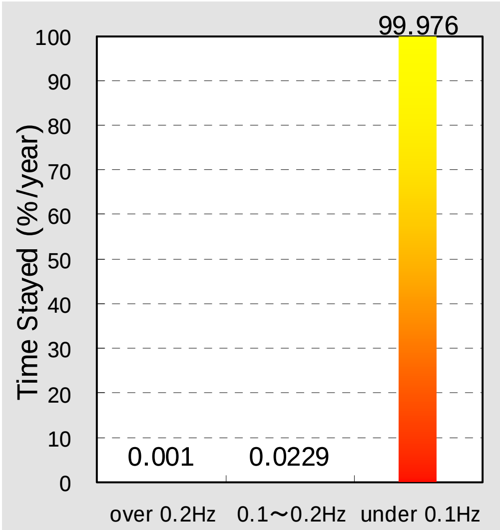


(Source: NLDC's study document on Availability Based Tariff)

Figure 6.1-2 Histogram of frequency deviation during April 24 – May 15 in 2014

According to NLDC's minute-wise frequency record during April 24 – May 15 in 2014, Average frequency was 50.2833 (Hz), and its standard deviation was 0.50997 (Hz), in contrast to Tokyo Electric Power Company's case: 50.0 Hz on average and less than 0.1 Hz in deviation.





(Source: TEPCO's Operational Record (not disclosed to the public))

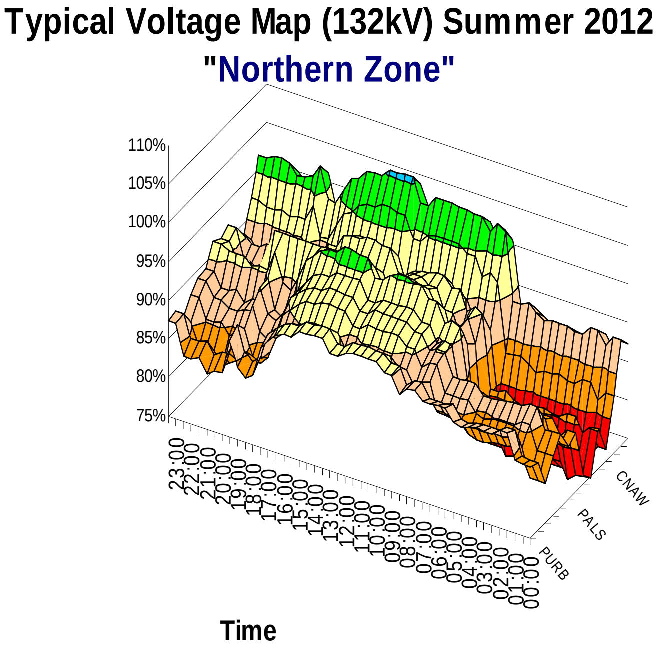
Figure 6.1-3 Frequency fluctuation of TEPCO system (with large system disturbance), and Histogram of frequency deviation in TEPCO

This unstable frequency is mainly caused by the lack of sufficient spinning margin of the power system, which necessitates NLDC operators to exercise their last resort of power frequency control: Load shedding. Also, this frequency fluctuation reduces the power system's stability by limiting Underfrequency Relay Protection zone, which should be wide enough to secure necessary time to balance the power demand and power generations. The table below shows the current Under Frequency Relay (UFR) relay zone is limited to from 48.9 Hz to 48.6 Hz to avoid unnecessary load shedding during daily operation. If NLDC can limit the frequency fluctuation within the range Grid Code imposes, power system stabilization scheme with UFR works better to avoid the blackout of the entire power system, which occued on 1st November, 2014 due to the trip of large capacity interconnection.

Table 6.1-1 Loadshedding Amount of Underfrequency Relay Stages

Frequency	Loadshedding Setting
49.1 Hz	0MVA
49.0 Hz	0MVA
48.9 Hz	20MVA
48.8 Hz	150MVA
48.7 Hz	240MVA
48.6 Hz	240MVA
48.5 Hz	(UFR Trip of All generators)

Also, insufficient transmission capacity in some regions of the power system causes severe voltage drops, which sometimes fall to 80% of nominal voltage as shown below.



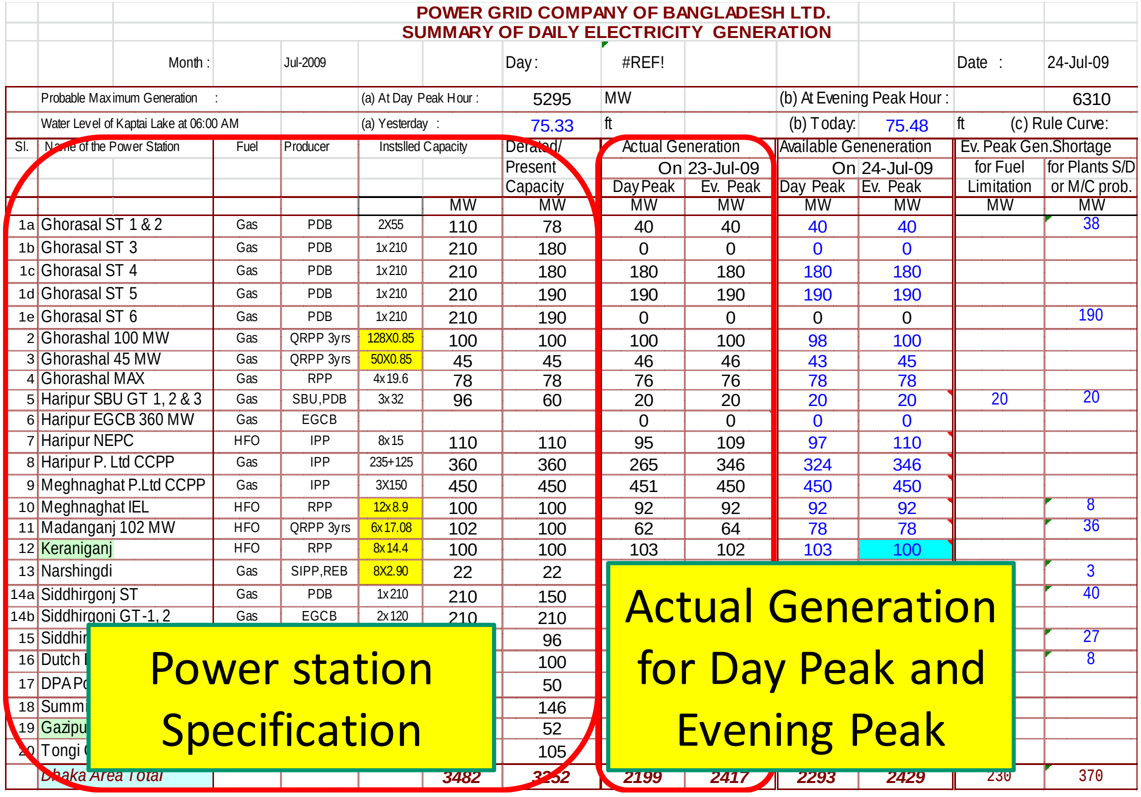
(Source: NLDC EMS system report data (Voltage & time))

Figure 6.1-4 Voltage Profile in 132 kV northern Bangladesh Power System

6.2 Historical Data Analysis on Power Demand and Generation Performance

In order to survey the power supply performance of Bangladesh and to identify the reason of power generation shortage, historical data on power demand and generation performance were analyzed for 365 days of 2013, which had been recorded as NLDC daily report.

An example of generation daily report is shown below.



POWER GRID COMPANY OF BANGLADESH LTD.
SUMMARY OF DAILY ELECTRICITY GENERATION

Month : Jul-2009 Day: #REF! Date : 24-Jul-09

Probable Maximum Generation : (a) At Day Peak Hour : 5295 MW (b) At Evening Peak Hour : 6310

Water Level of Kaptai Lake at 06:00 AM (a) Yesterday : 75.33 ft (b) Today: 75.48 ft (c) Rule Curve:

Sl.	Name of the Power Station	Fuel	Producer	Instslled Capacity		Derated/ Present Capacity	Actual Generation On 23-Jul-09		Available Geneneration On 24-Jul-09		Ev. Peak Gen.Shortage	
							Day Peak	Ev. Peak	Day Peak	Ev. Peak	for Fuel Limitation	for Plants S/D or M/C prob.
					MW	MW	MW	MW	MW	MW	MW	MW
1a	Ghorasal ST 1 & 2	Gas	PDB	2X55	110	78	40	40	40	40		38
1b	Ghorasal ST 3	Gas	PDB	1x210	210	180	0	0	0	0		
1c	Ghorasal ST 4	Gas	PDB	1x210	210	180	180	180	180	180		
1d	Ghorasal ST 5	Gas	PDB	1x210	210	190	190	190	190	190		
1e	Ghorasal ST 6	Gas	PDB	1x210	210	190	0	0	0	0		190
2	Ghorashal 100 MW	Gas	QRPP 3yrs	128X0.85	100	100	100	100	98	100		
3	Ghorashal 45 MW	Gas	QRPP 3yrs	50X0.85	45	45	46	46	43	45		
4	Ghorashal MAX	Gas	RPP	4x19.6	78	78	76	76	78	78		
5	Haripur SBU GT 1, 2 & 3	Gas	SBU,PDB	3x32	96	60	20	20	20	20	20	20
6	Haripur EGCB 360 MW	Gas	EGCB				0	0	0	0		
7	Haripur NEPC	HFO	IPP	8x15	110	110	95	109	97	110		
8	Haripur P. Ltd CCPP	Gas	IPP	235+125	360	360	265	346	324	346		
9	Meghnaghat P.Ltd CCPP	Gas	IPP	3X150	450	450	451	450	450	450		
10	Meghnaghat IEL	HFO	RPP	12x8.9	100	100	92	92	92	92		8
11	Madanganj 102 MW	HFO	QRPP 3yrs	6x17.08	102	100	62	64	78	78		36
12	Keraniganj	HFO	RPP	8x14.4	100	100	103	102	103	100		
13	Narshingdi	Gas	SIPP,REB	8X2.90	22	22						3
14a	Siddhirgonj ST	Gas	PDB	1x210	210	150						40
14b	Siddhirgonj GT-1, 2	Gas	EGCB	2x120	210	210						
15	Siddhir					96						27
16	Dutch					100						8
17	DPA P					50						
18	Summ					146						
19	Gazipu					52						
20	Tongi					105						
	Dhaka Area Total				3482	3252	2199	2417	2293	2429	230	370

Figure 6.2-1 Example of Generation Daily Report

Power demand peak occurs at evening of around 21:00 due to lighting demand at households.

NLDC records two peak demands: day peak at 12:00 and evening peak at 21:00 for its generation control. The red patched area in the daily curve below shows the load shedding demand due to the shortage of generation. Base load is supplied by Gas power plants, which have lower fuel costs and the middle portion of the load is generated by Oil power plants which has relatively expensive fuel costs.

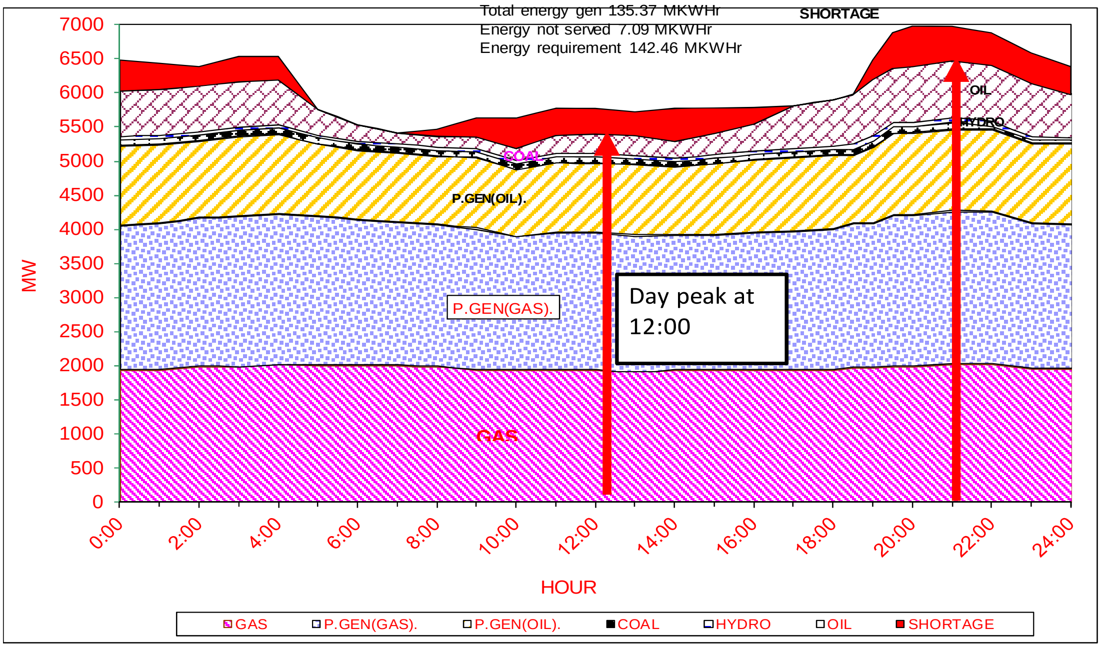


Figure 6.2-2 Example of Demand Curve at the day of yearly maximum demand

The second figure shows the summary of the data analysis conducted.

Although power plant has its specific installed generation capacity, some power plants runs low to their power capacity due to deterioration and insufficient maintenances. Thus the actual power generation shall be evaluated on de-rated capacity. In Bangladesh, de-rated capacity is 94% of the sum of installed generation capacity.

In daily operations, some power plants can not generate its power due to unexpected fuel shortage or machine accidents. This study focuses this undesirable power plant outage to analyze the reason for plant accidents, the power plant availability and the occurrence of load shedding over the year of 2013.

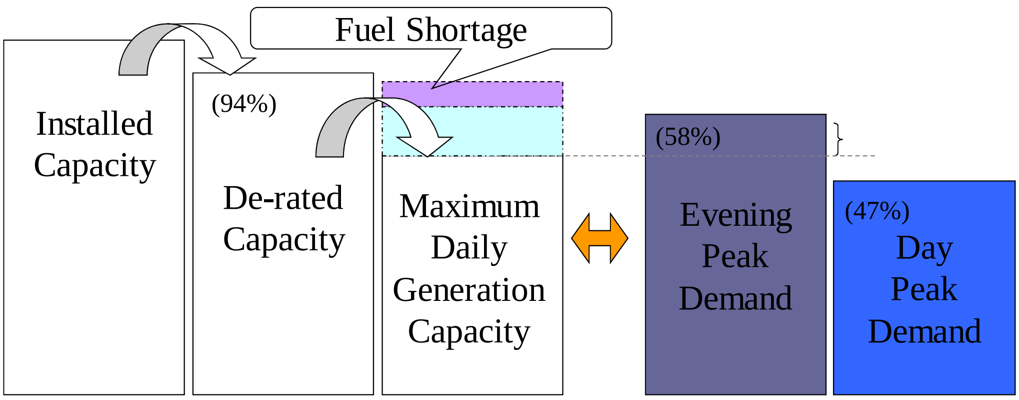


Figure 6.2-3 Data Analysis Overview

The following figure shows the evening peak demands in 2013 by month.

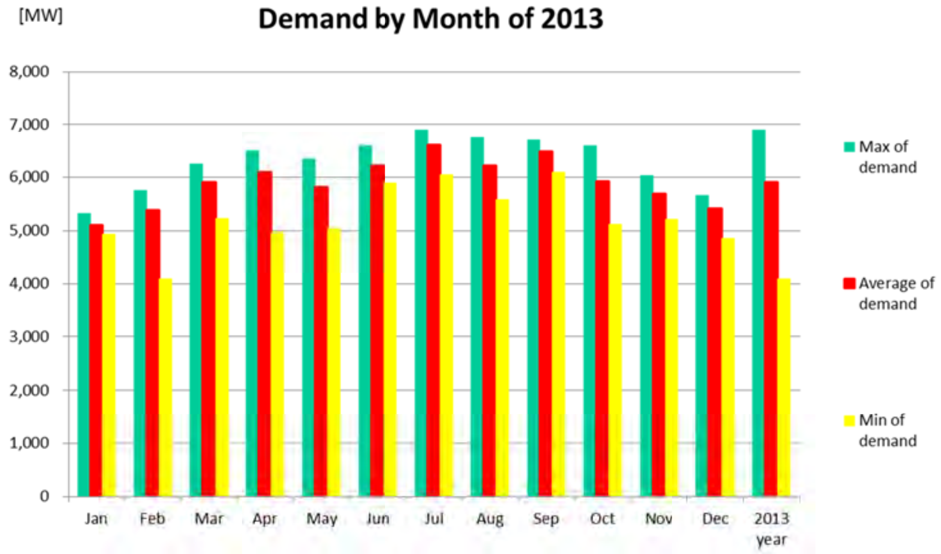


Figure 6.2-4 Power Demand by month

Bangladesh has its electricity peak demand in the rainy summer season, which starts from July to September, up to 6,900 MW in comparison with the yearly average demand: 5,911 MW. During dry winter season from December to February, power demand tends to relatively decrease in comparison with summer demand.

Based on practical power operation experience in Japan, the reserved power generation capacity shall be assured at 8% to 10% of its power demand. But Bangladesh power industry is suffering from constant power shortage due to the very lower power plant performance as described in the latter section.

The next first figure shows the daily histogram of evening peak demand in the year of 2013.

It is one of characteristics for Bangladesh that peak demand is likely to be concentrated around the average and 60% of 365 days are located from 5,600 MW to 6,200 MW. This means that if the generation capacity excess the level of 6,200 MW, 80% of a year can avoid the load shedding and the customer can afford the benefit of the uninterrupted power supply except 20% of peak demand days.

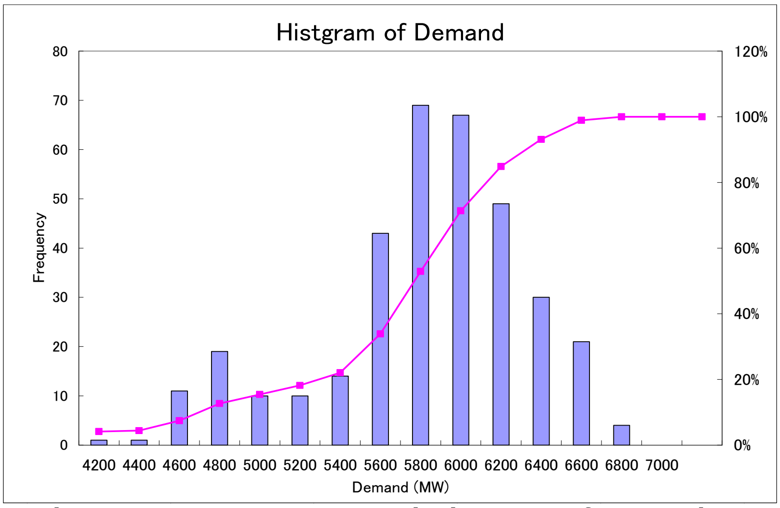


Figure 6.2-5 Power Demand Histogram for Evening Peak

The following figure is the number of load shedding day and its amount of shed load in 2013. Days of power shortage amounts up to 175 days and account for 48% all over the year. This means that the load shedding happened once every two days and it is not acceptable in the modern industry society. Average of shortage power goes up to 372 MW and its ratio to the average demand reaches 6.3%. This means that if the generation power increases by 10%, most of power shortage can be avoidable. Therefore this study will proceed to analyze the power plant availability in the following section.

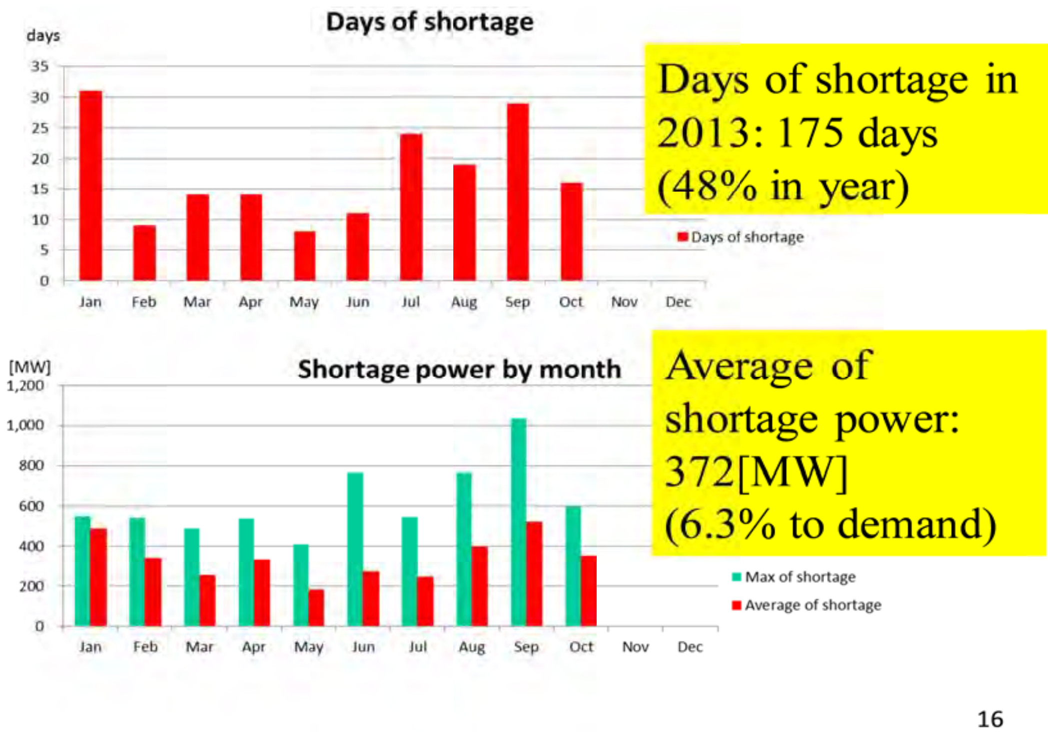


Figure 6.2-6 Load Shedding Occurrence and Power Shortage Quantity

For all power plants in 93 sites, respective power station availability has been calculated as shown in the following figure.

Availability at evening peak is very important for stable power supply because every power station must generate its assigned power in order to meet the peak demand and avoid the power shortage.

The availability is defined as the following formula.

$$P/S\_Availability[\%] = \left[\sum_{n=1}^{365} \frac{Generated\_actual\_power\_of\_P/S\_at\_evening\_peak[MW]}{De-rated\_power\_of\_P/S[MW]} \right] \div 365 \times 100$$

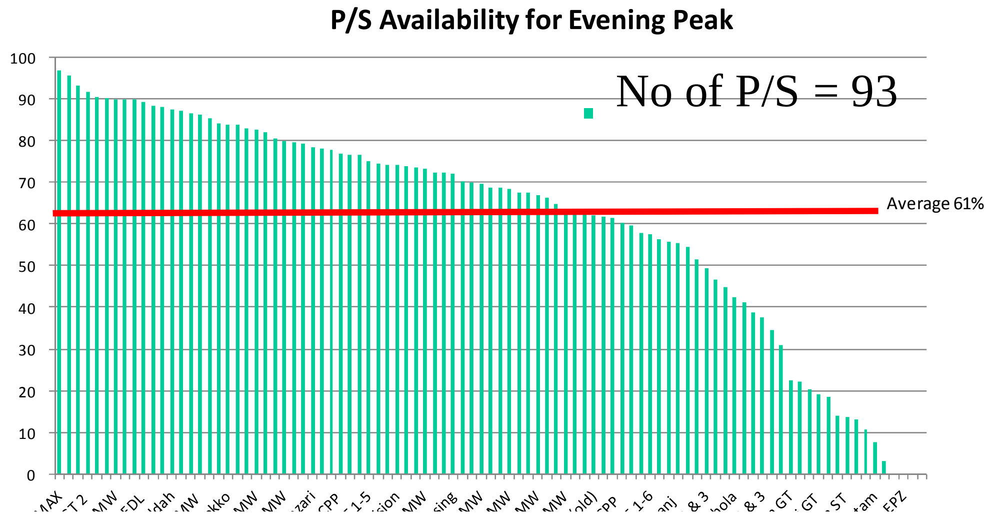


Figure 6.2-7 Power Plant Availability for Evening Peak

Some well-operated power plants such as Ghorashal MAX and Baghabari GT2 yields its availability more than 90% , while one-fourth of power plants are available to operate at less than 50% in 2013. The average availability over all of 93 P/S is 61% and this figure is likely to be lower comparing with the other industrialized countries performance of being 80% up to 90%. Therefore, lower availability of P/S is one of the biggest issues for Bangladesh power industry in assuring the reliable power supply and maintains the reasonable energy cost.

The next figure shows the power plant day-peak availability. The average of day-peak availability is 45% and 16% lower than evening-peak one of 61%. This is because some peak generations such as oil-fueled power and Gas turbine power operate only at evening-peak time.

However the average availability of 45% is still considered to be lower and the more power generation output shall be guaranteed in every day-time.

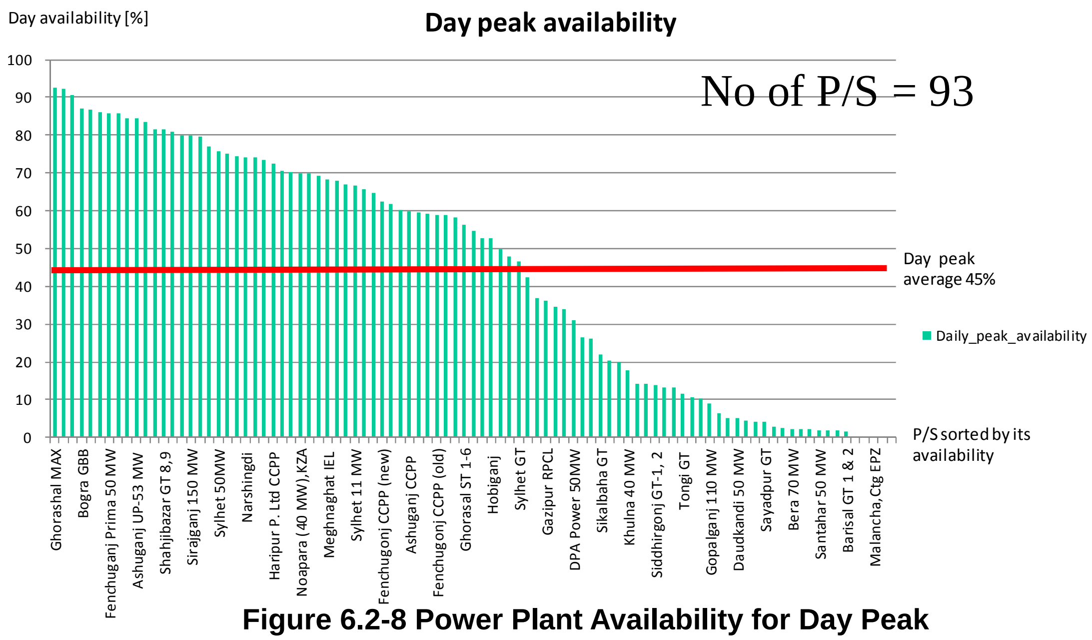


Figure 6.2-8 Power Plant Availability for Day Peak

The next figure shows the availability of P/S in respect to evening peak V.S. day peak.
Base load P/S has the higher figure in both evening and day peak and on the other hand, the peak load P/S has the higher availability of evening peak than day peak.

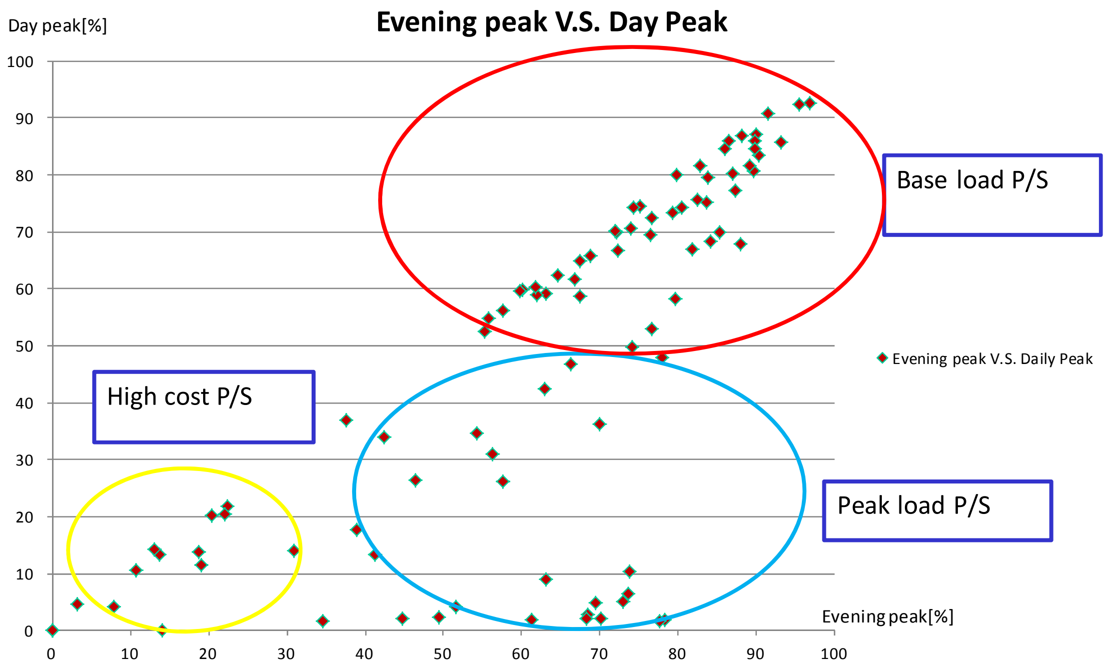


Figure 6.2-9 Power Plant Availability Distribution regarding with Evening Peak V.S. Day Peak

The JICA further studied why the power plants stop unexpectedly and frequently, and result in generation shortage of NLDC power grid. One big reason for generation shortage is the intermittent shortage of gas and oil supply. The other reason is machine trouble & repair in power plants. The following section discusses the power plant operation problem according to plant shutdown causes in detail.
The figure below shows the power generation shortage due to fuel shortage.
The generation shortage due to fuel limitation amounts to 936 MW on yearly average. This figure accounts for 16% of average demand which is 5,911 MW.
This means that the sufficient fuel supply is the most crucial issue to attain the stable power generation resources. However, this is considered to be a very difficult social and economic problem in Bangladesh and to be solved by the national energy strategy scheme.

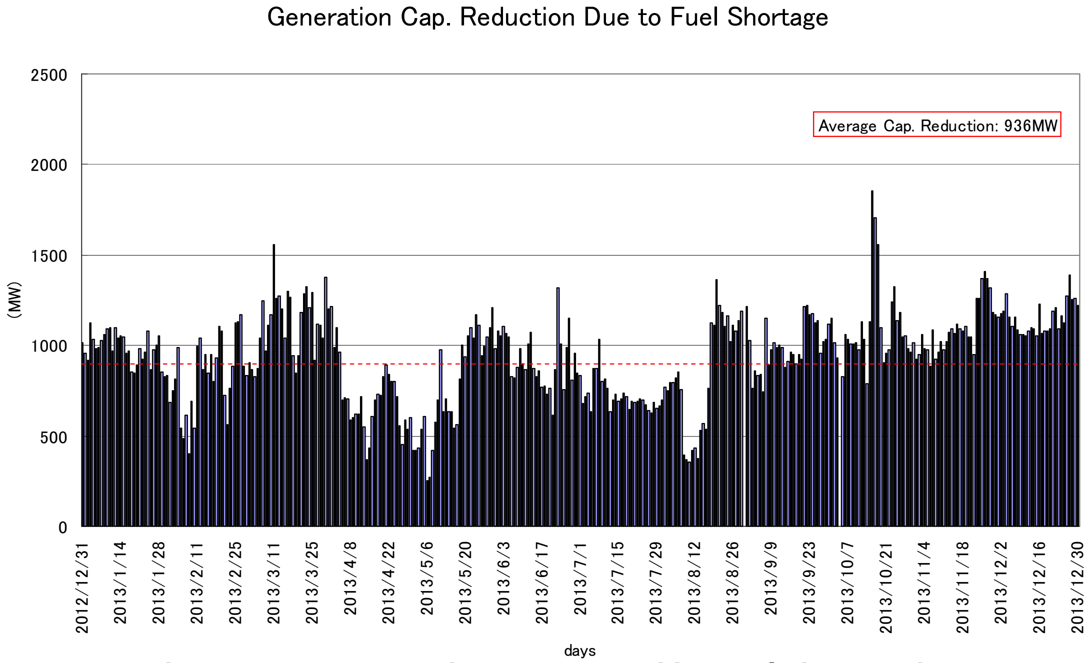


Figure 6.2-10 Power shortage caused by Fuel shortage in 2013

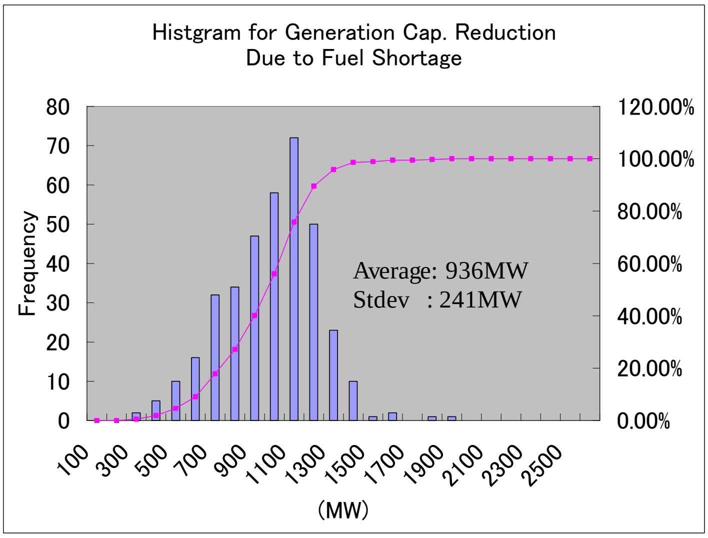


Figure 6.2-11 Histogram of Power shortage caused by Fuel shortage

The generation reduction due to machine trouble & repair is shown in the following figure and its histogram in the second one.

The average of power reduction goes up to 1,451 MW in 2013 which is 1.5 times as much as one due to fuel shortage of 936 MW. The power reduction due to machine trouble & repair accounts for 24% of the average demand and this is the biggest troublesome for NLDC power operation.

It is definitely necessary for NLDC to introduce some intensive mechanism in order to improve the power plant reliability.

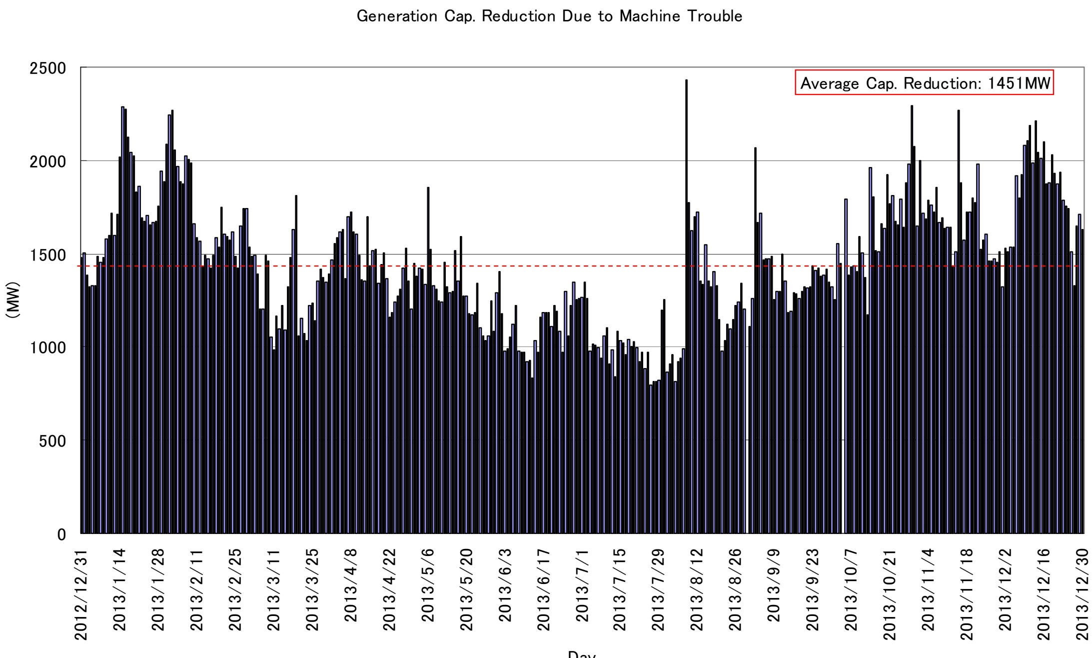


Figure 6.2-12 Power shortage caused by Machine trouble & Repair in 2013

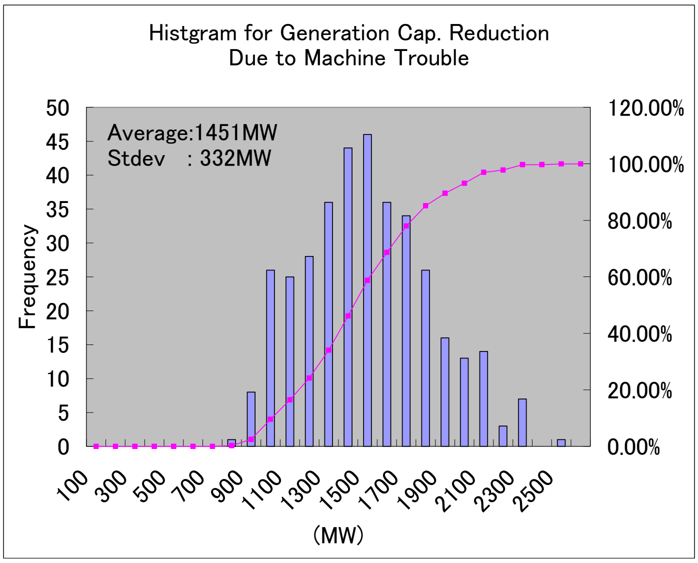


Figure 6.2-13 Histogram of Power shortage caused by Machine trouble & repair

The Historical Data Analysis on NLDC power operation can be summarized as follows:

(1) Load shedding is frequently enforced as much as once every two days, and power shortage accounts for 7% of power demand.

(2) Power plant availability is very low as much as 61% on average and this is one of main problem to cause the power shortage.

(3) There are two major factors to cease the plant operation undesirably. One reason is serious fuel shortage and the other is machine trouble & repair. The power shortage due to these accidents accounts for 40% of power demand and this situation shall be solved for Bangladesh power sector to develop a stable and economic power supply system.

(4) If every power plant can make efforts to reduce the intolerable shutdown by half, the plant availability will go up to 80% and all of power shortage problem will be ameliorated.

From this point of view, NLDC shall investigate the possibility of some intensive mechanism implementation such as “Availability Based Tariff “through the negotiation with the relevant power development institution.

The following figure shows the distribution chart in relation with P/S capacity and its availability. The power plant of greater than 100 MW would be more strongly encouraged to improve its availability than the smaller capacity plants because of its greater power capacity benefit.

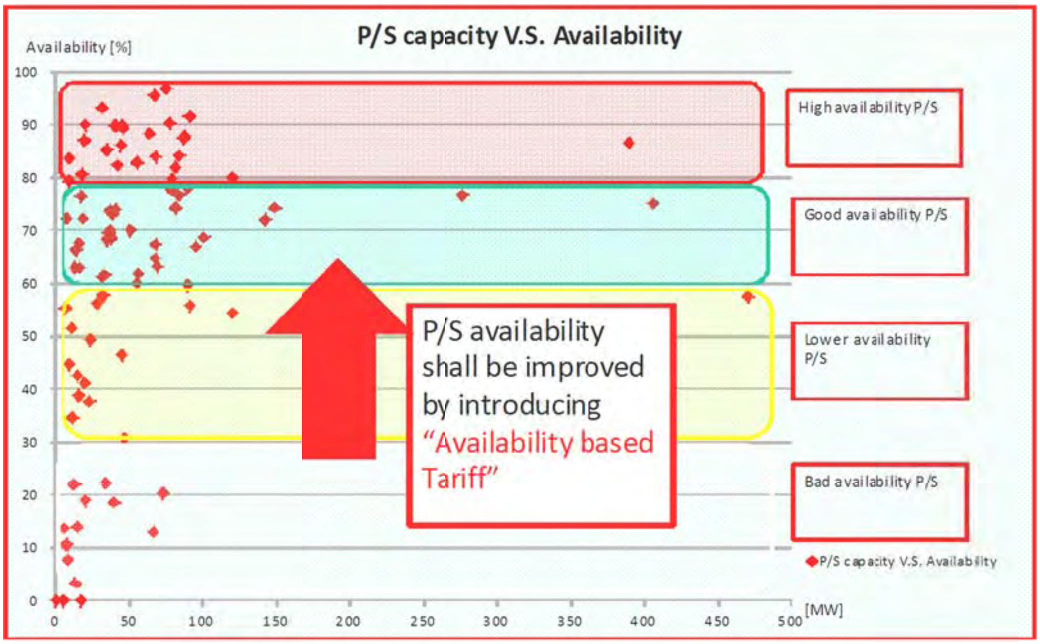
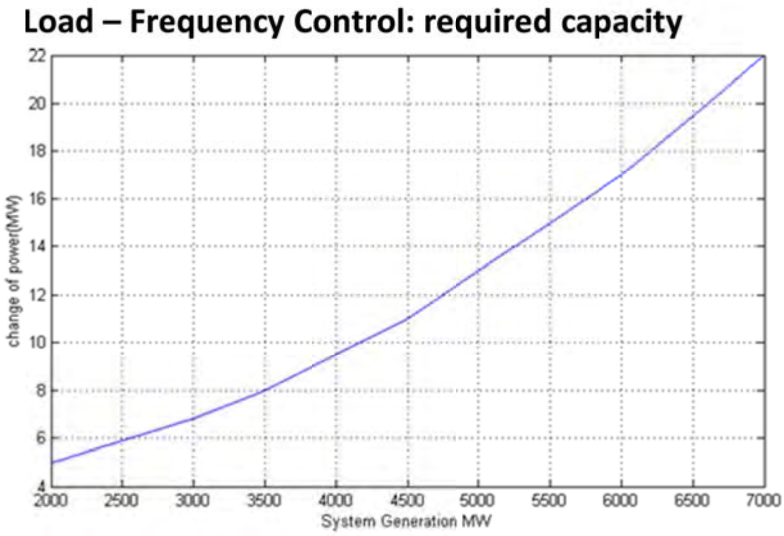


Figure 6.2-14 Power Plant Capacity V.S. Plant Availability

6.3 Feasibility test of frequency control

In addition to the problem of power quantity discussed above, NLDC has another technical operation issue: frequency control implementation. The quality of frequency is very low and the fluctuation of frequency is ten times as much as ones in Japan.

The required power capacity for load-frequency control is estimated to be 22MW/0.1Hz at the maximum demand of 7,000MW as shown in the figure below.



(Source: The NLDC interview done by The JICA Survey Team)

Figure 6.3-1 Load-Frequency characteristics in NLDC power grid

Table 6.3-1 Candidate Power Plants for AGC and/or LFC contro

Sl.	Name of the Power Station	Fuel	Producer	Instslled Capacity		Derated/ Present Capacity	Day peak Jan-Dec of 2013 Average MW/day	Day peak Jan-Dec of 2013 Availavility to Present Capacity	Evening peak Jan-Dec of 2013 Average MW/day	Evening peak Jan-Dec of 2013 Availavility to Present Capacity
					MW	MW	MW	%	MW	%
4b	Sikalbaha GT	Gas	PDB	1x150	150	150	33	22	33	22
	Chittagong area Total				***150***					
5	Shahjibazar GT 8,9	Gas	PDB	2X35	70	66	54	82	55	83
8	Sylhet 150 MW	Gas	PDB	x150+1x7	142	142	88	62	95	67
	Sylhet Area Total				***212***					
8	Khulna 150MW	HSD	NWZPGCL	1x150	150	150	21	14	46	31
	Khulna Area Total				***150***					
1a	Baghabari GT 1	Gas	SBU,PDB	1X71	71	71	62	87	63	88
1b	Baghabari GT 2	Gas	SBU,PDB	1X100	100	100	91	91	91	91
	Rajshahi Area Total				***171***					
	Total				***683***	***679***	***348***	***51***	***383***	***56***

The current NLDC EMS/SCADA system manufactured by AREVA is capable of load-frequency control functions as its standard software but is not applied to the practical power operation because there is no agreement on real-time generation control between NLDC and power plants' capacity for Load Frequency Control (LFC) operation. Also, the EMS functions of the NLDC system has not been in operation because the necessary database for EMS functions, such as generation unit parameters for all power plants, has not been built. NLDC has been trying to utilize the EMS/SCADA system to improve their power system operation, and succeeded in activating all SCADA functions of the system now. This year, NLDC revised their Annual Maintenance Contract with Alstom (formerly Areva) to include necessary data gathering for activating EMS functions as well.

JICA also encouraged NLDC to conduct the tiny simulation of frequency control with the current SCADA system as a feasibility test of the future on-line generation control, which is shown in the following figure. This simulation is intended to confirm whether the generation control signal of SCADA can appropriately manage the generation governor of power plant in future. The signal will be not connected to the physical control channel but just logged to an electronic file. However, the discussions of Areva engineers revealed that the database of network parameters are necessary to enable this automatic frequency control function, and the development of network parameter database may take another one year to get the result of the data gathering work done as a part of the annual maintenance contruct. Thus, this simulation shall be completed as a part of a next capacity building project for NLDC with the disclosure of generator unit parameters from BPDB and IPPs.

The most favorable candidates of plant for Automatic Generation Control (AGC) and/or LFC are listed in the second figure below. Now all of six Gas Turbine power plants such as Sikalbaha, Sylhet and Khulna cooperate with NLDC for manual power adjustment over telephone at daily operation.

It is expected that the real-time frequency control will be applied to these power plants after the completion of technical feasibility study.

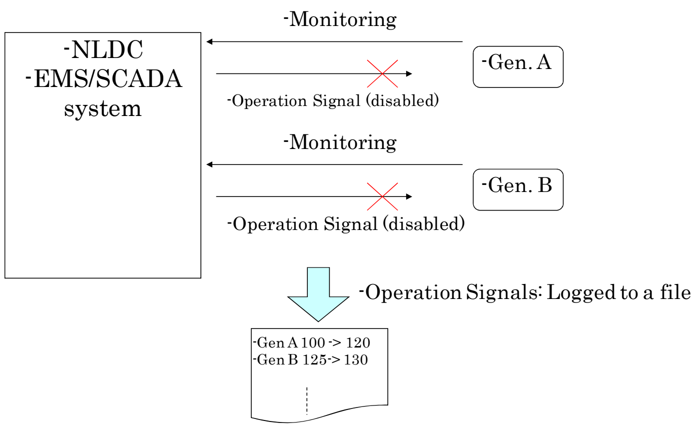


Figure 6.3-2 Load-Frequency control signal monitoring test

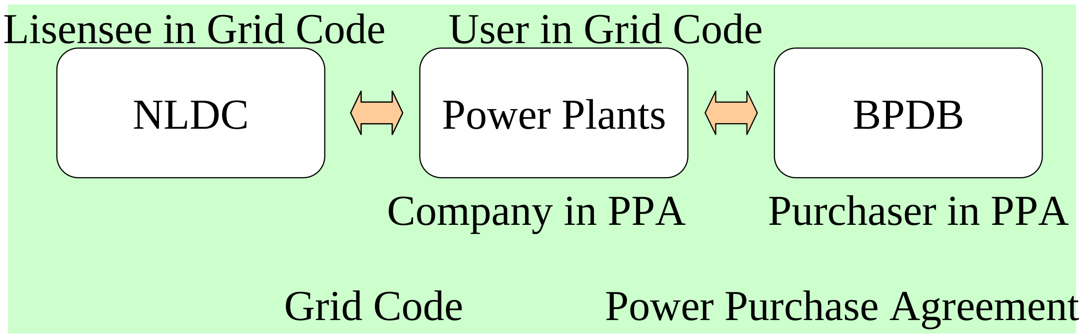
6.4 Regulations for NLDC's operation

The Bangladesh Energy Regulatory Commission has the authority in power sector, and it developed the Bangladesh Energy Regulation Commission Electricity Grid Code, which establishes the authority and duty of Transmission Licensee: PGCB, Generators, and Distribution Companies to fulfill the objectives of the Bangladesh Energy Regulatory Commission Act 2003. The Code contains several criteria and provisions on power system operations: Connection, Outage, Schedule and Dispatch, Operations, Protection, Metering, and Performance Standard.

In particular, the chapter 8 of the Code: Frequency and Voltage Management defines the responsibilities for Generators to follow the dispatch instructions, however any ancillary service and AGC from NLDC is not stipulated yet in the Code. Another contract related to power generation is Power purchase Agreement between BPDB and Generators, with which tariffs and service conditions are agreed bilaterally, playing an important role in achieving stable and economical electricity supply with a limited generation units and resources.

According to the operational data analysis, the survey team found that the current generation planning in the Grid Code is not working as expected because of uncertainties in power plants' generation, which is often caused by the shortage of fuel and unexpected troubles in generation machinery. To reduce the uncertainty in generation, JICA has proposed to stipulate all power plants to accept routine inspection of power system operators, which is called as Licensee in the Code, to reduce the frequency of generation troubles by accommodating necessary requirements in the Electricity Law, 2013, which is currently reviewed by corresponding ministries of Bangladesh.

In accordance with the revision of Electricity Law, related Grid Code and Power Purchase Agreements must be revised to operate the entire power network in a more reliable and efficient manner. Most importantly, the revised set of power system operational rules shall establish stronger authorities of NLDC and PGCB in terms of power generation planning (long-term, middle-term, and short-term) enabling to develop comprehensive power system development plan by reflecting ongoing problems in the Bangladesh's power system.



The Survey Team found that Current Grid Code covers most of necessary procedures and allocation of authorities of power system operation, For example, the section 7: Schedule and Dispatch defines the duty of power producers in terms of generation planning and procedures to be followed.

However necessary ancillary services for the stable power operation and necessary arrangement including incentives for the power produces have not been defined in the Grid Code yet and not established as the current operational practices. On the contrary, in the developed countries where the de-privatizations of energy market has been adopted, ancillary services and necessary procedures are well defined. For example, Energy Regulators Regional Association explains the ancillary service in an energy market as follows:

"Ancillary services can be thought of as those components of the overall energy product that are necessary to maintain the safe and reliable operation of the electric grid (transmission system).1 These services include (1) regulation and frequency response, (2) reactive supply and voltage control, (3) scheduling, system operation control and dispatch, (4) energy imbalance service, (5) operating reserves, and (6) black start service."

Source: Website document "Issues in the Determination of Tariffs for Ancillary Services" of Energy Regulators Regional Association, http://www.erranet.org/

Notably, many power system operators pay for these ancillary services as ruled in their Grid Code contrary to Bangladesh's grid code where no definition and incentives are defined.

Moreover, the incentives for allowing NLDC to operate generators, compensating reactive power losses, and securing enough spinning reserve are well defined in their Grid Code.
For another example of generation control in power system, Japanese electric power companies, which own most of generators, have introduced comprehensive energy management systems, with which the automated and comprehensive control of power generators can be utilized. Although the current Areva's NLDC system in Bangladesh's NLDC is equipped with some software components for Automatic Generation Control, it is not utilized yet because of the lack of generators' data for necessary on-line simulations and the lack of immediate scheme to transmit calculated operations.

Another difficulty in securing sufficient ancillary service is the lack of well-organized market scheme nor power operation agreement in current energy market in Bangladesh. Thus, the enforcement and revision of the operational procedure stipulated in Grid Code is urgently necessary. Some studies for better operational rules, such as Availability Based Tariff system, has already been studied in NLDC, and the cost-benefit analysis of new operational schemes applicable to Bangladesh shall be studied for the sake of more economic and more reliable operation of the grid.

6.5 Organization of National Load Dispatch Center

The National Load Dispatch Center is responsible for frequency control, generation control including hourly generation scheduling, voltage control, and load allocation to all 9 (10) regions by monitoring the entire system day and night. The NLDC's Study on Availability Based Tariff defines that "NLDC is the single authority to control all the generating stations both public and private.", besides long-term and middle-range generation planning, which are conducted by the planning section in BPDB. Nine Areal Load Dispatch Centers (ALDC) are responsible for region-wise voltage control and power flow control by opening/closing circuit breakers and controlling reactive power sources, shunt reactors and capacity banks, in service. The operational organization of the Bangladesh System is shown below.

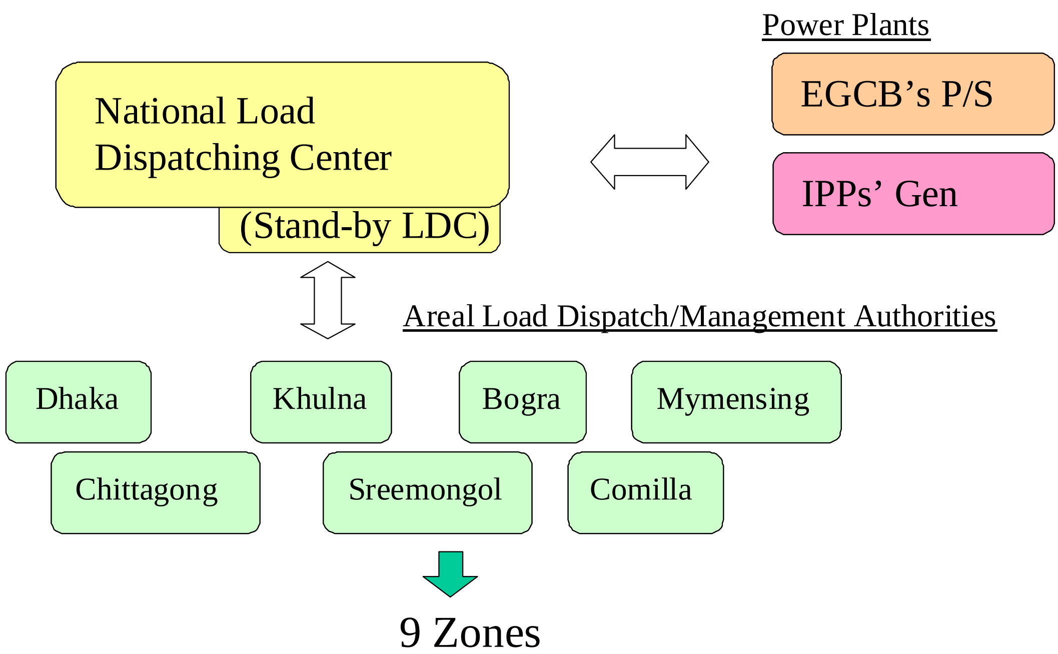


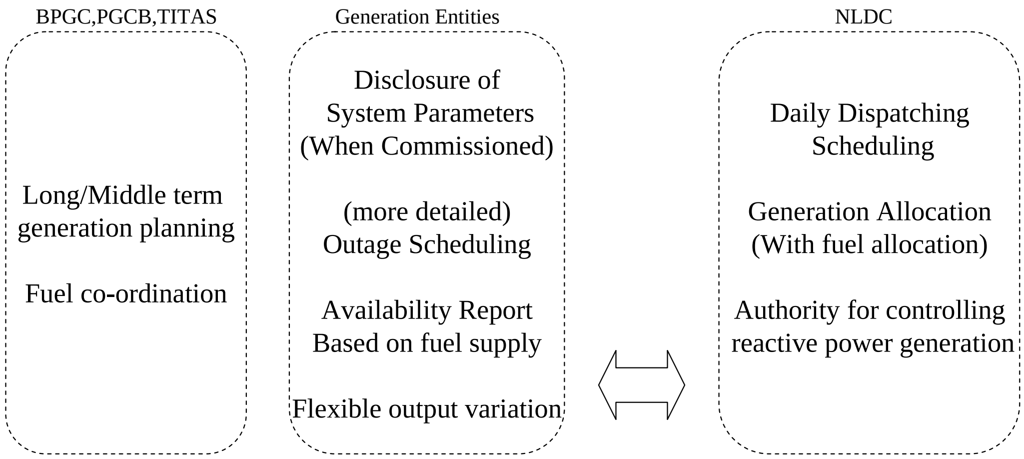
Figure 6.5-1 Operation Organization of Bangladesh Power System

According to the NLDC's Study on Availability Based Tariff system, (the "Study on ABT"), the actual procedure of frequency control orchestrated by NLDC is summarized as below:

> "System frequency is mainly controlled through:
> 1. Demand Side Management (DSM) mechanism.
> 2. In the case of availability of reserve generation, to a certain extent through generation control.
> 3. In emergency condition, both DSM and generation control are employed.
>
> NLDC allocates load for different zones (09 zones) as per the daily generation according to the zonal load distribution chart. ALDC distributes the load to different substations according to the load ratio defined by the load management committee. Time to time commands are given from NLDC to ALDCs to keep the load draw within their allocation."

(Source: Overview of Bangladesh Power System Operation)

It is quite notable that Demand Side Management, namely load shedding, is frequently exercised to meet the available generations, which may be reduced in the daytime because of the shortage of gas supply. Thus, generation planning is quite important to increase the quality of electricity supply, and co-operation of entities involved in electric power generation as summarized is necessary. NLDC's efforts.



(Source: A presentation of the Survey Team)

In particular, generation scheduling procedure could be improved with more information from generation companies and BPDB by setting a daily regional maximum demand allowance with consideration given to the availability of daily fuel supply and operable generation units.

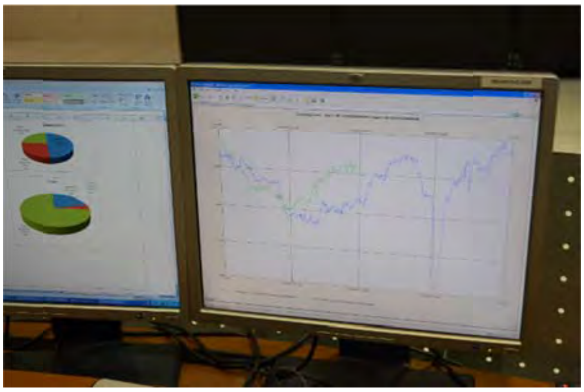
6.6 Current SCADA/EMS system in NLDC and its Usage

The current PGCB National Load Dispatch Centre started its operation in 2007 with funding support from Asian Development Bank (ADB) and GOB. Its SCADA/EMS system is manufactured by Areva and its telecommunication system was supplied by Furukawa Electric.

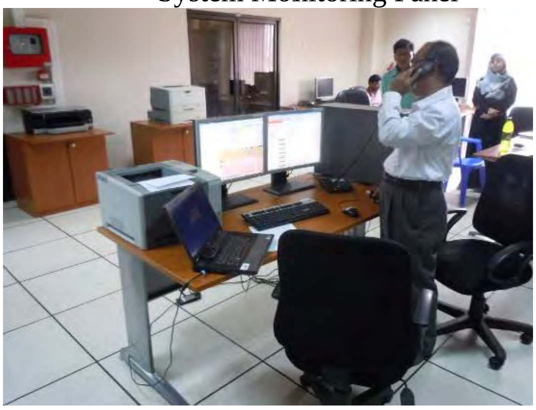
The NLDC SCADA/EMS system consists of 2 (two) Control Centers, Main & Standby, comprising 50 computers including 20 different servers. 145 RTUs located at 102 sites acquire data from and deliver commands to 34,350 interfacing points of field equipment. Input – Output signals. Its communication network consists of 4,500 km of Optical Fiber over 127 HV transmission lines with 137 SDH multiplexers, 113 PDH multiplexers, 216 pieces of tele-protection equipment, 690 telephone sets, Automatic Generation Control (AGC), and 6 Remote Consoles. The following figure shows the connection and SCADA/EMS systems, generators, and substations through the optical fiber based telecommunication system.

Overview

System Monitoring Panel



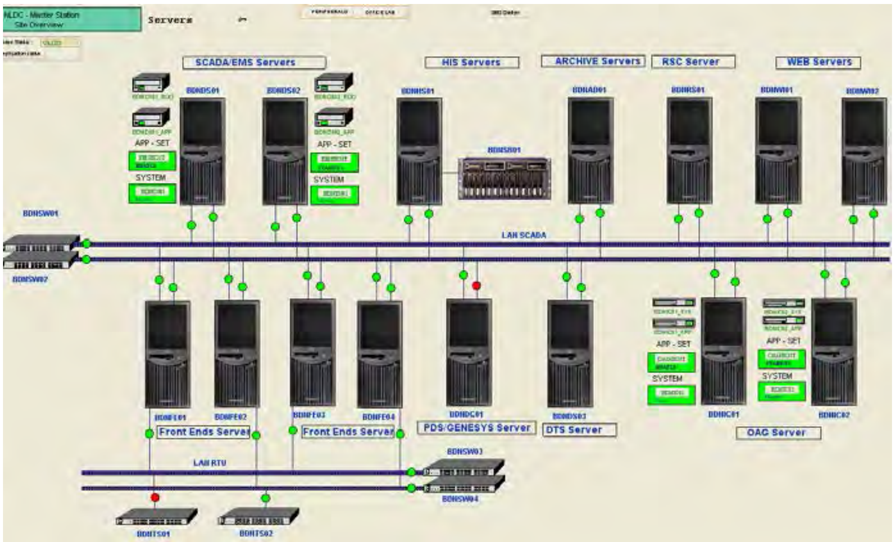
Operator Interface



Data Maintenance Terminals

Server and storage

Figure 6.6-1 SCADA/EMS System in NLDC (Main Building)



(Source: NLDC's presentation for JICA Survey Team on April 20th, 2014)

Figure 6.6-2 NLDC's System Configuration

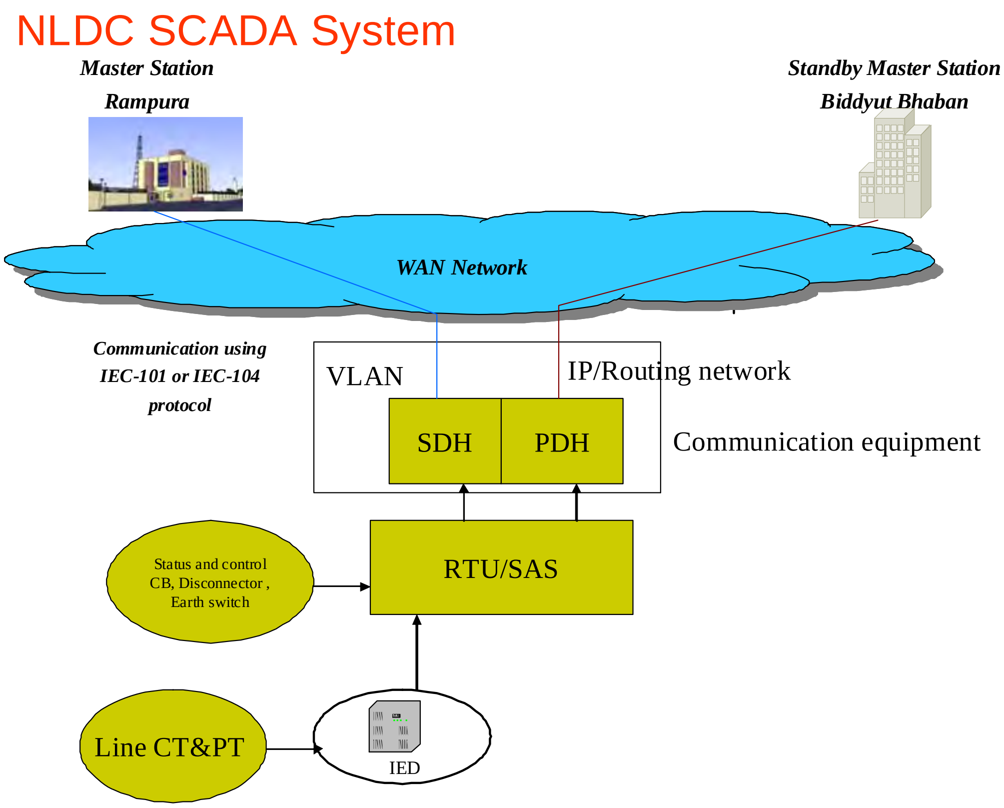


Figure 6.6-3 Telecommunication system configuration for NLDC system

(Source: NLDC's presentation for JICA Survey Team on April 20th, 2014)

The SCADA/EMS system's features are summarized below based on the survey team's interviews with NLDC engineers. Some functions are not utilized yet, and the reasons for this were also asked about in the interviews for further study.

Table 6.6-1 NLDC's operational functions and Current Usage

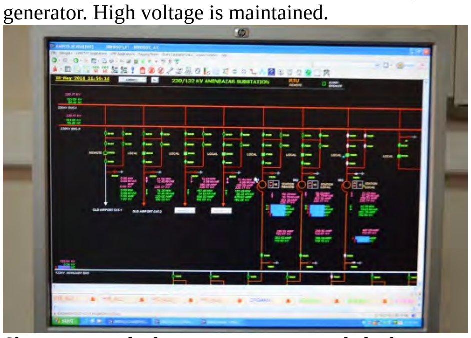
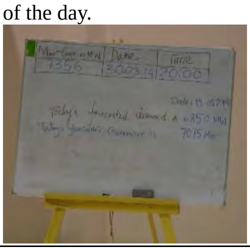
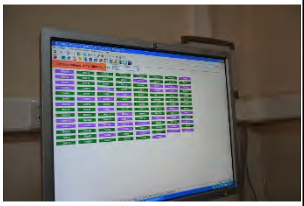
Functions		Degree of Utilization	Current Problems
SCADA Functions (Monitoring of the power system)	Monitor status change of power system by receiving supervisory and telemetry (TM) data from RTU. When detected status change and deviation of TM values, it will inform the operator through operation display. Following are monitored; - Frequency - Voltage - Power Flow - Post-fault Analysis	The monitoring function is available in the current system. The following information is currently received. - Frequency - Voltage - Power Flow - Post-fault Analysis	Information display failure on the system monitoring panel is recognized. Reasons as follows; - Failures existing in tele-communication between NLDC and substations. Failure occurs at substations including high voltage substation, substation apparatuses such as Trd, IED, RTU, power supply equipment installed at the substations. - Intermittent tele-communication between NLDC and other companies - Online information supply excluded from contract - Substation facilities mainly owned by PGCB, however do have substations owned by other company. - PGCB owns some power plants as well.
Load Frequency Control (LFC)	Maintain primary frequency regulation capacity. LFC function controls power output of generators based on frequency deviation, and maintain frequency in adequate range. Frequency control is accomplished through generator governor response (primary frequency regulation) and LFC.	Generator control is done by EMS operator providing control value to generator operator by telephone. To operate according to the control value or not is decided by the operator. Frequency is dependent on generator operation. Generator control priority given in order of; power plant>NLDC	Current problems includes the following; - Grid Code, Power Purchase Agreement (PPA) arrangements are not suitable for LFC and Automatic Generation Control (AGC) - No disclosure of Generation Parameters. Despite above, no complaints from customers about the frequency variation are received, since 60 % of the customers are not using electronic products (even used, only fan or lighting). Poor power quality is not a problem with motivation to solve, and there is no penalty to PGCB for providing such electricity.
Voltage and Reactive power control (VQC)	This function send reactive power signal to generators to regulate voltage targeted to this function. Reactive power signal originates from operators' key input value.	The voltage of existing power system is already low. Distribution line voltage is maintained in an adequate range.	Voltage condition of each region is as below; - West, and North: In poor condition due to long transmission line, and lack of generators. Deployment of line voltage regulator, static tap changer, shifting to higher voltage may be a solution. - South: Generally in good condition. Voltage is high at night, and low in daytime. - East: In good condition due to existence of large generator. High voltage is maintained.  Shunt reactor deployment is recommended when in high voltage. (Unsure whether exists.)
State Estimation, Network Security Analysis, and System Optimization	Real time contingency analysis for N-1 Security Real time monitoring of P-V curve and Voltage Stability	Function is appropriate, but it is an offline function. Can be simulated in advance and confirmed with actual results.	Problems regarding the state estimation includes the following; - There are places in result where the estimated value (pink) and measured value (green) are quite different. - Measured values not delivered in timely manner, and data update not completed in time. Regulation condition was poor. No regulated interface existed between EMS and SCADA system.

Table 6.6-2 NLDC's operational functions and Current Usage (Cont.d)

Functions		Degree of Utilization	Current Problems
Economic Dispatch Control (EDC)	EDC calculates economic dispatch output schedule for each generator of different efficiency to control its power output depending on the change of power demand. EDC is the short-term determination of the optimal output of a number of electricity generation facilities, to meet the system load, at the lowest possible cost, while serving power to the public in a robust and reliable manner. Scheduling / Real-Time Dispatching.	The EDC function exists and is available.	- EDC function was unused. - Generators operate in accordance to power generation planning at the power plants, hence NLDC is not involved in power generation plan.
Demand Forecast and Generation Scheduling	The Demand Forecast Function calculates total demand from weather forecast information and the past record data, and allocates most economical generation schedule of each generators by Generation Scheduling Function.	Calculate the total maximum demand by using the maximum temperature. The actual demand is monitored and shown together with the demand curve forecasted the day before. Operators receive weather information from the smartphone.	In Japan, dispatching systems receive weather information from the Japan Meteorological Agency. Weather forecast is important information because electricity demand differs significantly with even a 1 degree Celsius difference in maximum temperature. The Demand Forecast Function calculates total demand from weather forecast information and the past recorded data, and allocates most economical generation schedule of each generators by Generation Scheduling Function.
	The demand forecast function predicts the gross demand for the next day by using multiple regression analysis based on previous data, past weather conditions, type of the day (day of the week, singular point, etc.), and weather forecast information	Demand forecast function is either unused, or does not exist. Actual demand forecast is undertaken in morning, to calculate the maximum demand of the day. 	Lack of long term demand forecast program is a problem, and is needed. Desk calculation would be fine, if actual data analysis is possible.
Recording, Archiving	Event recording shall be displayed on monitor when an event occurs. Also the recorded data shall be able to be referred (displayed) on monitor.	The recording, archiving functions are available.	The operating staff is creating the daily report by hand, and it is not utilizing the record data which the system collected.
	Post-Fault Diagnosis	Fault diagnosis function has not been confirmed yet, but the failure history is preserved.	Failure history is preserved.
	Web Server for other Customer/administrative Services	There are WEB servers in the system configuration.	NLDC system is not connected to the outside world. Only within the NLDC.
Maintenance of database	Database (DB) modification for addition/deletion of power system components.	The database maintenance function is available.	Dedicated maintenance team is present. DB of the new substation and outgoing Matarbari are also being handled by the same team.
Configuration Control	Real-time Monitoring of SCADA/EMS network status	The configuration control function is available. 	Configuring component devices in the system configuration screen and confirmation of RTU state is possible. RTU status screen: Green is healthy, purple is disconnected (which also includes future reserve). As preparation for power failure of NLDC, backup power supply such as a diesel engine and UPS are available.

Current usage and modifications necessary for better system operation are discussed in the following sections.

6.7 SCADA Function

6.7.1 Monitoring System

Supervision of the entire power system is already enabled and most power stations and substations are continuously monitored on line. However, some newly built substations & power plants are not monitored yet because of the lack of RTUs in these stations, and the upstream data of a few substations were not transmitted because of the overheating of Phasor measurement Units (PMUs) on sites.

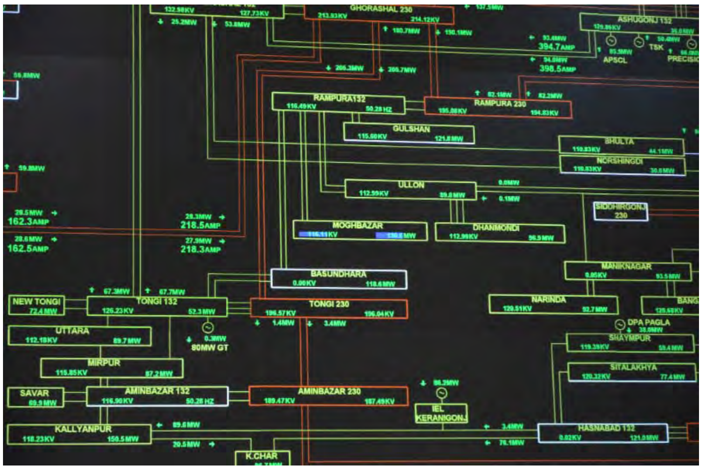


Figure 6.7-1 Representation of the error of upstream data on the system panel (numbers highlighted in blue were not successfully acquired)

6.7.2 Generation Control from NLDC

The NLDC's SCADA/EMS system is not completely connected to power generation units, and NLDC operation to power generation units is not transmitted electrically. The discussion on generator controls revealed that 1) NLDC is now planning to introduce an AGC system, 2) Operational Control from NLDC has not been realized because power plants hesitate to be controlled by other entities, 3) generation scheduling has not been successfully implemented due to inconsistent supply of fuels. NLDC engineers pointed out that current power purchase agreements and grid codes must be reviewed so that better control of generators can be achieved.

6.7.3 Generators' LFC, AGC control from NLDC

The LFC and Automatic Generator Control from NLDC are not implemented due to the lack of any legal or contractual stipulation upon generation companies, and consequently, the lack of control connection to generators.

The Survey team members visited two new generation facilities in Haripur: Haripur 360 MW CCP of Haripur Power Limited, and Haripur 412 MW CCP of Electricity Generation Company of Bangladesh (EGCB). They understand the importance of these advanced generation controls, and showed the possibilities of their implementation based on some contractual or legislative arrangements. However, they also pointed out their problem of securing a constant supply of fuels from the Titas Gas Transmission and Distribution Company, which often results in a shortage of generation for its planned output. To improve the power system supply quality, this survey must consider not only the improvement of demand-generation planning, but also the fuel supply planning of other authorities and companies.

6.7.4 Operation of circuit breakers and On-Load-Tap-Changers from NLDC

Most of the power flow controls done by opening/closing circuit breakers are done by areal load dispatch centers under the supervision of NLDC. NLDC can directly operate some of the 33kV feeders for demand-side load shedding. Voltage controls are also done by areal dispatch centers locally. Details of operation rules will be further studied in the next mission.

6.8 Energy Management System Function

Currently, NLDC's SCADA/EMS system features fundamental EMS functions, but most of these programs are not well utilized by operators because of the lack of power system parameters for detailed simulations, and the lack of operational rules to utilize the current systems.

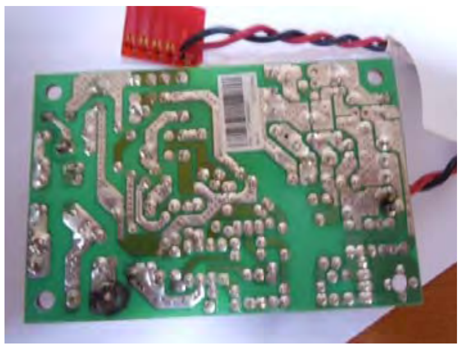
6.9 Supply parts and maintenance contract for SCADA/EMS system

NLDC operators are now concerned with the discontinuation of supply parts, and the high repair cost for damaged parts. For example, the system monitoring panel consists of BARCO's rear-projection system, and the manufacturer of the display reported the discontinuation of supply parts to NLDC. The Survey team also found the repair history of power supply parts, hard-disk failures, and capacitors of servers, which were voluntarily repaired with open-market third-party parts. Software-wise, the system is equipped with Windows XP terminals as Man-Machine Interface, and its discontinuation of technical support could be critical to the sustained operation of the NLDC system.

BARCO's troubled display

Usage of Windows XP OS

exploded capacitor



faulty circuit board for power supply

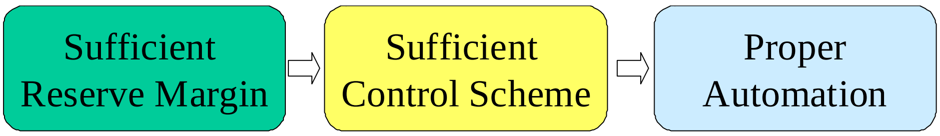
repaired motherboard of HMI terminal

Faulty harddisk drives

Figure 6.9-1 Example of faulty parts of SCADA/EMS system

6.10 Current Issues and Proposed Solutions

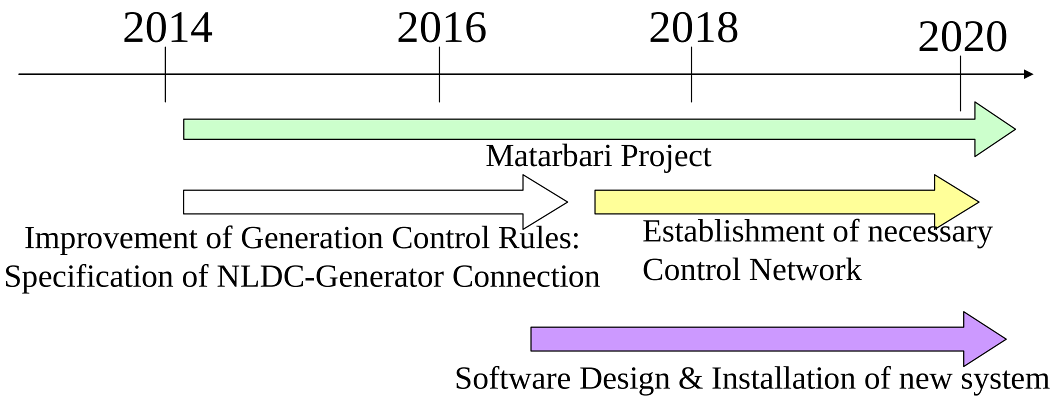
According to the team's studies conducted so far, the quality of the Bangladesh electricity power supply can be improved by 1) increasing power generation capacity as planned, and securing continuous fuel supply, 2) devising better generation planning procedures and on-line control among all entities concerned with the revision of current electricity laws, rules and PPAs contracts. In other words, NLDC's operational duties cannot be fulfilled as designed without sufficient active and reactive power generation under their control, both of which are now limited due to the lack of power generation units, sufficient operational infrastructure, and practical operational agreements between NLDC and power generators.



For further study of administrative rules on generation planning, the Survey team discussed Bangladesh's current plan on relevant law revisions with JICA, and the team found that he has already developed a proposal for electricity law revision. According to the Survey team's visits to power generation companies, contractual obligations and monetary incentives for power generation companies to supply reactive power to the grid must be devised and clearly stated in their PPA, and detailed generation scheduling procedure among stakeholders must be revised to deal with the increasing uncertainties of Bangladesh's electric power supply infrastructure.

Thus, in accordance with the amendment/revision of electricity law, Grid code and other practices should be reviewed. And in a similar manner, existing PPA contracts will be studied in this Survey and subsequent JICA capacity building project planned next year for NLDC to include NLDC's technical requirements, the specification of necessary information for Generators, and procedures for disclosing fundamental information. To develop reasonable PPA contracts, NLDC's operational requirements, incentives for better co-operation, and penalties for significant negative impact on network operation will be studied in the following missions of the Survey team.

To start with, Matarbari Power Project, which starts its operation in 2021, and JICA generation plant projects will be used to develop better NLDC control schemes because these projects increase total generation capacity with relatively large generation units based on new generation control systems, and in a similar manner, future generation projects must be designed to maximize NLDC's operational flexibility. Thus, the technical study for advanced generation control from NLDC must be studied at least along with the design specification of Matarbari Power Project based on the planned JICA capacity building project for NLDC. Also, system parameters for power system analysis and dynamic power system simulation shall be immediately reviewed to enable the current SCADA/EMS system to be fully operated. To utilize the power generation control functions of the SCADA/EMS system, some frequently controlled power generation units must be connected to NLDC electrically to conduct Automated Generation Control based on the revised power generation scheduling procedures by 2020.



After clarifying the better control scheme, the current SCADA/EMS system will be replaced with a new system with expanded features for better generation scheduling, generation control, demand forecasting, and more reliability in system components by securing replacement parts. By considering the expected lifetime of current SCADA/EMS system, which is estimated to be operable till around 2020, the specifications for the new SCADA/EMS system software design must be started by 2017.

Chapter 7
Power System Analysis
for
Dhaka-Chittagong System

Chapter 7 Power System Analysis for Dhaka-Chittagong System

7.1 Study Conditions for Power System Analysis

7.1.1 General

The objective of the power system analysis is to ascertain the status of the future system, such as generating conditions, loading of the lines, bus voltage, etc., for formulating the new 400 kV transmission system expansion plan of PGCB.

The active and reactive flows on transmission lines, and voltages and phase angles at each bus in power stations and substations were to be simulated in the load flow calculation, and the peak loading conditions were simulated. Following the load flow calculations, the fault currents of 3-phase-short-circuit on concerned buses have been calculated for the peak demand. Short-circuit breaking capacity of the circuit breakers in objective substations was verified with the result of the 3-phase-short-circuit current. Dynamic performances of the power system have been simulated by analyzing transient performance of the power system following a sudden change or disturbance in normal operation.

7.1.2 Power System Analysis Modeling

The whole 400 kV, 230 kV, and 132 kV Bangladesh power system in 2021 was modeled using Power System Simulator for Engineering (PSS/E) software. PGCB has provided all the necessary data on the existing and future network required for the analysis including line constants, transformer capacities, generating conditions, etc. as described in the following tables.

a) Load Data

The estimated loads at 132kV substations that PGCB provided were modeled. Their power factors were assumed as 0.9. The following table shows the load data of active power that were modeled in the system data of PSS/E as the 2021 system.

Table 7.1-1 Load Data for PSS/E Model

Bogra		Chittagong		Comilla		Dhaka		Dhaka North		Dhaka South		Khulna	
Substation Name	2021Load	Substation Name	2021Load	Substation Name	2021Load	Substation Name	2021Load	Substation Name	2021Load	Substation Name	2021Load	Substation Name	2021Load
Barapukuria	83	Bakulia	93	Ashuganj	72	Ghorasal	91	Gulshan	115	Bangabhaban	60	Bagerhat	85
Bogra	108	Cox'bazar	90	Chandpur	83	Haripur	116	Kallayanpur	122	Dhanmondi	123	Barisal	104
Ishurdi	78	Dohazari	104	Chhatak	39	Hasnabad	84	Mirpur	111	Kamrangirchar	93	Bandharia	54
Joypurhat	85	Halishahar	124	Chowmuhani	91	Abdullapur	51	Dhamal Koat	103	Madanganj	81	Bheramara	83
Lalmonirhat	49	Hathazari	115	Comilla (N)	113	Jamalpur	105	Aftabnagar	101	Maniknagar	90	Chuadanga	64
Naogaon	103	Sitakundu	81	Comilla (S)	100	kabirpur	110	Agargaon	98	Matuail	95	Faridpur	85
Chowdala	49	Juldah	55	Lalmai	60	Keraniganj	90	Banani	122	Maghbazar	107	Gallamari	120
Natore	78	Kaptai	34	Daudkandi	99	Manikganj	79	Bashundhara	122	Narinda	106	Goalpara	82
Niamotpur	100	Khulsi	104	Feni	104	Munshiganj	106	Dumni	82	Shyampur	117	Gopalganj	68
Pabna	78	Madunaghat	72	Shahajibazar	73	Mymensingh	116	Purbachal	61	Ullon	124	Jhenaidah	78
Rajshahi	109	Shahmirpur	57	B.baria	98	M.gacha	88	Tongi New	120	Fatullah	102	Khulna (C)	114
Rangpur	101	Sikalbaha	104	Beanibazar	59	Nawabganj	73	Uttara	111	Kazla	122	Madaripur	89
Saidpur	81	Agrabad	113	Chaddugram	81	Netrokona	102	Uttara-3rd Phase	79	Lalbagh	98	Magura	56
Sirajganj	94	Baroaulia	103	Fenchuganj	54	Savar	113	Airport	88	Madertek	84	Mongla	76
Thakurgaon	93	Baroirhat	74	Nabiganj	61	Deldwar	70	Mirpur-II	78	Motijheel	90	Noapara	79
Amnura	76	Chandraghona	51	Kachua	64	Tangail	97	United City	62	Panthapath	88	Patuakhali	64
Bera	73	Kalurghat	86	Kulauara	61	Tongi	127	Uttarkhan	65	Postogola	121	Satkhira	85
Chapai	68	Khagrachari	49	Ramganj	103	Bhaluka	119			Satmasjit	93	Barisal (N)	106
Jaldhaka	61	Matarbari	58	Srimongal	60	Bhulta	70			Siddirganj	119	Benapole	68
Kurigram	61	Rampur	120	Sunamganj	54	Dhamrai	93			Sitalakhya	112	Jessore	106
Mahastanghar	103	Rangamati	49	Sylhet	116	Joydevpur	99			Zigatola	102	Kustia	106
Mithapukur	83	Sholoshahar	77	Sylhet (S)	116	Kishoreganj	78			Charsaidpur	83	Narail	64
Palashbari	66	F.hat	72	Chandina	60	Kodda	91			New Ramna	111	Rajbari	71
Panchagarh	68	Newmooring	86	Gazaria	68	Mirjapur	91			Basila	82	Shariotpur	46
Purbasadipur	73	Patiya	58	Laksham	68	Norshingdi	90			Ctg Road	90	Bangha	59
Rajshahi (N)	103			Muradnagar	103	Pachduna	63			Demra	77	Phultola	74
Shahajadpur	66			Sonapur	68	Rupshi	127			Khanpur	95	Gangni	78
Sherpur(Bogra)	99			Sylhet (N)	96	Sherpur	81			Khilgaon	105	Jalokati	51
Bangura	49			Feni-2	85	Sonargaon	105			Tejgaon	75	Kalapara	46
Bonpara	44					Sreenagar	74					Kaliganj	73
Bogra (New)	86					Sreepur	95					Kesabpur	73
Dinajpur	61					Sreepur-2	82					Rupsha	92
Gaibandah	42					Araihazar	85					Bhola	54
Paglapir	73					Aricha	61						
Patnitola	90					Ashulia	107						
Pirganj	85					Bajitpur	66						
Puthia	66					Bandor	90						
Ullapara	44					Boardbazar	79						
						Dhaka EPZ	82						
						Ghatail	85						
						Hemayetpur	93						
						Kanchon	74						
						Madobdi	80						
						Marjal	103						
						Nabinagar	110						
						Phulpur	38						
						Pubail	82						
						Rajendrapur	65						
Sub Total	2929	Sub Total	2029	Sub Total	2309	Sub Total	4276	Sub Total	1640	Sub Total	2847	Sub Total	2555
													18585

b) Transmission Line

Transmission lines were modeled based on the power network plan of PGCB for 2021 with 400 kV, 230 kV and 132 kV. The parameters used for the study are shown below.

The 4-bundles of Low Loss Aluminum Conductor Steel Reinforced (LL-ACSR) 560 mm^2 with the same resistance of Finch will be used as the conductor for the Project lines. We used the line parameters of 4-bundles of Finch instead of LL-ACSR 560 mm^2 for the Project line model and it seems reasonable for the purpose of this system analysis because the original system parameters PGCB have provided did not contain the line parameters of LL-ACSR and the differences of reactance and capacitance between both types of conductors are just around 0.7%.

Table 7.1-2 Positive Sequence Impedance for 400 kV Lines

Unit: pu (100 MVA Base)

Conductor	Resistance	Reactance	Admittance
QUAD_FINCH	0.000008554	0.000151229	0.007651757
TWIN_FINCH	0.000016745	0.00019033	0.006062925

Table 7.1-3 Positive Sequence Impedance for 230 kV Lines

Unit: pu (100 MVA Base)

Conductor	Resistance	Reactance	Admittance	Amp.	MVA
ACSR600 sq. mm.	0.0001	0.00057	0.002046	750	298.77876
Finch1113 Milli-Circular-Mil (MCM)	0.00011	0.00076	0.00153	869	346.18499
Mallard795 MCM	0.00015	0.00077	0.001488	723	288.02273
Twin 300 sq. mm	0.0001	0.00057	0.002046	750	298.77876
Twin Mallard2x795 MCM	0.00008	0.00055	0.00211	1446	576.04546

Table 7.1-4 Positive Sequence Impedance for 400 kV designed 230 kV Lines

Unit: pu (100 MVA Base)

Conductor	Resistance	Reactance	Admittance	Capacity
QUAD_FINCH	0.0000180977	0.000319956	0.003616651	1384.74

Table 7.1-5 Positive Sequence Impedance for 132 kV Lines

Conductor	Resistance	Reactance	Admittance	Amp	MVA
HAWK477 MCM	0.00077	0.00225	0.000517	560	128.0332
AAAC636 MCM	0.00058	0.0022	0.00052	660	150.89627
AAAC804 sq. mm	0.00028	0.00226	0.000517	1200	274.35685
Grosbeak636 MCM	0.00058	0.00221	0.000521	629	143.80871
Twin AAAC37/4.176 mm.	0.000579999	0.002199971	0.000522	0	0
XLPE800 sq. mm	0.000259042	0.001157834	0.0123902	0	

Table 7.1-6 Positive Sequence Impedance for 230 kV designed 132 kV Lines

Unit: pu (100 MVA Base)

	Resistance	Reactance	Admittance
TWIN_AAAC37	0.000303604	0.001730544	0.000673904
FINCH	0.000333965	0.002307392	0.000503946
TWIN_FINCH	0.000303604	0.001730544	0.000673904
TWIN_MALLARD	0.000455406	0.002337753	0.000490112

Table 7.1-7 400 kV Transmission Line Data

Zone	From	To	Length (km)	No. Circuits	Conductor
Chittagong	Madunaghat	Meghnaghat	214	2	QUAD_LL-ACSR
Chittagong	Madunaghat	Anowara	38	2	QUAD_LL-ACSR
Chittagong	Madunaghat	Moheskhali	100	2	QUAD_LL-ACSR
Chittagong	Matarbari	Anowara	62	2	QUAD_LL-ACSR
Dhaka	Aminbazar	Meghnaghat	55	2	QUAD_EGRET
Dhaka	Ashuganj	Bhulta	70	2	TWIN_FINCH
Dhaka	Ghorasal	Tongi	28	2	QUAD_FINCH
Dhaka	Gopalganj	Aminbazar	85	2	QUAD_FINCH
Dhaka	Kaliakoir	Bibiyana	168	2	TWIN_FINCH
Khulna	Mongla	Gopalganj	85	2	QUAD_FINCH
Khulna	Rooppur	Gopalganj	150	2	QUAD_FINCH

Table 7.1-8 230 kV Transmission Line Data

Zone	From	To	Length (km)	No. of Circuits	Conductor
Bogra	Baghabari	Sirajganj	38	2	TWIN_AAAC37
Bogra	Barapukuria	Purbasadipur	45	2	TWIN_FINCH
Bogra	Barapukuria	Rangpur	45	2	TWIN_FINCH
Bogra	Bogra(S)	Naogaon	45	2	TWIN_MALLARD
Bogra	Bogra(S)	BARAPUKURIA	106	2	TWIN_AAAC37
Bogra	Ishurdi	Rajshajhi	70	2	TWIN_MALLARD
Bogra	Rajshajhi	Naogaon	80	2	TWIN_FINCH
Bogra	Rooppur	Ishurdi	6	2	Quad_Mallard
Bogra	Rooppur	Baghabari	55	2	TWIN_AAAC37
Bogra	Sirajganj	Bogra(S)	72	2	TWIN_AAAC37
Chittagong	AKSPL	Rampur	8	2	XPLE_2000 SQ. MM
Chittagong	Anowara	Sikalbaha	12	2	QUAD_FINCH
Chittagong	Anowara	Rampur	15	2	QUAD_FINCH
Chittagong	Hathazari	BSRM	50	2	FINCH
Chittagong	Hathazari	Madunaghat	15	2	QUAD_FINCH
Chittagong	Hathazari	Raozan	23	2	TWIN_MALLARD
Chittagong	Hathazari	AKSPL	10	2	TWIN_FINCH
Chittagong	Madunaghat	Madunaghat Old	8	2	TWIN_FINCH
Chittagong	Madunaghat	Sikalbaha	25	2	QUAD_FINCH
Comilla	Ashuganj	Comilla(N)	80	2	FINCH
Comilla	Bibiyana	Shahjibazar	65	2	TWIN_MALLARD
Comilla	Comilla(N)	Feni230	70	2	FINCH
Comilla	Daudkandi	Comilla(N)	40	2	TWIN_MALLARD
Comilla	Fenchuganj	Bibiyana	33	2	TWIN_MALLARD
Comilla	Feni230	BSRM	30	2	FINCH
Comilla	Meghnaghat	Daudkandi	20	2	TWIN_MALLARD
Comilla	Shahjibazar	Comilla(N)	100	2	TWIN_MALLARD
Dhaka	Aminbazar	Dhanmondi	12	2	XLPE_2000 MM2
Dhaka	Aminbazar	OldAirport	10	2	XPLE_2000 SQ. MM
Dhaka	Ashuganj	Sripur	70	2	TWIN_MALLARD
Dhaka	Bhulta	Rampura	12	4	TWIN_MALLARD
Dhaka	Bhulta	Ghorasal	38	2	TWIN_MALLARD
Dhaka	Birulia	Aminbazar	10	2	TWIN_MALLARD
Dhaka	Dhamrai	Rooppur	110	2	SINGLE MALL
Dhaka	Ghorasal	Tongi	27	2	SINGLE MALL

Dhaka	Ghorasal	Dhamrai	70	2	SINGLE MALL
Dhaka	Ghorasal	Ashuganj	45	2	FINCH
Dhaka	Haripur	Meghnaghat	12	4	TWIN_MALLARD
Dhaka	Haripur	Shampur	6	2	TWIN_MALLARD
Dhaka	Haripur	Siddhirganj	2	2	TWIN_FINCH
Dhaka	Haripur	Bhulta	10	2	TWIN_MALLARD
Dhaka	Hasnabad	Keraniganj	8	2	TWIN_MALLARD
Dhaka	Kaliakoir	Muktagacha	80	2	TWIN_FINCH
Dhaka	Kaliakoir	Birulia	40	2	TWIN_MALLARD
Dhaka	Keraniganj	Aminbazar	14	2	TWIN_MALLARD
Dhaka	Kodda	Kaliakoir	28	2	TWIN_MALLARD
Dhaka	Meghnaghat	Madanganj	10	2	TWIN_FINCH
Dhaka	Rampura	Ullon	4	2	XLPE_2000 MM2
Dhaka	Shampur	Hasnabad	8	2	TWIN_MALLARD
Dhaka	Siddhirganj	Maniknagar	11	2	TWIN_MALLARD
Dhaka	Sripur	Sirajganj	75	2	TWIN_MALLARD
Dhaka	Tongi	Kodda	15	2	TWIN_MALLARD
Khulna	Bhola	Barisal(N)	62	2	TWIN_MALLARD
Khulna	Gopalganj	Barisal(N)	65	2	Quad_Mallard
Khulna	HVDC	Ishurdi	10	2	TWIN_AAAC37
Khulna	HVDC	Bheramara	3	2	TWIN_MALLARD
Khulna	HVDC	Jhenaidah	75	2	TWIN_AAAC37
Khulna	Jhenaidah	Jessore	40	2	TWIN_AAAC39
Khulna	Khulna(S)	Mongla	24	2	Quad_Mallard
Khulna	Khulna(S)	Jessore	70	2	TWIN_AAAC38
Khulna	Rupsha	Mongla	20	2	Quad_Mallard

Table 7.1-9 132 kV Transmission Line Data

Zone	From	To	Length (km)	No. of Circuits	Conductor
Bogra	Amnura	Kansat	30	1	GROSBEAK
Bogra	Baghabari	Bangura	30	1	Grosbeak
Bogra	Baghabari	Ullapara	40	2	Grosbeak
Bogra	Baghabari	Sirajganj	42	1	Grosbeak
Bogra	Baghabari	Shahajadpur	7	2	Grosbeak
Bogra	Banpara	Natore	20	2	AAAC37
Bogra	Barapukuria	Dinajpur	30	2	Grosbeak
Bogra	Bhera	Baghabari	13	1	HAWK
Bogra	Bogra	Pirganj	35	1	Grosbeak
Bogra	Bogra	Mahastanghar	15	2	Grosbeak
Bogra	Bogra	Naogaon	52	2	Grosbeak
Bogra	Bogra	Bogra(S)	2	2	TWIN_AAAC37
Bogra	Bogra	Shepur(B)	20	2	Grosbeak
Bogra	Bogra(S)	Bogra(N)	12	2	FINCH
Bogra	Chapai Nawabganj	Amnura	15	1	GROSBEAK
Bogra	Ishurdi	Pabna	18	1	Grosbeak
Bogra	Ishurdi	Bhera	50	1	HAWK
Bogra	Ishurdi	Natore	45	2	TWIN_MALLARD
Bogra	Ishurdi	Banpara	22	2	AAAC38
Bogra	Joypurhat	Patnitola	30	1	Grosbeak

Bogra	Mahastanghar	Palashbari	35	2	Grosbeak
Bogra	Mahastanghar	Bogra(N)	13	2	FINCH
Bogra	Mithapukur	Palashbari	28	2	Grosbeak
Bogra	Naogaon	Niamotpur	46	2	AAAC37
Bogra	Naogaon	Joypurhat	45	2	Grosbeak
Bogra	Natore	Bogra	60	2	AAAC37
Bogra	Natore	Puthia	20	2	GROSBEAK
Bogra	Pabna	Shahajadpur	41	1	GROSBEAK
Bogra	Paglapir	Saidpur	27	2	Grosbeak
Bogra	Paglapir	Rangpur	15	2	Grosbeak
Bogra	Palashbari	Gaibanda	28	2	Grosbeak
Bogra	Purbasadipur	Thakurgaon	40	2	Grosbeak
Bogra	Puthia	Rajshajhi	20	2	GROSBEAK
Bogra	Rajshajhi	Rajshajhi(N)	12	2	GROSBEAK
Bogra	Rajshajhi(N)	Chapai Nawabganj	35	1	GROSBEAK
Bogra	Rajshajhi(N)	Amnura	48	2	GROSBEAK
Bogra	Rangpur	Lalmonirhat	38	1	Grosbeak
Bogra	Rangpur	Kurigram	43	1	Grosbeak
Bogra	Rangpur	Mithapukur	25	2	Grosbeak
Bogra	Saidpur	Purbasadipur	25	2	Grosbeak
Bogra	Saidpur	Barapukuria	35	2	Grosbeak
Bogra	Saidpur	Jaldhaka	40	2	Grosbeak
Bogra	Shahajadpur	Sirajganj	35	1	Grosbeak
Bogra	Sirajganj	Shepur(B)	46	2	Grosbeak
Bogra	Thakurgaon	Panchgarh	45	1	Grosbeak
Chittagong	Bakulia	M.Steel	7	1	GROSBEAK
Chittagong	Bakulia	Sikalbaha	4	2	GROSBEAK
Chittagong	Baroirhat	Hathazari	60	2	GROSBEAK
Chittagong	Chandraghona	Kaptai	10.5	2	GROSBEAK
Chittagong	Chandraghona	Rangamati	30	2	GROSBEAK
Chittagong	Coxsbazar	Matarbari	50	2	GROSBEAK
Chittagong	Dohazari	Matarbari	75	2	GROSBEAK
Chittagong	F.hat	Baroawlia	8	2	GROSBEAK
Chittagong	Halishahar	Julda	7	1	GROSBEAK
Chittagong	Hathazari	Madunaghat	11	2	GROSBEAK
Chittagong	Hathazari	Kaptai	46	2	GROSBEAK
Chittagong	Hathazari	Baroawlia	10	2	GROSBEAK
Chittagong	Julda	Shahmirpur	6	2	GROSBEAK
Chittagong	Kulshi	F.hat	8	2	GROSBEAK
Chittagong	Kulshi	Rampur	9	2	GROSBEAK
Chittagong	Kulshi	Bakulia	10	1	GROSBEAK
Chittagong	Kulshi	M.Steel	3	1	GROSBEAK
Chittagong	Madunaghat	Chandraghona	27	2	GROSBEAK
Chittagong	Madunaghat	TK	11	1	GROSBEAK
Chittagong	Madunaghat	Sikalbaha	17	1	GROSBEAK
Chittagong	Madunaghat	Sholoshahar	6	2	GROSBEAK

Chittagong	Madunaghat	Kalurghat	7	2	GROSBEAK
Chittagong	Patiya	Dohazari	22	2	GROSBEAK
Chittagong	Rampur	Halishahar	7	2	GROSBEAK
Chittagong	Rampur	Agrabad	6	2	XLPE_800 MM2
Chittagong	Rampur	Newmooring	5	2	XLPE_800 MM2
Chittagong	Rangamati	Khagrachari	50	2	GROSBEAK
Chittagong	Sholoshahar	Kulshi	6	2	GROSBEAK
Chittagong	Sikalbaha	TK	6	1	GROSBEAK
Chittagong	Sikalbaha	Julda	8	1	GROSBEAK
Chittagong	Sikalbaha	Shahmirpur	10	2	GROSBEAK
Chittagong	Sikalbaha	Patiya	10	2	GROSBEAK
Comilla	Ashuganj	Shahjibazar	58	1	GROSBEAK
Comilla	Ashuganj	B.baria	18	2	GROSBEAK
Comilla	B.baria	Shahjibazar	52	2	GROSBEAK
Comilla	Chandpur	Ramganj	30	2	GROSBEAK
Comilla	Chhatak	Sunamganj	30	2	GROSBEAK
Comilla	Chouddagram	Laksam	25	2	GROSBEAK
Comilla	Chowmuhani	Feni230	30	2	GROSBEAK
Comilla	Chowmuhani	Sonapur	15	2	GROSBEAK
Comilla	Comilla(N)	Muradnagar	20	2	GROSBEAK
Comilla	Comilla(N)	Comilla(S)	16	4	GROSBEAK
Comilla	Comilla(N)	Kachua	35	2	GROSBEAK
Comilla	Comilla(N)	Chandina	17	2	GROSBEAK
Comilla	Comilla(S)	Chouddagram	30	2	GROSBEAK
Comilla	Daudkandi	Gazaria	15	2	FINCH
Comilla	Daudkandi	Chandpur	65	2	TWIN_FINCH
Comilla	Fenchuganj	Sylhet (S)	25	2	GROSBEAK
Comilla	Fenchuganj	Kulaura	25	2	GROSBEAK
Comilla	Fenchuganj	Fenchuganj PS	4	4	GROSBEAK
Comilla	Feni	Chouddagram	36	2	GROSBEAK
Comilla	Feni	Baroirhat	25	2	GROSBEAK
Comilla	Feni230	Feni	4	2	TWIN_MALLARD
Comilla	Feni230	Feni2	15	2	GROSBEAK
Comilla	Kachua	Chandpur	30	2	GROSBEAK
Comilla	Muradnagar	Daudkandi	35	2	GROSBEAK
Comilla	Ramganj	Chowmuhani	38	2	GROSBEAK
Comilla	Shahjibazar	Srimongal	36	2	GROSBEAK
Comilla	Srimongal	Fenchuganj	49	2	GROSBEAK
Comilla	Sylhet	Chhatak	32	2	GROSBEAK
Comilla	Sylhet (S)	Sylhet	8	2	GROSBEAK
Comilla	Sylhet (S)	Sylhet (N)	12	2	GROSBEAK
Comilla	Sylhet (S)	Beanibazar	30	1	GROSBEAK
Dhaka	Agargaon	Cantonment	7	2	XLPE_800 MM2
Dhaka	Aminbazar	Savar	15	2	GROSBEAK
Dhaka	Aminbazar	Hemayetpur	8	2	GROSBEAK
Dhaka	Araihazar	Madobdi	8	2	GROSBEAK

Dhaka	Aricha	Manikganj	30	1	GROSBEAK
Dhaka	Ashulia	Birulia	6	2	GROSBEAK
Dhaka	B.baria	Narshingdi	55	2	GROSBEAK
Dhaka	Bajitpur	Ashuganj	25	2	GROSBEAK
Dhaka	Bandar	Madanganj	6	2	GROSBEAK
Dhaka	Basila	Kallayanpur	6	2	GROSBEAK
Dhaka	Basundhara	United City	4	2	GROSBEAK
Dhaka	Basundhara(New)	Basundhara	3	2	XLPE_800 MM2
Dhaka	Basundhara(New)	Dumni	4	2	XLPE_800 MM2
Dhaka	Basundhara(New)	Banani	7	2	XLPE_800 MM2
Dhaka	Basundhara(New)	Purbachal	3	2	XLPE_800 MM2
Dhaka	Bhulta	Narshingdi	16	2	GROSBEAK
Dhaka	Bhulta 400	Bhulta	4	2	GROSBEAK
Dhaka	Bhulta 400	Araihazar	10	2	GROSBEAK
Dhaka	Birulia	Uttara 3p	3	1	XLPE_800 MM2
Dhaka	Birulia	Mirpur	6	2	GROSBEAK
Dhaka	Boardbazar	Kabirpur	15	2	GROSBEAK
Dhaka	Demra	Ullon	10	2	GROSBEAK
Dhaka	Dhamrai	DEPZ	9	2	GROSBEAK
Dhaka	Dhamrai	Manikganj	25	2	GROSBEAK
Dhaka	Dhamrai	Nabinagar	12	2	GROSBEAK
Dhaka	Dhanmondi	Panthapath	5	2	XLPE_800 MM2
Dhaka	Dhanmondi	Zigatola	5	2	XLPE_800 MM2
Dhaka	Dhanmondi	New Ramna	4	2	XLPE_800 MM2
Dhaka	Fatullah	Hasnabad	14	1	GROSBEAK
Dhaka	Fatullah	Shampur(New)	6	2	GROSBEAK
Dhaka	Gatail	Muktagacha	45	2	GROSBEAK
Dhaka	Ghorasal	Pubail	15	2	GROSBEAK
Dhaka	Ghorasal	Marjal	30	2	GROSBEAK
Dhaka	Ghorasal	Narshingdi	18	2	GROSBEAK
Dhaka	Haripur	Rupshi	10	2	GROSBEAK
Dhaka	Haripur	Sonargaon	15	2	GROSBEAK
Dhaka	Haripur	Bandar	6	2	GROSBEAK
Dhaka	Haripur	Siddirganj	2	2	GROSBEAK
Dhaka	Haripur	Maniknagar	14	1	GROSBEAK
Dhaka	Hasnabad	Basila	18	2	GROSBEAK
Dhaka	Hasnabad	Postogola	6	2	GROSBEAK
Dhaka	Jamalpur	Sherpur	25	2	GROSBEAK
Dhaka	Joydevpur	Kodda	6	2	GROSBEAK
Dhaka	Kabirpur	Kodda	9	2	GROSBEAK
Dhaka	Kabirpur	Kaliakoir	15	2	GROSBEAK
Dhaka	Kabirpur	DEPZ	8	2	GROSBEAK
Dhaka	Kaliakoir	Mizapur	10	2	GROSBEAK
Dhaka	Kaliakoir	Dhamrai	20	2	GROSBEAK
Dhaka	Kallayanpur	Aminbazar	4	2	GROSBEAK
Dhaka	Kamrangirchar	Lalbag	2	1	GROSBEAK

Dhaka	Keraniganj	Lalbag	8	3	GROSBEAK
Dhaka	Keraniganj	Kamrangirchar	6	1	GROSBEAK
Dhaka	Keraniganj	Nawabganj	25	2	GROSBEAK
Dhaka	Keraniganj	KeraniganjPP	6	4	GROSBEAK
Dhaka	KeraniganjPP	Sreenagar	15	2	GROSBEAK
Dhaka	Khilgaon	New Ramna	5	2	XLPE_800 MM2
Dhaka	Kishoreganj	Bajitpur	25	2	GROSBEAK
Dhaka	Lalbag	Zigatola	5	2	XLPE_800 MM2
Dhaka	Madanganj	Munsiganj	4	2	GROSBEAK
Dhaka	Madanganj	Sitalakhya	4	1	GROSBEAK
Dhaka	Madanganj	Fatullah	12	1	GROSBEAK
Dhaka	Madanganj	Charsyedpur	4	2	GROSBEAK
Dhaka	Madertek	Rampura	5	2	XLPE_800 MM2
Dhaka	Maniknagar	Motijheel	4	2	XLPE_800 MM2
Dhaka	Maniknagar	Narinda	8	2	XLPE_800 MM2
Dhaka	Maniknagar	Kazla	4	2	XLPE_800 MM2
Dhaka	Marjal	Ashuganj	15	2	GROSBEAK
Dhaka	Mirpur	Mirpur II	4	2	GROSBEAK
Dhaka	Mirpur II	Aminbazar	5	2	GROSBEAK
Dhaka	Mizapur	Tangail	30	2	GROSBEAK
Dhaka	Mogbazar	Rampura	6	2	GROSBEAK
Dhaka	Motijheel	Bangabhaban	2	2	XLPE_800 MM2
Dhaka	Muktagacha	Jamalpur	40	2	GROSBEAK
Dhaka	Muktagacha	Phulpur	35	2	GROSBEAK
Dhaka	Muktagacha	RPCL	20	2	GROSBEAK
Dhaka	Mymensingh	Muktagacha	20	2	GROSBEAK
Dhaka	Mymensingh	Netrokona	34	2	GROSBEAK
Dhaka	Mymensingh	Bhaluka	30	2	GROSBEAK
Dhaka	Mymensingh	Kishoreganj	59	2	GROSBEAK
Dhaka	Pubail	Joydevpur	15	2	GROSBEAK
Dhaka	Rajendrapur	Kodda	15	2	GROSBEAK
Dhaka	Rampura	Gulshan	6	2	XLPE_800 MM2
Dhaka	RPCL	Mymensingh	5	2	GROSBEAK
Dhaka	Rupshi	Bhulta 400	3	2	GROSBEAK
Dhaka	Satmasjid	Agargaon	6	2	XLPE_800 MM2
Dhaka	Shampur(New)	Shampur	5	2	GROSBEAK
Dhaka	Shampur(New)	Matuail	3	2	GROSBEAK
Dhaka	Shampur	Ctg Road	5	1	GROSBEAK
Dhaka	Siddirganj	Demra	6	2	GROSBEAK
Dhaka	Siddirganj	Maniknagar	10	2	GROSBEAK
Dhaka	Siddirganj	Khanpur	5	2	XLPE_800 MM2
Dhaka	Sitalakhya	Hasnabad	12	1	GROSBEAK
Dhaka	Sonargaon	Daudkandi	62	2	GROSBEAK
Dhaka	Sripur	Bhaluka	35	2	GROSBEAK
Dhaka	Sripur	Rajendrapur	20	2	GROSBEAK
Dhaka	Tangail	Gatail	35	2	GROSBEAK

Dhaka	Tangail	Kaliakoir	45	2	TWIN_MALLARD
Dhaka	Tongi	Boardbazar	8	2	GROSBEAK
Dhaka	Tongi	Uttarkhan	4	2	GROSBEAK
Dhaka	Tongi	Airport	5	2	XLPE_800 MM2
Dhaka	Tongi	Tongi New	0.5	2	XLPE_800 MM2
Dhaka	Tongi	Ashulia	10	2	GROSBEAK
Dhaka	Ullon	Rampura	4	2	XLPE_800 MM2
Dhaka	Ullon	Dhanmondi	8	3	XLPE_800 MM2
Dhaka	Ullon	Khilgaon	4	2	XLPE_800 MM2
Dhaka	Ullon	Tejgaon	4	2	XLPE_800 MM2
Dhaka	United City	Rampura	4	2	GROSBEAK
Dhaka	Uttara	Birulia	5	1	GROSBEAK
Dhaka	Uttarkhan	Basundhara	6	2	GROSBEAK
Khulna	Bagerhat	Bhandaria	40	1	HAWK
Khulna	Bagerhat	Rupsha	20	2	GROSBEAK
Khulna	Bangha	Gopalganj 400	25	2	Grosbeak
Khulna	Barisal	Patuakhali	38.5	2	GROSBEAK
Khulna	Barisal(N)	Barisal	15	3	GROSBEAK
Khulna	Barisal(N)	Jalokhati	25	2	GROSBEAK
Khulna	Benapole	JESSORE	27	2	AAAC37
Khulna	Bheramara	Ishurdi	10	2	Grosbeak
Khulna	Bheramara	Gangni	60	1	Grosbeak
Khulna	Bheramara	Rajbari	70	2	Grosbeak
Khulna	Faridpur	Rajbari	40	2	Grosbeak
Khulna	Faridpur	Bangha	35	2	Grosbeak
Khulna	Fultola	Noapara	13	2	AAAC37
Khulna	Gallamari	Rupsha	13	2	GROSBEAK
Khulna	Goalpara	Khulna(C)	2.5	2	AAAC37
Khulna	Goalpara	Goal EGCB	0.3	1	XLPE_800 MM2
Khulna	Gopalganj 400	Gopalganj	40	2	GROSBEAK
Khulna	Jalokhati	Bhandaria	35	2	GROSBEAK
Khulna	Jessore	Kaliganj	30	2	AAAC37
Khulna	Jhenaidah	Magura	28	2	GROSBEAK
Khulna	Jhenaidah	Kustia	43	2	AAAC37
Khulna	Jhenaidah(N)	Jhenaidah	6	3	AAAC37
Khulna	Kalapara	Patuakhali	45	1	GROSBEAK
Khulna	Kaliganj	Jhenaidah(N)	20	2	AAAC37
Khulna	Chuadanga	Jhenaidah(N)	28	2	AAAC37
Khulna	Keshbpur	Satkhira	30	1	AAAC37
Khulna	Khulna(C)	Goal EGCB	2.5	2	XLPE_800 MM2
Khulna	Khulna(C)	Khulna(S)	9	2	TWIN_AAAC37
Khulna	Khulna(C)	Fultola	12	2	AAAC37
Khulna	Khulna(S)	Satkhira	56	1	AAAC37
Khulna	Khulna(S)	Keshbpur	35	1	AAAC37
Khulna	Khulna(S)	Gallamari	4.2	2	GROSBEAK
Khulna	Kustia	Bheramara	27	2	AAAC37

Khulna	Madaripur	Gopalganj 400	8	4	Grosbeak
Khulna	Madaripur	Barisal(N)	45	2	Grosbeak
Khulna	Madaripur	Shariatpur	35	2	GROSBEAK
Khulna	Magura	Narail	40	1	Grosbeak
Khulna	Mongla	Bagerhat	31	2	Grosbeak
Khulna	Noapara	Jessore	27	2	AAAC37
Khulna	Rupsha	Goalpara	15	2	GROSBEAK
Khulna	Rupsha	Gopalganj	46	2	GROSBEAK

The following list shows the transmission lines that were assumed to be reinforced by adding circuits to avoid overloading observed by the initial power flow calculation.

Table 7.1-10 Reinforced Transmission Line Data in Power System Model

	Voltage	Bus Name	Bus Name		Number of Circuits	
					Original	Modified
Khulna	230	Jhenaidah	Jessore	40km	2	4
Khulna	230	Khulna(S)	Jessore	70km	2	4
Bogra	230	Barapukuria	Bogra(S)	106km	2	4
Bogra	230	Sirajganj	Bogra(S)	72km	2	6
Bogra	230	Ishurdi	HVDC	10km	2	6
Dhaka	132	Haripur	Rupshi	10km	2	4
Dhaka	132	Rampura	United City	4km	2	4
Comilla	132	Fenchuganj	Sylhet (S)	25km	2	4
Bogra	132	Joypurhat	Naogaon	45km	2	4
Bogra	132	Thakurgaon	Purbasadipur	40km	2	4

c) Transformers

400/230 kV, 400/132 kV and 230/132 kV transformers were modeled according to the tables below, given by PGCB. Impedance of transformer was assumed as 12.5%.

Table 7.1-11 400/230 kV and 400/132 kV transformers

SN	Substation Name		Transformer Capacity	**No. of Transformers**
1	Kaliakoir	400/132	320	2
2	Kaliakoir	400/230	520	1
3	Aminbazar	400/230	750	3
4	Mongla	400/230	520	2
5	Gopalganj	400/132	320	2
6	Gopalganj	400/230	750	2
7	Rooppur	400/230	750	3
8	Meghnaghat	400/230	750	2
9	Madunaghat	400/230	750	3
10	Anowara	400/230	750	1
11	Bibiyana	400/230	520	2
12	Bhulta	400/132	320	2
13	Bhulta	400/230	520	2
14	Ashuganj	400/230	520	1

Table 7.1-12 230 kV Transformers

Substation Name	Transformer Capacity	No. of Transformers	Substation Name	Transformer Capacity	No. of Transformers
Hathazari	150	4	Maniknagr	300	2
Tongi	225	3	Silabaha	300	2
Haripur	225	3	Rampura	300	2
Hasnabad	225	3	AKSPL	300	1
Rampura	225	3	BSRM	225	1
Aminbazar	225	3	Ullon	300	2
Ishurdi	225	3	Basundhara	300	2
Barapukuria	225	2	Shyampur	300	2
Bogra	225	2	Keraniganj	300	3
Baghabari	225	2	Sripur	300	2
Khulna(S)	225	3	Daudkandi	300	2
Comilla(N)	225	2	Feni	300	2
Fenchuganj	300	2	Madunaghat	300	3
Ashuganj	150	2	Madanganj	300	3
Ghorasal	125	2	Birulia	300	3
Old Airport	300	2	Dhanmondi	300	3
Siddhirganj	300	2	Dhamrai	300	2
Rajshajhi	300	2	Mukhtagacha	300	2
Naogaon	300	2	Purbasadipur	300	2
Bheramara	300	2	Ramgpur	300	2
Jhenaidah	300	2	Jessore	300	2
Barisal	300	2	Rupsha	300	3

d) Generators

The generators in the system under 33 kV were embedded in loads of 132 kV substations and the generators connected to the system over 132 kV were obviously modeled in the analysis data. The list of newly installed generators was based on the plan of BPDB that PGCB provided. The power outputs of generators were set out as follows.

- The information about the future operation of the existing generators was only for 2023. Thus, the power outputs of the abolished power generators among the existing ones were estimated to be decreased at a constant ratio year by year to reach zero in 2023.
- The power outputs of the generators that were currently operated and still operated in 2021 were set out as their de-rated capacities in 2023.
- Power factor was assumed as 85%

According to the generation plan, Matarbari 600 MW x 2 and Anowara 1,000 MW will be operated up to 2021. The following tables show the list of generators to be modeled in the system data of 2021.

Table 7.1-13 Modeled Generators (1)

No.	Area	Name of Power Station/ Location	Capacity (MW)	CCC	COD Date
1	Chittagong	Karnaphuli Hydro 2	40	Hydro	8-Jan-1962
2	Chittagong	Karnaphuli Hydro 1	30	Hydro	26-Feb-1962
3	Chittagong	Karnaphuli Hydro 3	50	Hydro	8-Jan-1982
4	Chittagong	Karnaphuli Hydro 4	50	Hydro	11-Jan-1988
5	Chittagong	Karnaphuli Hydro 5	50	Hydro	11-Jan-1988
6	Dhaka	Ghorasal (Polash, Norshindi) 210 MW ST3	180	Gas	14-Sep-1986
7	Dhaka	Ghorasal (Polash, Norshindi) 210 MW ST4	180	Gas	18-Mar-1989
8	Chittagong	Raozan (Chittagong) (210 MW) 1	180	Gas	28-Mar-1993
9	Dhaka	Ghorasal (Polash, Norshindi) 210 MW ST5	190	Gas	15-Sep-1994
10	Chittagong	Raozan (Chittagong) (210 MW) 2	180	Gas	21-Sep-1997
11	Dhaka	Ghorasal (Polash, Norshindi) 210 MW ST6	190	Gas	31-Jan-1999
12	Dhaka	RPCL (Mymenshing) (210 MW)	197	Gas	20-Nov-1999
13	Dhaka	Haripur Power Ltd. (360 MW CC)	360	Gas	23-May-2001
14	Dhaka	Meghnaghat power Ltd. (450 MW) (Norshindhi)	450	Gas	26-Nov-2002
15	Dhaka	Siddhirganj (210 MW) ST	150	Gas	3-Sep-2004
16	Dhaka	Tongi (105 MW) (Dhaka)	105	Gas	28-Mar-2005
18	Dhaka	Tangail SIPP (Doreen)	22	Gas	12-Nov-2008
19	Dhaka	Narsindi SIPP (REB) (Doreen)	22	Gas	21-Dec-2008
21	Comilla	Shahjibazar 15 Yrs RPP	86	Gas	9-Feb-2009
22	Comilla	Feni SIPP (Doreen)	22	Gas	16-Feb-2009
23	Bogra	Ullapara SIPP (REB) (Summit)	11	Gas	2-Mar-2009
25	Comilla	Mahipal, Feni SIPP (REB)	11	Gas	22-Apr-2009
26	Dhaka	Mouna, Gazipur SIPP (REB)	33	Gas	12-May-2009
28	Dhaka	Rupganj , Narayanganj SIPP (REB)	33	Gas	9-Jun-2009
29	Comilla	Jangalia, Comilla SIPP (Summit)	33	Gas	25-Jun-2009
31	Comilla	Fenchuganj 15 Years RPP (Barakatullah)	51	Gas	18-Oct-2009
32	Chittagong	Shikalbaha 150 MW Peaking PP	50	Gas	18-Aug-2010
33	Dhaka	SIDDHIRGANJ 2x120 MW #2 EGCB	105	Gas	14-Oct-2010
34	Comilla	Ashugonj 50 MW	51	Gas	30-Apr-2011
35	Bogra	Baghabari 50 MW Peaking PP	52	F.Oil	29-Aug-2011
36	Comilla	FENCHUGANJ CC (104 MW) 2 nd Unit	104	Gas	26-Oct-2011
37	Bogra	Bera 70 MW Peaking PP	71	F.Oil	28-Oct-2011
38	Comilla	Titas, Doudkandi 50 MW Peaking PP	52	F.Oil	29-Oct-2011
39	Dhaka	Faridpur 50 MW Peaking PP	54	F.Oil	4-Nov-2011
40	Dhaka	Gopalgonj 100 MW Peaking PP	109	F.Oil	16-Nov-2011
42	Chittagong	Hathazari 100 MW Peaking PP	98	F.Oil	23-Dec-2011
43	Chittagong	Sangu, Dohazari 100 MW Peaking PP	102	F.Oil	1-Jan-2012
44	Comilla	Sylhet 150 MW Power Plant	142	Gas	28-Mar-2012
45	Dhaka	Gazipur 50 MW Power Plant RPCL	52	F.Oil	1-Jul-2012
46	Comilla	Chandpur 150 MW CCPP	163	Gas	1-Jul-2012
47	Bogra	Sirajganj 150 MW GT (China Mechinaries EXIMCO)	150	Gas/ HSD	1-Sep-2012
48	Bogra	Santahar 50 MW Peaking Power Plant	50	F.Oil	1-Dec-2012
49	Bogra	Katakhali 50 MW Peaking Power Plant	50	F.Oil	1-Dec-2012
50	Chittagong	Raozan 25 MW Peaking PP	25	F.Oil	3-May-2013
51	Dhaka	Haripur 360 MW CCPP	412	Gas	Test Run
52	Khulna	Khulna 150 MW GT	150	HSD	23-Sep-2013
53	Comilla	Ashugonj 51 MW (Midland) PP	51	Gas	6-Dec-2013
56	Bogra	Natore 52 MW Power Plant (Raj Lanka Power)	52	F.Oil	24-Jan-2014
57	Bogra	Sirajgonj 150 MW PP Conversion (NWPGC)	75	Gas/ HSD	1-May-2014
58	Dhaka	Ghorashal, Narsingdi 100 MW PP	108	Gas	1-May-2014
59	Chittagong	Baraka-Patanga, Chittagong 50 MW PP	50	F.Oil	1-May-2014

Table 7.1-14 Modeled Generators (2)

No.	Area	Name of Power Station/ Location	Capacity (MW)	CCC	COD Date
60	Dhaka	Gogonnagar, Narayangonj 100 MW PP	102	F.Oil	1-May-2014
61	Chittagong	Potiya, Chittagong 100 MW Power Plant	108	F.Oil	1-May-2014
62	Dhaka	Kathpotti, Munshigonj 50 MW Power Plant	53	F.Oil	1-Jun-2014
63	Dhaka	Meghnaghat 300-450 MW CCPP (2nd Unit)	335	Gas/ F.Oil	1-Oct-2014
64	Dhaka	Alir Tak, Narayangonj 50 MW Power Plant	53	F.Oil	1-Dec-2014
65	Dhaka	Nababgonj 55 MW PP	55	F.Oil	1-Dec-2014
66	Dhaka	Bosila, Keranigonj 108 MW PP (CLC Power)	108	F.Oil	1-Dec-2014
67	Dhaka	Manikganj 55 MW PP	55	F.Oil	1-Mar-2015
68	Comilla	Jangalia, Comilla 52 MW PP	52	Gas/ F.Oil	1-Mar-2015
69	Dhaka	Ashugonj 225 CCPP	225	Gas	1-Jun-2015
70	Dhaka	Ashuganj (South) 450 MW CCPP	373	Gas	1-Jun-2015
71	Dhaka	Keranigonj 100 MW Power Plant (Relocate from Khulna)	100	F.Oil	1-Jun-2015
72	Dhaka	Bosila, Keranigonj, (Dhaka West) 108 MW PP	108	F.Oil	1-Jun-2015
73	Dhaka	Jamalpur 100 MW Power Plant	95	Gas/ F.Oil	1-Jun-2015
74	Dhaka	Gabtoli, Dhaka 108 MW PP	108	F.Oil	1-Jun-2015
75	Dhaka	Ashugonj 195 MW Modular PP	195	Gas	1-Jun-2015
76	Dhaka	Fenchugonj 50 MW Power Plant	50	Gas	1-Jun-2015
77	Dhaka	Bhairab, Kishorgonj 50 MW PP	50	F.Oil	1-Aug-2015
78	Dhaka	Kodda, Gazipur 150 MW Power Plant	150	F.Oil/ Gas	1-Sep-2015
79	Comilla	Sylhet 150 MW PP Conversion	75	Gas	1-Sep-2015
80	Khulna	Up gradation of Khulna 150 MW to 225 MW (NWPGCL)	75	Gas/ HSD	1-Sep-2015
81	Dhaka	Siddirganj 335 MW CCPP	335	Gas	1-Dec-2015
82	Khulna	Bhola 225 MW CCPP	195	Gas	1-Dec-2015
83	Chittagong	Kaptai Solar	8	Solar	1-Dec-2015
85	Dhaka	Madangonj 50 MW Peaking Plant(Re. from Shantahar)	50	F.Oil	1-Dec-2015
86	Khulna	Barisal 100 MW PP (Re. from Syedpur)	100	F.Oil	1-Dec-2015
88	Bogra	Dhorola 30 MW Solar Park	30	Solar	1-Dec-2015
89	Dhaka	Bibiana 300-450 MW CCPP (2nd Unit)	341	Gas	1-Jan-2016
90	Dhaka	Munshigonj 50 MW PP	50	F.Oil	1-Jun-2016
91	Khulna	Satkhira 50 MW PP	50	F.Oil	1-Jun-2016
92	Dhaka	Fenchugonj 163 MW CCPP	163	Gas	1-Jun-2016
93	Bogra	Chapai Nababganj 104 MW PP	104	F.Oil	1-Jun-2016
94	Bogra	Bagabari 100 MW PP Conversion	50	Gas	1-Jun-2016
95	Comilla	Shajibazar 70 MW PP Conversion	35	Gas	1-Jun-2016
96	Dhaka	Bibiana #3 CCPP	400	Gas	1-Dec-2016
97	Comilla	Shajibazar CCPP	332	Gas	1-Dec-2016
98	Chittagong	Chittagong 65-85 MW CCPP	65	Naphtha/Gas	1-Dec-2016
99	Chittagong	Wind	100	Wind	1-Dec-2016
100	Dhaka	Ashugonj (North) CCPP	381	Gas	1-Jan-2017
101	Dhaka	Ghorasal 3rd Unit Repowering (Capacity Addition)	206	Gas	1-Jan-2017
102	Khulna	Bheramara 360 MW CCPP (NWPGC)	360	Gas	1-Jan-2017
103	Dhaka	Ghorasal 363 MW CCPP	363	Gas	1-Mar-2017
104	Chittagong	Shikalbaha 225 MW CCPP	225	Gas/ F.Oil	1-Mar-2017
105	Bogra	Sirajganj 300-450 MW CCPP	367	Gas/ HSD	1-Mar-2017
106	Bogra	Sirajgonj 225 MW CCPP (2nd Unit):(NWPGC)	220	Gas/ HSD	1-Apr-2017
107	Bogra	Barapukuria 275 MW (3rd Unit)	274	Coal	1-Jun-2017
108	Dhaka	Ghorasal 6th Unit Repowering (Capacity Addition)	206	Gas	1-Sep-2017
109	Comilla	Bibiana South 300-450 MW CCPP	450	Gas	1-Dec-2017
110	Bogra	Sirajgonj 150-225 MW CCPP (LANKO)	218	Gas	1-Dec-2017
111	Dhaka	Maowa, Munshiganj 522 MW Coal Fired Power Project (Orion)	522	Imp. Coal	1-Dec-2017
112	Khulna	Khulna 630 MW Coal Fired PP (Orion)	630	Imp. Coal	1-Jan-2018
113	Dhaka	Ghorasal 4th Unit Repowering (Capacity Addition)	206	Gas	1-Jun-2018
114	Khulna	BIFPCL, Rampal, Khulna 1300 MW Coal Fired Power Project	1,320	Imp. Coal	1-Dec-2018
115	Chittagong	Anowara, Chittagong 1000 MW CCPP	1,000	LNG	1-Dec-2019
117	Chittagong	Matarbari 1200 MW Coal Power Plant (CPGCL)	600	Imp. Coal	1-Jun-2021
117	Chittagong	Matarbari 1200 MW Coal Power Plant (CPGCL)	600	Imp. Coal	1-Jun-2021
118	Khulna	Ruppur Nuclear 1000 MW (BAEC) 1st Unit	1,180	Nuclear	1-Dec-2021
		Total	19,545		

e) Shunt Capacitors and Reactors

The capacitor banks and shunt reactors were assumed at 132 kV, to be installed so as to keep the bus voltage around 1.0 pu.

f) Line Charge Compensating Shunt Reactors

The 400 kV line charges between Meghnaghat, Madunaghat and Matarbari are as follows.

Meghnaghat - Madunaghat 400 kV 210 km 164 MVA/cct

Matarbari - Madunaghat 400 kV 100 km 76 MVA/cct

These line charges should be compensated by installation of shunt reactors to prevent generators from absorbing too much reactive power and avoid over voltage of the system.

The highest line voltage would appear when the line between Meghnaghat and Madunaghat, which has the largest distance among the targeted 400 kV transmission lines, is opened at the receiving end. The results of the system analysis showed that the difference in the voltage between the sending and the receiving end of 500 kV transmission lines would be around 3% at most and the voltage of the open end would be less than 110% in the case of disconnecting shunt reactors to the lines. Thus, the shunt reactors do not need to be directly connected to the 500 kV transmission lines. However, the shunt reactors will be connected directly to 400 kV lines owing to its cost reduction and its methodology is still effective. The following shunt reactors are recommended.

Line Charge Compensating Shunt Reactors for Meghnaghat – Madunaghat

Meghnaghat: 80 MW x 2

Madunaghat: 80 MW x 2

Line Charge Compensating Shunt Reactors for Matarbari – Madunaghat

Madunaghat: 80 MW x 2

An example of installation of a shunt reactor directly connected to a transmission line in one-and half bus scheme is illustrated in the figure below.

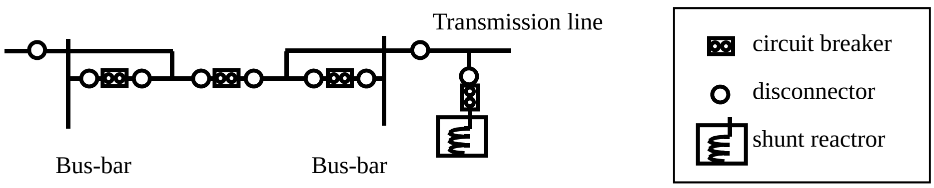


Figure 7.1-1 Example of Installation of a Shunt Reactor

g) System Criteria

To confirm the adequacy of power system facilities, the following criteria were set out.

- Under normal operating conditions, the loading of transmission lines shall not exceed their thermal ratings. In the case of a single circuit fault for the interval with more than double circuits, the power flow of remaining facilities must be within the rated capacity (N-1 criteria).
- Under normal operating conditions, the loading of transformers shall not exceed the rated capacity of transformers allowed by the available mode of cooling. Under N-1 contingency conditions, a short period (one hour) of overloading of up to 120% of rated capacity is allowed.
- Bus voltage for power stations/substations must be in the range of 95% to 105% at normal operating conditions, and in the range of 90% to 110 % at N-1 condition.

7.2 Power Flow Analysis

a) Case with Small Power Outputs in Chittagong during Peak Demand Period of Time

The load at Madunaghat substation would become heavy during the peak demand period of time when the power output from generators in the Chittagong area was small. To check the adequacy of the main specifications of the power supply system facilities in the Chittagong area, the following generation condition was set out firstly.

- Generation Pattern A

This pattern would face severe situations for the power supply system in Chittagong. The loads at 132 kV were set out as their peak values in 2021. The power outputs of Kaptai hydropower plants were assumed as 40% of their nominal capacities. Wind turbines in Chittagong were assumed to be generated at half of their nominal capacities. Gas thermal power stations were assumed not to be operated except for Anowara and Sikapaha. The total amount of power output in the whole system was forced to meet its power demand by adjusting power output in Dhaka.

The power supply demand balance in the whole system was calculated on the condition of Generation Pattern A as shown in the following table. The results of power flow calculations are shown in the figures depicted in the following pages.

Table 7.2-1 Power Supply Demand Balance in the Whole System in 2021 in Generation Pattern A

(Unit: MW)

	Generation	Load	Loss	Interchange
Dhaka	6,758	8,835	146	-2,222
Chittagong	2,900	2,029	33	838
Comilla	2,080	2,237	79	-235
Khulna	4,429	1,555	93	2,781
Bogra	1,878	2,929	111	-1,162
Total	18,045	17,585	461	-0

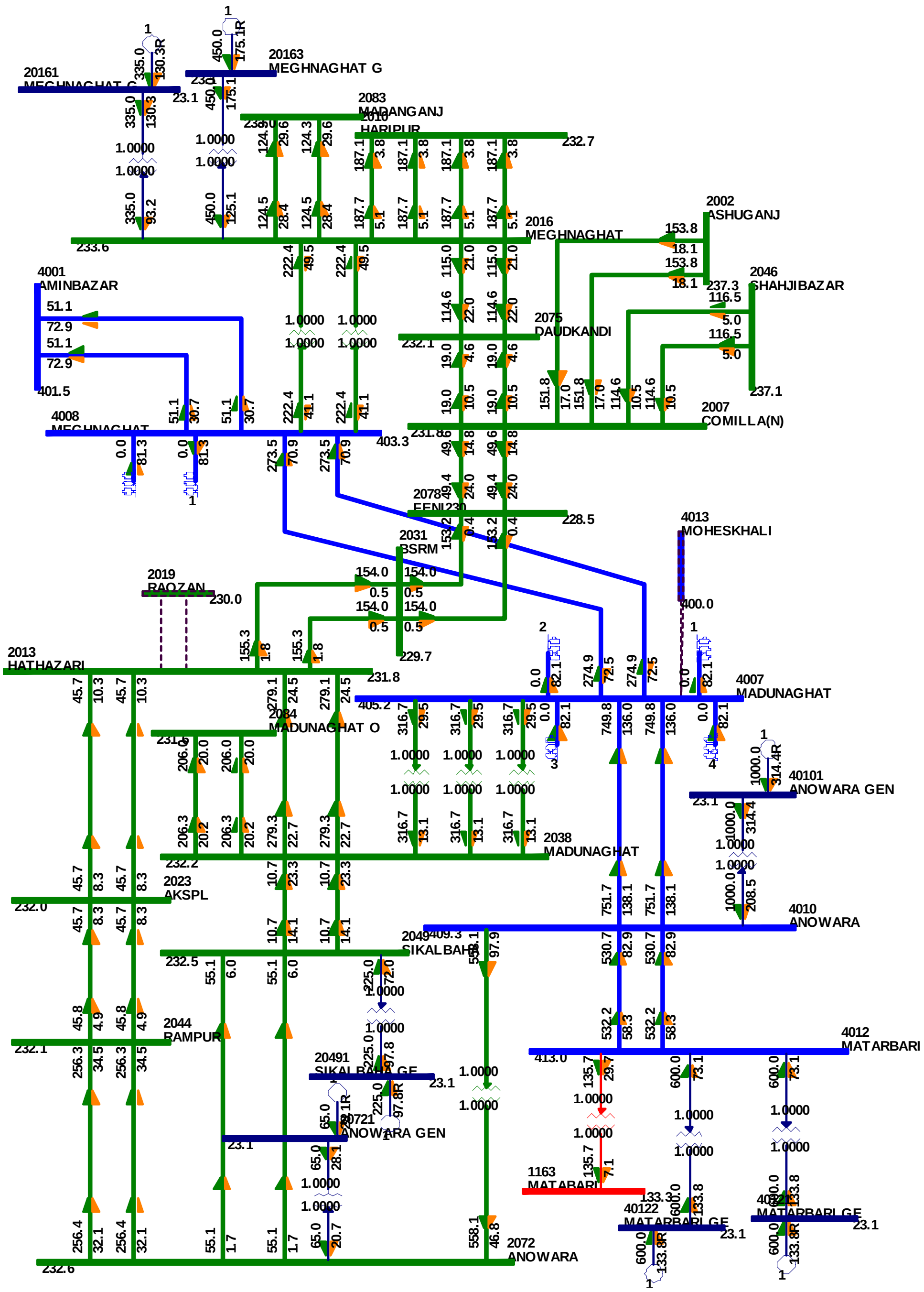


Figure 7.2-1 Power Flow of 400 kV and 230 kV System in Dhaka – Chittagong Area in 2021 (Generation Pattern A, Madunaghat 400/230 kV 750 MVA x 3) (Unit: MW, MVar)

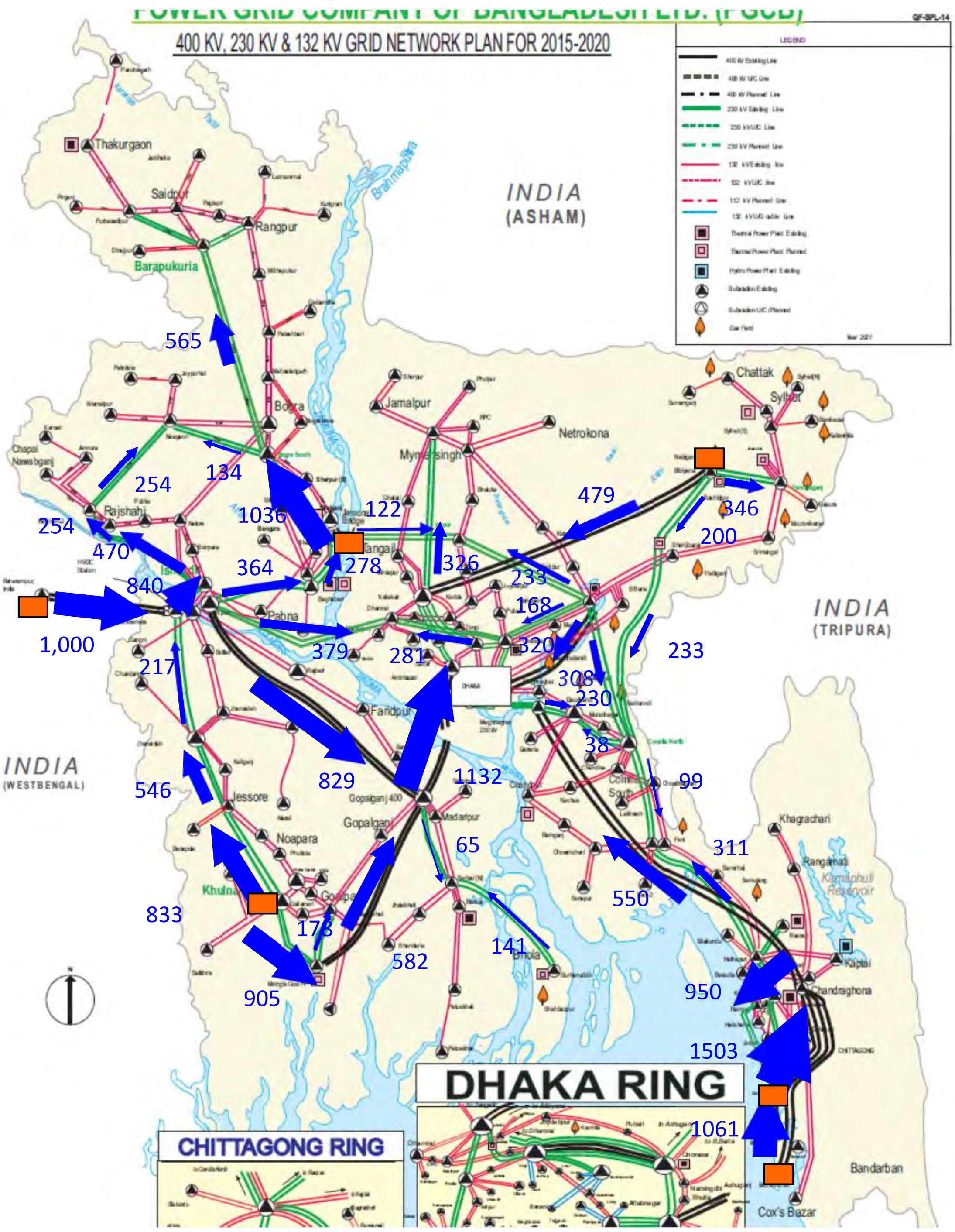


Figure 7.2-2 Power Flow of Whole System in Generation Pattern A (2021)

- Unit Capacity and the number of 400/230 kV Transformers

400/230 kV transformers with 750 MVA x 2 at Meghnaghat and 750 MVA x 3 at Madunaghat are planned to be installed. Their unit capacities and number of transformers were found to be adequate because even in N-1 contingency, the remaining transformers can supply power within their nominal capacity in Generation Pattern A, as shown in the figure on the next page. The plan for Anowara power station is not certain and there is a high possibility of it not being installed up to 2021. The figure on the page after next shows the power flow when Anowara substation is not installed. In this case, Anowara substation cannot support supplying power through the 230 kV system and Madunaghat has heavier loading. If only two units of 1,000 MVA transformers are installed, the remaining transformer of a unit would be overloaded when N-1 criteria are considered. If 1,000 MVA is applied as a transformer unit capacity, three transformers would still be required at Madunaghat and the number of transformers could not be reduced, making its installation cost high. Thus, a unit capacity of 750 MVA is recommended.

- Conductor size of 230kV Transmission Line between Madunaghat and Old Madunaghat

The transmission line from Madunaghat to Old Madunaghat takes the role of power transmission to 230 kV Old Madunaghat. The original plan and power system data include its conductor size as Twin Mallard with a capacity of under 600 MW per circuit or Twin Finch with approximately 700 MW per circuit. The power flow at this transmission line was calculated as 412 MW in Generation Pattern A; however, the maximum power flow would be expected to be more around 600 MW because Madunaghat 230 kV substation has 300 MVA x 3 transformers and its maximum load is expected to be around 600 MW eventually. This amount of power is approximately the same as the load of the lines between Hathazari and Sikalbaha, which is 559 MW in 2021, and expected to have around 600 MW in future. Therefore, it is recommended that the conductor size of the transmission line between Madunaghat and Old Maghnaghat be applied as almost the same size as the transmission line between Hathazari and Sikalbaha, which will have almost the same maximum power as this line.

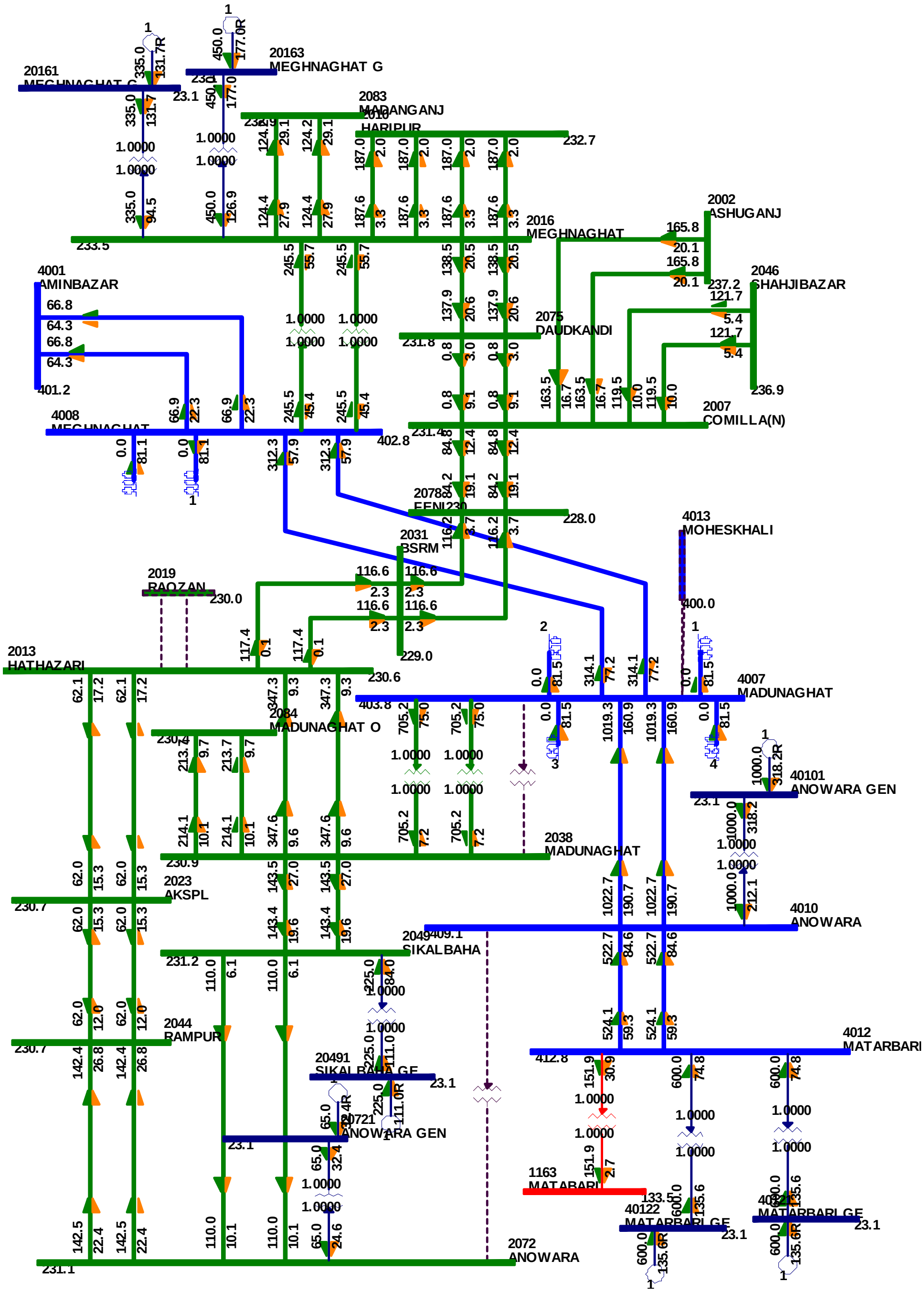


Figure 7.2-3 Power Flow of 400 kV and 230 kV System in Dhaka – Chittagong Area in 2021 (Generation Pattern A, Madunaghat 400/230 kV 750 MVA x 2, without Anowara) (Unit: MW, MVar)

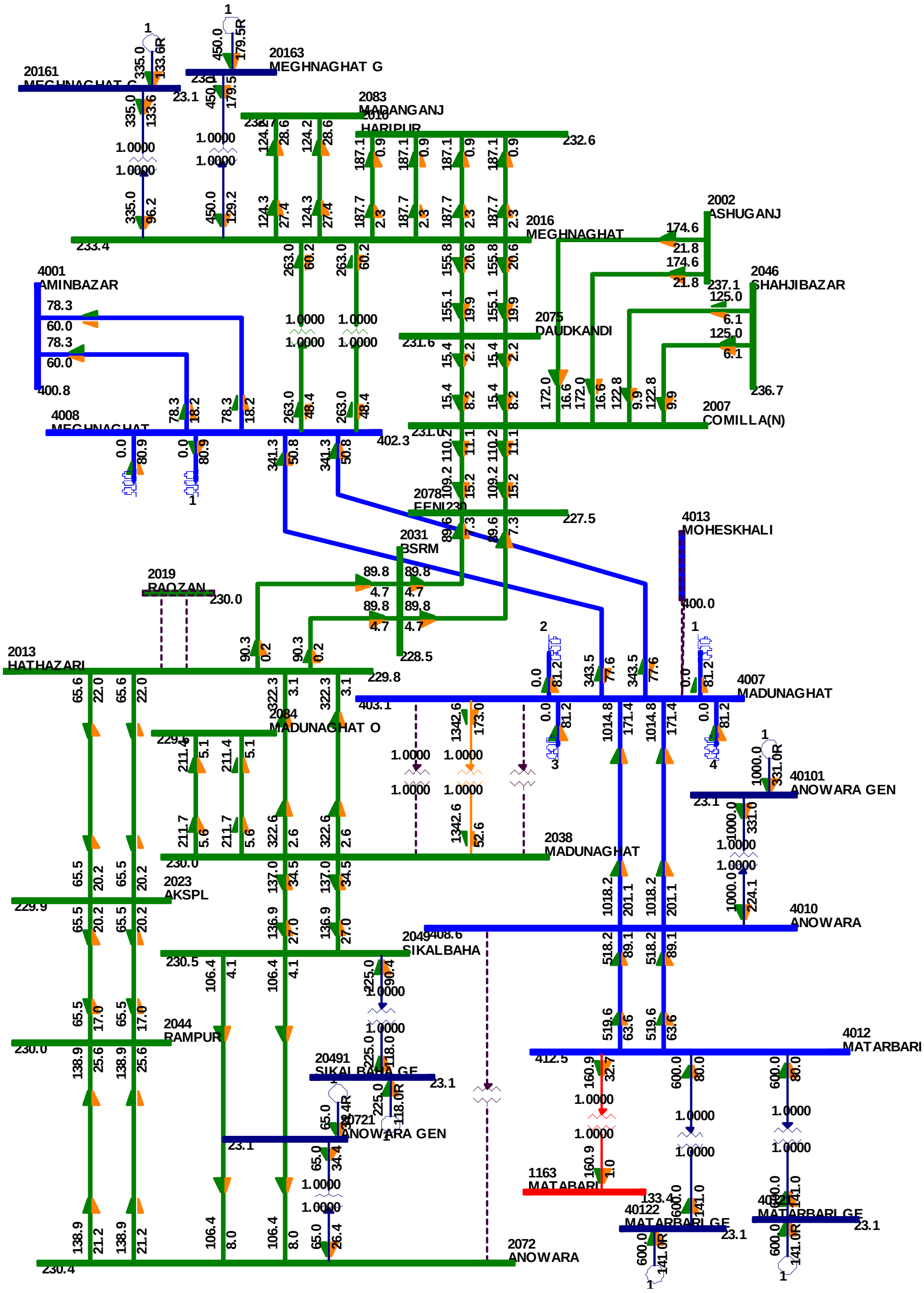


Figure 7.2-4 Power Flow of 400 kV and 230 kV System in Dhaka – Chittagong Area in 2021 (Generation Pattern A, Madunaghat 400/230 kV 1,000 MVA x 1, without Anowara) (Unit: MW, MVar)

b) Case with Large Power Outputs in Chittagong during Peak Demand Period of Time

The power flow from Chittagong to Dhaka would become heavy during the peak demand period of time when the power outputs from generators in the Chittagong area was large. To check the adequacy of the main specifications of the power supply system facilities from Chittagong to Dhaka, the following generation condition was set out secondly.

- Generation Pattern B

Kaptai hydropower units were assumed to be operated at their nominal capacities. Gas thermal power plants in Chittagong were assumed to be operated at their nominal capacities except for a 230 kV Raozan thermal power plant. Wind turbines in Chittagong were assumed to be operated at their full capacity of 100 MW.

The power supply demand balance in the whole system was calculated on the condition of Generation Pattern B as shown in the following table. The result of power flow calculation is shown in the figure depicted in the following page.

Table 7.2-2 Power Supply Demand Balance in the Whole System in 2021 in Generation Pattern B

(Unit: MW)

	Generation	Load	Loss	Interchange
Bogra	6,346	8,835	150	-2,638
Chittagong	3,326	2,029	37	1,259
Comilla	2,075	2,237	77	-239
Dhaka	4,429	1,555	94	2,780
Khulna	1,878	2,929	111	-1,162
COLUMN	18,054	17,585	469	-0

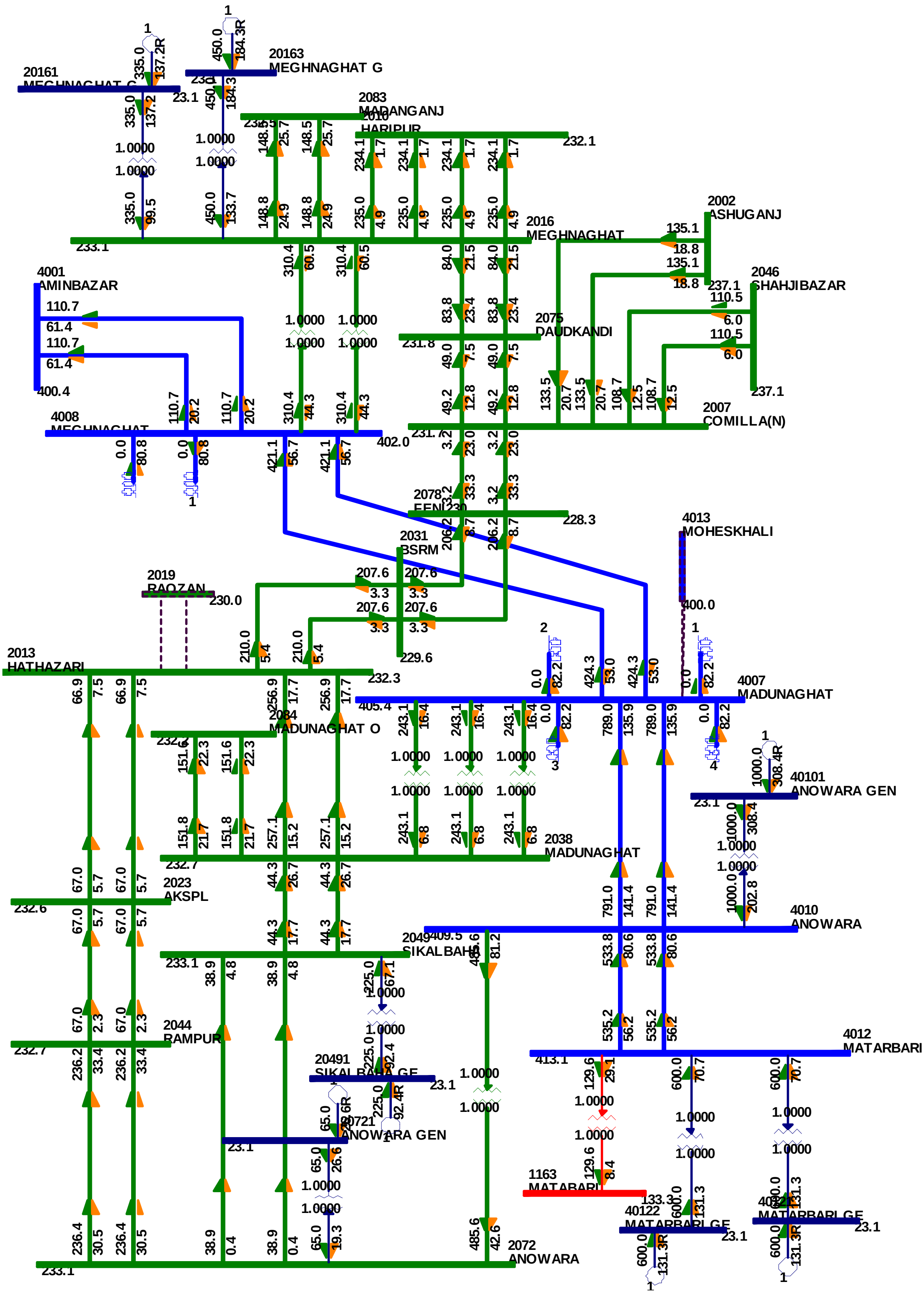


Figure 7.2-5 Power Flow of 400 kV and 230 kV System in Dhaka – Chittagong Area in 2021 (Generation Pattern B) (Unit: MW, MVar)

c) Case with off peak demand period of time

Usually, the power outputs of generators during the off peak demand period of time are reduced. However, in this study, examining the large power flow from Chittagong to Dhaka, the power outputs in Chittagong were assumed to be operated at their full capacity even during the off peak demand period of time and the total amount of power generation in Bangladesh was adjusted by other areas' generators.

- Generation Pattern of Off Peak Demand

The loads at 132 kV substations were 43% of their maximum values (this ratio was recorded in 2013). Matarbari and Anowara 400 kV generators are operated at their full capacities. Kaptai hydropower stations were assumed to be operated at their nominal capacities. 230 kV Raozan thermal power station was operated at half of its nominal capacity. Wind turbines in Chittagong were assumed to be operated at their full capacity of 100 MW. Other gas thermal power stations were adjusted to match their power output to the off peak demand.

The result of the power flow analysis for the Chittagong – Dhaka area is shown in the figure on the next page. The load at the 400 kV Madunaghat substation was reduced to 286 MW and the power flow from Madunaghat to Meghnaghat increased to 1,484 MW.

・ Conductor Size of 400 kV Meghnaghat - Madunaghat - Matarbari

The LL -ACSR 560 mm^2 x 4, whose resistance is equivalent to ACSR Finch x 4, has its thermal capacity around 2,600 MW per circuit and is expected to be applied for the 400 kV transmission lines between Meghnaghat, Madunaghat and Matarbari from the viewpoints of loss reduction and its required thermal capacity. The calculated power flows between Meghnaghat, Madunaghat and Matarbari in all the patterns were far below the thermal capacity of this interval as shown in the figures and its size is suitable from the viewpoint of thermal capacity.

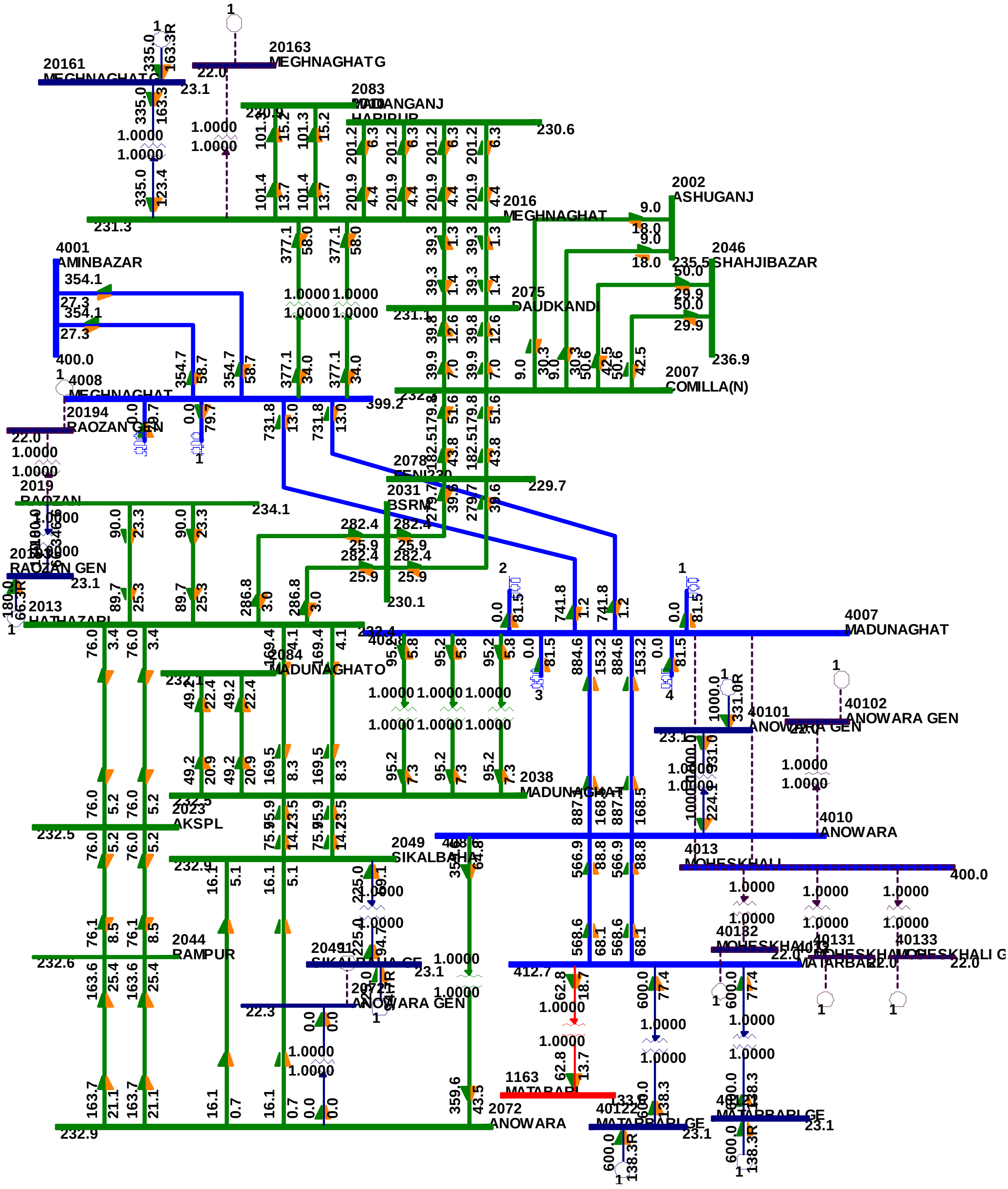


Figure 7.2-6 Power Flow of 400 kV and 230 kV System in Dhaka – Chittagong Area in 2021 (Generation Pattern of Off Peak Demand)

7.3 Fault Current

Three phase short circuit currents at the peak demand in 2021 were calculated as follows.

- Symmetric and asymmetric components of the fault currents after a fault occurs at the point of the lines close to bus-bars were calculated assuming fault clearing times of 160 ms for 230 kV and 100 ms for 400 kV according to IEC 60909 fault calculation. Asymmetrical breaking current includes a direct-current component caused by transient phenomena and symmetric breaking current indicates a symmetrical component of breaking current.

- All the lines and generators that are connected over a 132 kV system are operated during the peak period of time
- Sub-transient reactance was used as generator reactance for fault current calculation

The results of the fault current calculation are shown in the following tables.

Table 7.3-1 Three phase short circuit currents at 230 kV buses

[Unit: Kilo-Amperes(kA)]

Bus Name	Voltage	3 Phase Fault Current (kA)		Bus Name	Voltage	3 Phase Fault Current (kA)	
		Symmetric	Asymmetric			Symmetric	Asymmetric
Meghnaghat	230	56.4	59.7	AKSPL	230	27.5	28.8
Haripur	230	52.2	53.4	Bheramara	230	27.2	27.3
Ghorasal	230	47.9	50.9	Madunaghat Old	230	26.8	27.1
Siddhirganj	230	48.9	49.9	Kaliakoir	230	26.6	26.7
Aminbazar	230	46.9	49.0	Mongla	230	25.7	26.5
Bhulta	230	48.0	48.4	Comilla(N)	230	25.9	25.9
Khulna(S)	230	34.4	46.1	Kodda	230	25.3	25.3
Ashuganj	230	38.8	41.8	Jessore	230	23.5	23.5
Rampura	230	40.1	40.3	Baghabari	230	23.3	23.3
Madanganj	230	38.7	38.9	Bogra(S)	230	23.1	23.2
Keraniganj	230	38.2	38.3	Jhenaidah	230	21.4	21.4
Dhanmondi	230	37.2	37.8	Bibiyana	230	17.1	21.1
Madunaghat	230	32.4	37.3	Gopalganj	230	16.0	19.0
Ullon	230	36.7	36.8	Rupsha	230	17.6	17.7
Shampur	230	36.4	36.4	Sripur	230	16.9	16.9
Hasnabad	230	36.2	36.2	Dhamrai	230	16.7	16.7
Rooppur	230	34.5	36.0	BSRM	230	15.5	15.5
Birulia	230	35.2	35.2	Feni230	230	15.5	15.5
OldAirport	230	34.8	35.0	Naogaon	230	14.7	14.7
Sikalbaha	230	29.4	33.8	Rajshajhi	230	14.1	14.1
Anowara	230	29.3	33.7	Barapukuria	230	13.7	13.8
Hathazari	230	30.0	32.6	Shahjibazar	230	11.7	11.7
Ishurdi	230	31.9	32.4	Fenchuganj	230	11.5	11.5
Tongi	230	31.6	32.1	Muktagacha	230	11.1	11.1
Daudkandi	230	30.6	30.6	Barisal(N)	230	9.4	9.6
HVDC	230	30.1	30.3	Rangpur	230	9.3	9.3
Rampur	230	27.8	30.2	Purbasadipur	230	9.0	9.0
Maniknagar	230	30.1	30.1	BHOLA	230	6.3	6.5
Sirajganj	230	27.3	28.8				

Table 7.3-2 Three Phase Short Circuit Currents at 400 kV Buses

(Unit: kA)

Bus Name	Voltage	3 Phase Fault Current (kA)	
		Symmetric	Asymmetric
Aminbazar	400	27.8	31.2
Meghnaghat	400	26.7	30.8
Anowara	400	21.2	28.4
Madunaghat	400	21.3	26.2
Gopalganj	400	23.1	25.6
Rooppur	400	20.3	24.0
Matarbari	400	17.0	22.6
Ghorasal	400	14.5	18.2
Bhulta	400	15.3	17.7
Mongla	400	15.4	17.0
Tongi	400	13.6	16.4
Ashuganj	400	13.3	15.8
Bibiyana	400	10.7	14.3
Kaliakoir	400	9.7	10.3

Meghnaghat 230 kV bus has a fault current of 56.4 kA as a symmetric component and 59.7 kA as an asymmetric one.

Meghnaghat 400 kV, and Madunaghat 400 kV and 230 kV buses have fault currents of 30.8 kA, 26.2 kA and 37.3 kA as asymmetric ones.

If the 230 kV bus of Meghnaghat is split as shown in the following figure (Bus section A is connected to 400 kV transformers and lines to Haripur and Bus section B is connected to the lines to Comilla and Madanganj and generators), each bus section has the following three phase fault currents.

However, the scheme of 230 kV bus configuration of Meghnaghat has not been fixed yet, it will be continued to be studied.

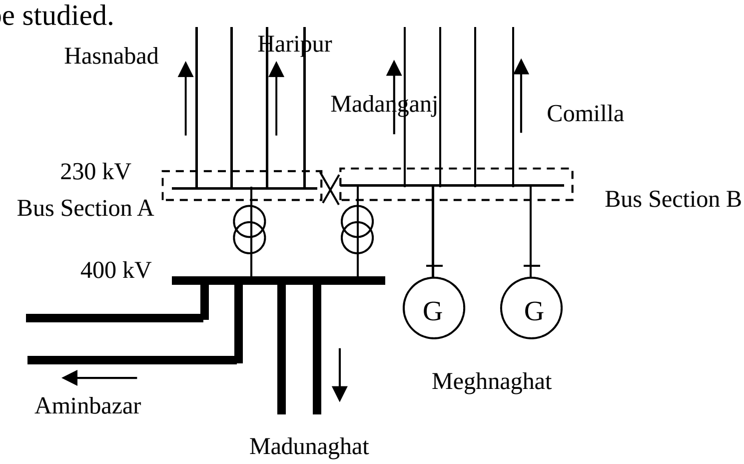


Figure 7.3-1 Example of 230 kV Bus Splitting at Meghnaghat

Table 7.3-3 Three Phase Short Circuit Currents at Split 230 kV Buses at Meghnaghat

(Unit: kA)

	Symmetric	Asymmetric
Bus Section A	39.4	40.5
Bus Section B	31.8	38.2

In this case, 40 kA seems enough for the fault breaking capacity of Bus Section B. Thus, if split operation is applied for Meghnaghat 230 kV buses, the existing circuit breakers with 40 kA are still effective on the Bus Section B side.

Figure 7.3-2 shows the fault currents and power flows in Dhaka when the 230 kV bus of Meghnaghat substation is split in the manner shown in Figure 7.3-1.

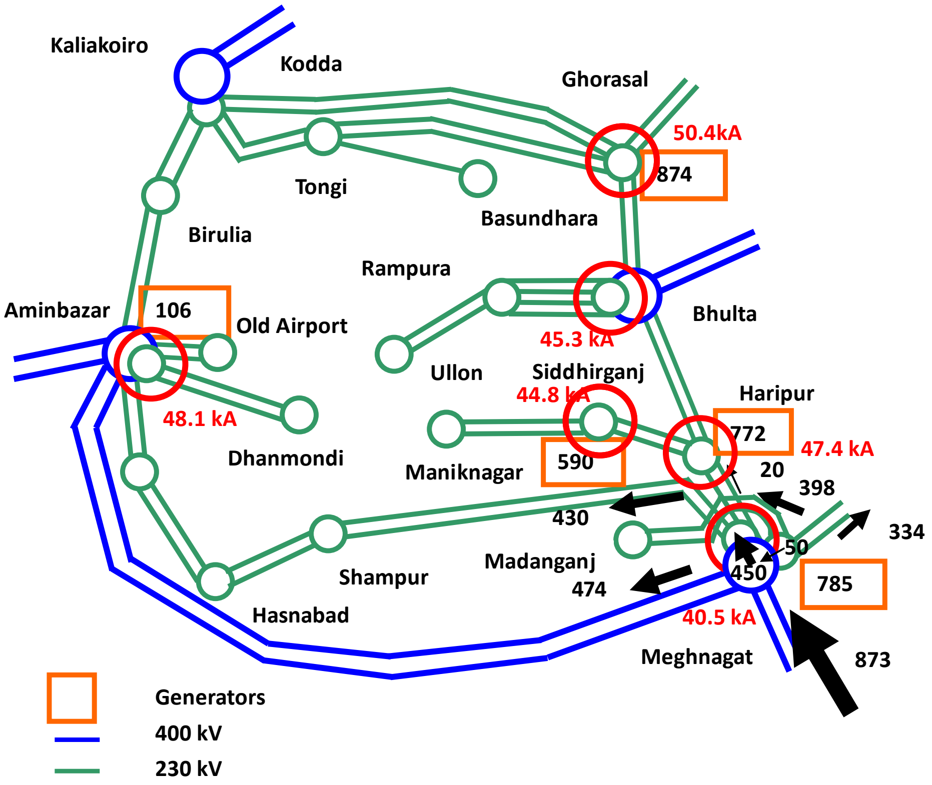


Figure 7.3-2 Fault Currents and Power Flows in Dhaka when the 230 kV Bus of Meghnaghat Substation

Figure 7.3-3 shows the fault currents around Chittagong assuming power generation of around 9,000 MW installed in the 400 kV system (around 4,900 MW connected to New Madunaghat) when the 230 kV transmission line between Sikalbaha and Anowara is opened or 230 kV bus of Madunaghat substation is split. In those cases, 50 kA seems enough for the fault breaking capacity of buses of the 400 kV and 230 kV systems around Chittagong. It should be noted that one 400 kV substation, such as New Madunaghat, could directly collect power generation of 4,000 to 5,000 MW at most in comparison with the future system peak load to maintain a safe system frequency in order to avoid blackouts of the entire power system when dropping a 400 kV substation.

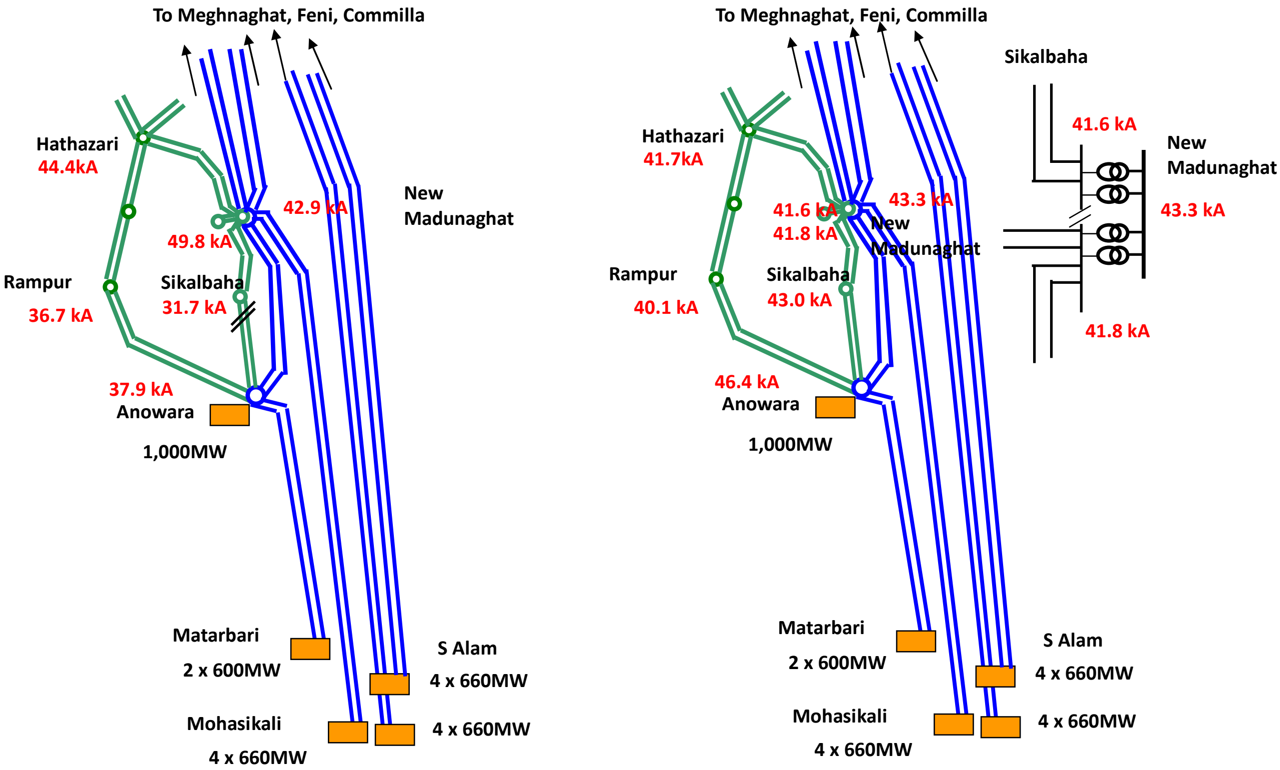


Figure 7.3-3 Fault Currents around Chittagong assuming Power Generation of around 4,900MW connected to New Madunaghat

7.4 Stability Analysis

7.4.1 Rough Restricted Model

Stability analysis has been carried out for the regional restricted model to estimate the required number of circuits of the 400 kV transmission line from Meghnaghat to Matarbari through Madunaghat as follows.

- Loads of Chittagong were modeled as the values according to the PGCB's presentation material at the second kick-off meeting.
- The swing curve of the difference of power angle between Matarbari and Meghnaghat was observed for 10 seconds by modeling the sequent events.
- The assumed sequent events are a three phase short circuit fault and line trip.
- Three phase short circuit fault was assumed at the interval of a circuit between Madunaghat and Meghnaghat.
- Its circuit was assumed to be tripped out just 100 ms after the fault to clear.
- If its swing curve is converged, the system is deemed to be stable.

When the double circuit 400 kV transmission line is assumed between Meghnaghat and Madunaghat, with Matarbari operating at 1,200 MW and Moheskhali at 1,320 MW, taking the system configuration shown in Figure 7.4-2, the result of the stability analysis was depicted as shown in Figure 7.4-1 and the system can be said to be stable in this case.

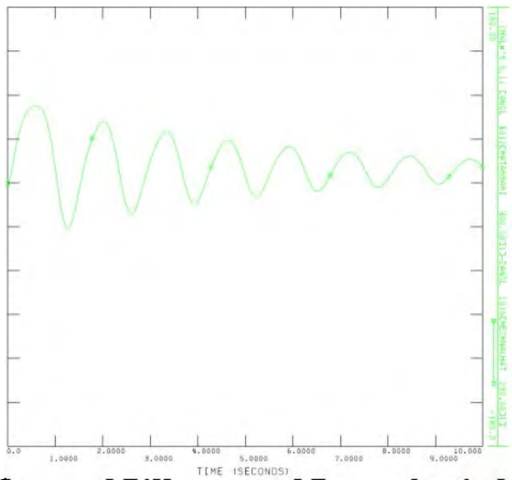


Figure 7.4-1 Swing Curve of Difference of Power Angle for Double Circuit T/L between Matarbari and Meghnaghat in Case of Matarbari 1,200 MW and Moheskhali 1,320 MW

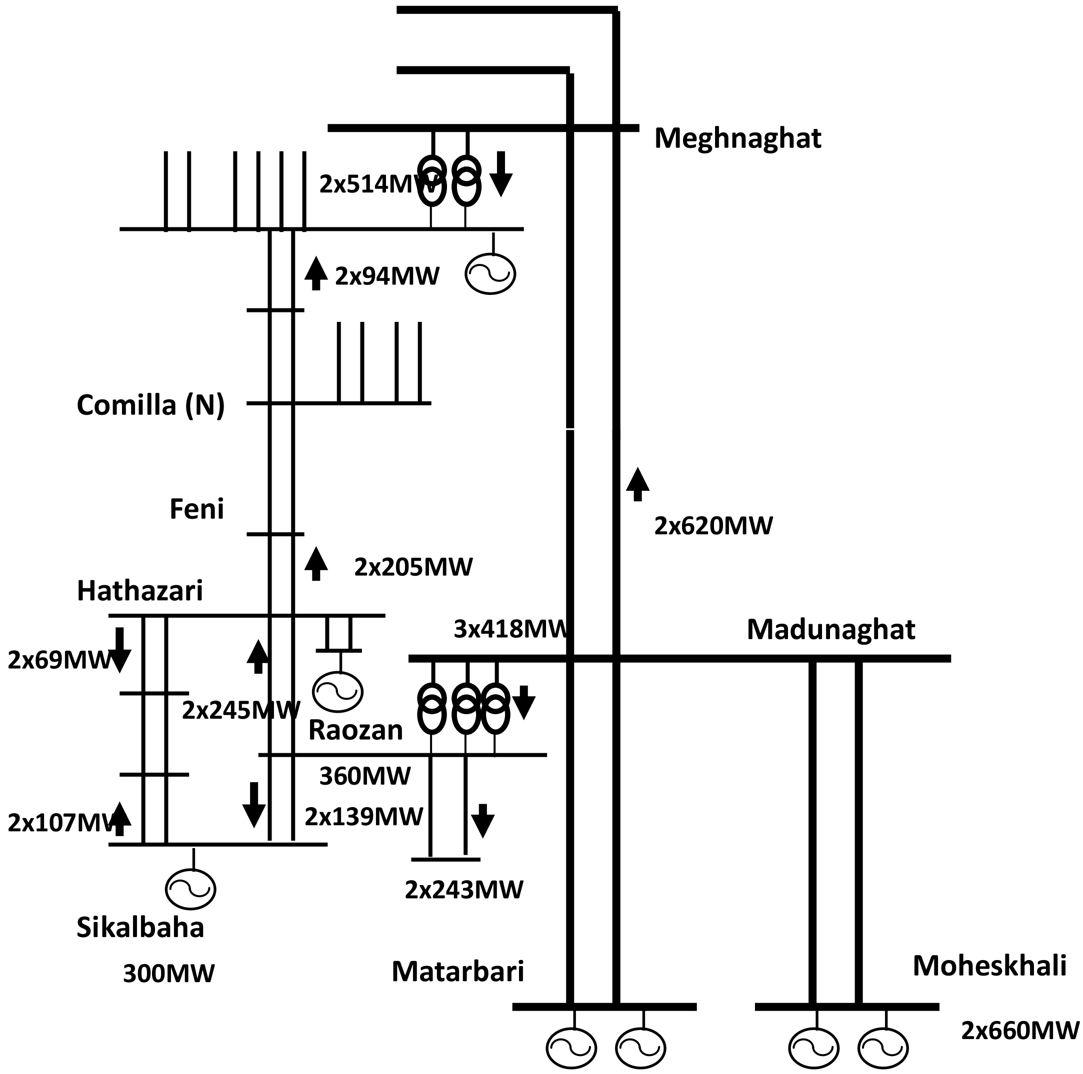


Figure 7.4-2 System Configuration for Stability Analysis (1)

Next, the case of the 400 kV double circuit transmission line from Meghnaghat and Matarbari, with Anowara 1,000 MW added to the Matarbari 1,200 MW and Moheskhali 1,320 MW, was assumed. The result of the simulation for this case showed that the system was not stable due to the fast drop of the synchronizing of generators.

However, the case of 400 kV four circuit transmission line from Meghnaghat and Matarbari, with Anowara 1,000 MW added to the Matarbari 1,200 MW and Moheskhali 1,320 MW, as shown in Figure 7.4-3, was found to be stable in its stability simulation.

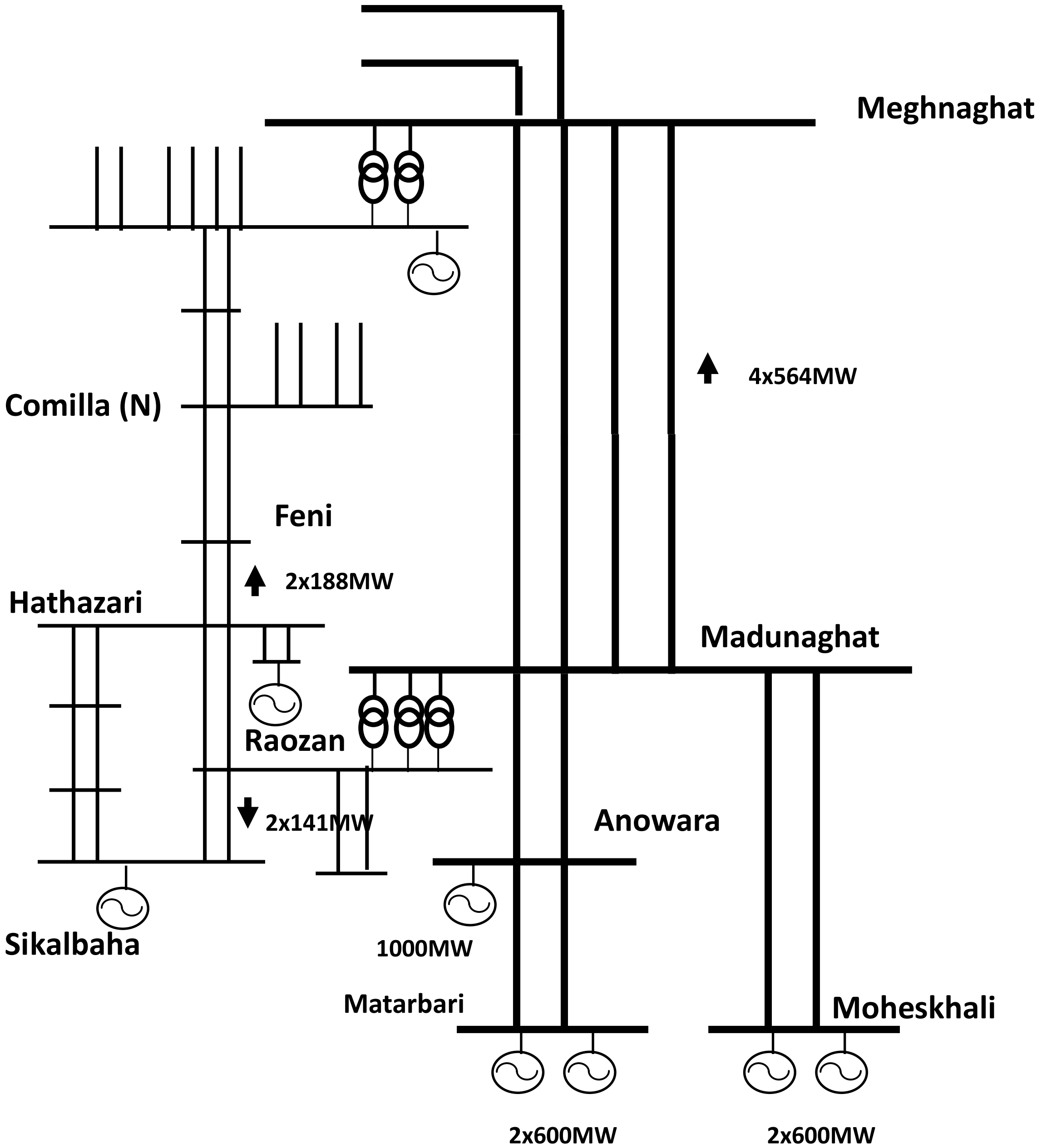


Figure 7.4-3 System Configuration for Stability Analysis (2)

Thus, the 400 kV double circuit transmission line between Meghnaghat and Madunaghat can transmit power to Dhaka, connecting with Matarbari 1,200 MW and Moheskhali 1,320 MW, by dropping some loads at Chittagong. However, new circuits may be required for additional power stations such as Anowara.

7.4.2 Model of 2021

The simulations were performed using the 2021 model made under the conditions described in 7.1.

The generator parameters of coal thermal power plants and combined cycles were used as shown in the following tables provided by PGCB. Other thermal power plants and hydropower plants used the typical parameters as shown in the following tables. Exciter and Power System Stabilizer (PSS) models were used as the typical ones.

Table 7.4-1 Generator Parameters for Coal Thermal

Xd	Xq	X'd	X'q	X"d = X"q	Xl	S(1.0)	S(1.2)
2.26	2.2	0.275	0.405	0.214	0.1	0.12	0.6
T'do	T"do	T'qo	T"qo	Inertia H	Speed Damping D		
8.73	0.045	0.97	0.068	2.6073	0		

Table 7.4-2 Generator Parameters for Combined Cycle

Xd	Xq	X'd	X'q	X"d = X"q	Xl	S(1.0)	S(1.2)
1.6336	1.6565	0.2815	0.4547	0.2284	0.1	0.12	0.6
T'do	T"do	T'qo	T"qo	Inertia H	Speed Damping D		
7.547	0.045	0.871	0.07	3.3	0.1		

Table 7.4-3 Generator Parameters for Other Thermal

Xd	Xq	X'd	X'q	X"d = X"q	Xl	S(1.0)	S(1.2)
1.4	1.35	0.3	0.6	0.2	0.1	0.03	0.4
T'do	T"do	T'qo	T"qo	Inertia H	Speed Damping D		
6	0.05	1	0.05	3	0		

Table 7.4-4 Generator Parameters for Hydropower

Xd	Xq	X'd	X"d = X"q	X1	S(1.0)	S(1.2)
1.5	1.2	0.4	0.2	0.12	0.03	0.25
T'do	T"do	T"qo	Inertia H	Speed Damping D		
5	0.05	0.06	5.084	1		

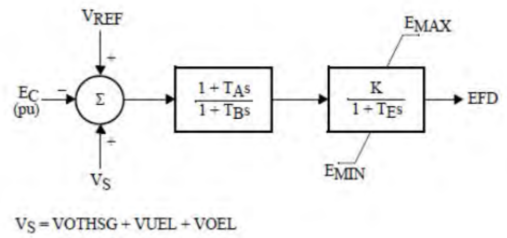


Figure 7.4-4 Exciter Model

Table 7.4-5 Parameters of Exciter

TA/TB	TB	K	TE	EMIN	EMAX
0.1	10	100	0.1	0	5

Table 7.4-6 Power System Stabilizer (PSS)

A1-A6	T1	T2	T3	T4	T5	T6	KS	LSMAX	LSMIN	VCU	VCL
0	0.06	0.18	0.06	0.18	5	5	-0.75	0.1	-0.1	0	0

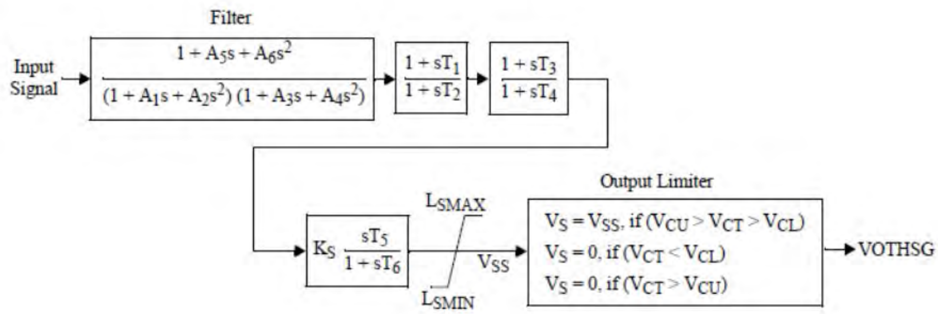


Figure 7.4-5 Power System Stabilizer (PSS) Model

System stability was calculated by changing the number of operating units of Matarbari, Anowara and Moheskhali for Generation Pattern B and Generation Pattern of Off Peak Demand.

The fault was assumed as three phase short circuit at a 400 kV transmission line close to Madunaghat 400 kV bus. The fault clearing time was assumed as 100 ms. After fault clearance, power angle oscillation between Dhaka (Ashuganj) and Matarbari was calculated for 10 seconds.

The following table shows the results of this stability calculation. Cases 1 to 5 were set by system model based on Generation Pattern B. Case 3-2 was a modified case of Case 3 just by adding Raozan operation.

Table 7.4-7 The Results of Power System Stability Analysis

	Case 1	Case 2	Case 3	Off Peak		Case 3-2	Case 4	Case 5
Matarbari (MW)	**600 x 2**	**600 x 2**	**600 x 2**	**600 x 2**		**600 x 2**	**600 x 2**	**600 x 2**
Anowara (MW)	1000 x 1	0	1000 x 1	1000 x 1		1000 x 1	0	1000 x 1
Moheskhali (MW)	0	660 x 2	660 x 1	0		660 x 1	660 x 3	660 x 2
Total (MW)	2200	2520	2860	2200		2860	3180	3520
Power Flow between Meghnaghat and Madunaghat (MW)	849	1,098	1,364	1,484		1,610	1,635	1,866
Stability	Stable	Stable	Stable	Stable		Stable	Unstable	Unstable

The results of the study indicate that the stability limit of the power flow between Madunaghat and Meghnaghat seems to be around 1,400 to 1,500 MW from the safety side for double circuits when N-1 is considered, although some cases can transmit power of around 1,600 MW.

In 2021, the project transmission line of 400 kV double circuits between Madunaghat and Meghnaghat can transmit power from Matarbari with 600 MW x 2. Furthermore, Anowara, with 1,000 MW x 1, and Moheskhali 660 MW x 1 can be added. Otherwise, Moheskhali 660 MW x 2 can be included.

Case 1.

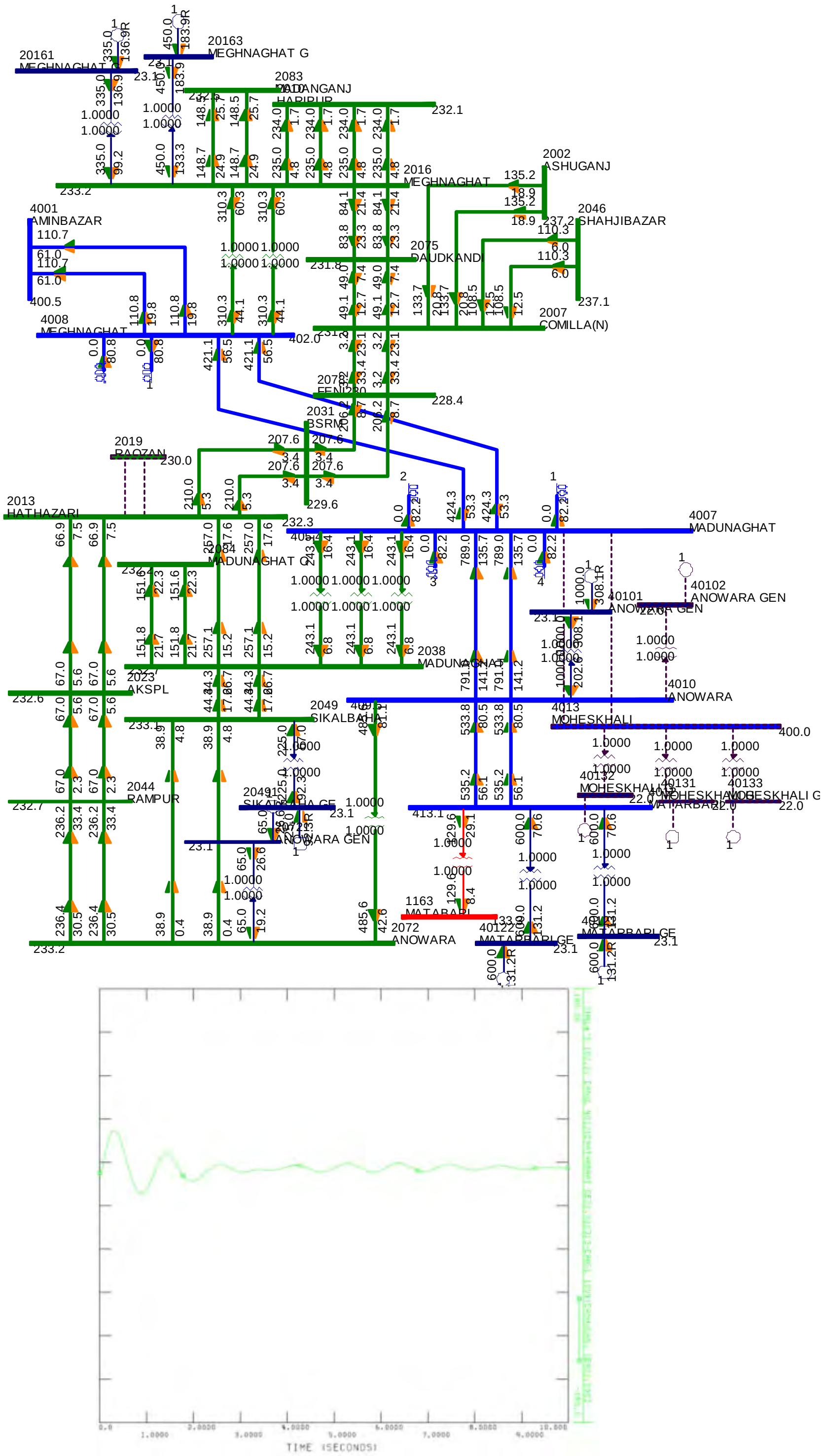
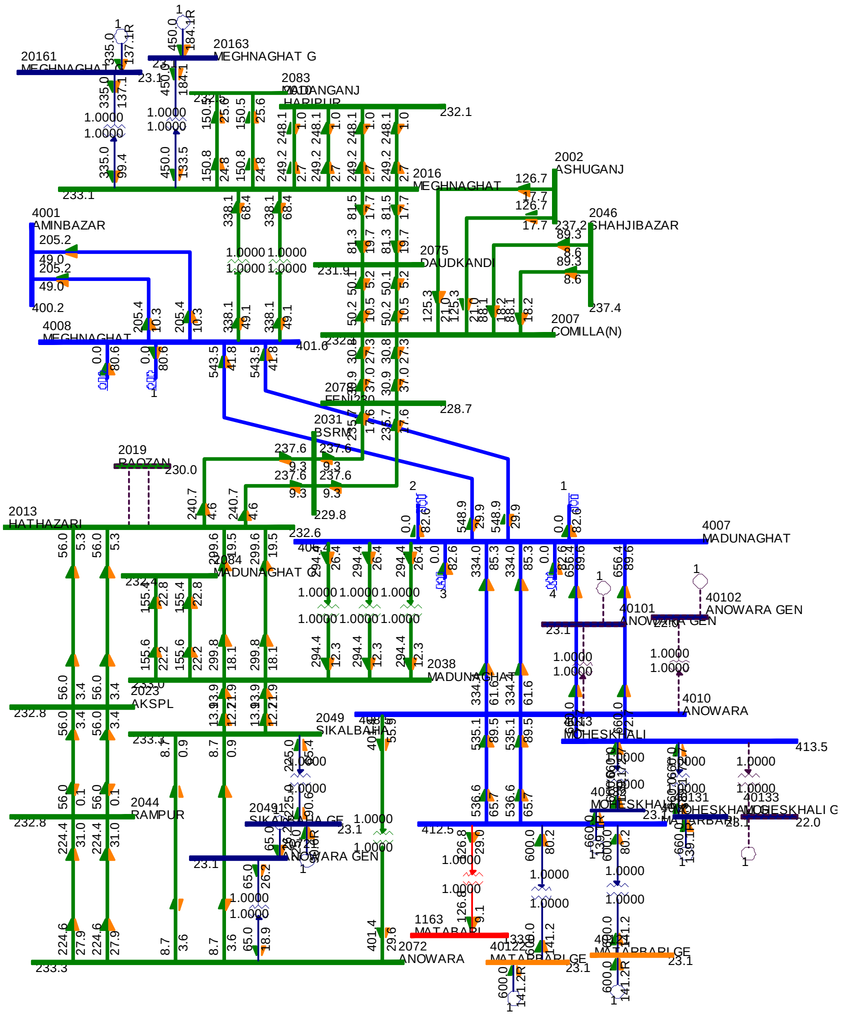


Figure 7.4-6 Power Angle Oscillation between Ashuganj-Matarbari when Madunaghat to Meghnaghat 400 kV Three Phase Line Grounding and Opening (3LGO) (Anowara 1,000 MW, Moheskhali stopped, Generation Pattern B)

Case 2.



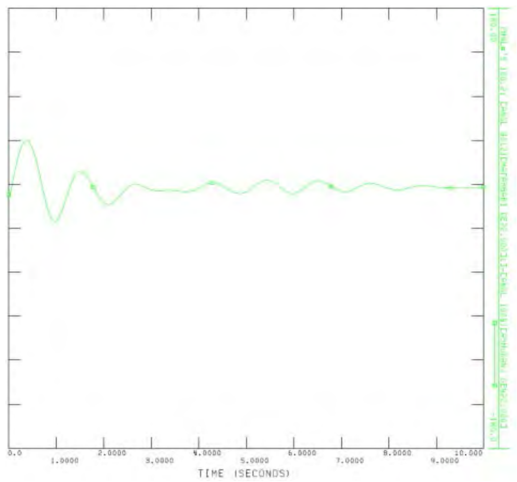


Figure 7.4-7 Power Angle Oscillation between Ashuganj-Matarbari when Madunaghat to Meghnaghat 400 kV 3LGO (Anowara Stopped, Moheskhali 1,320 MW, Generation Pattern B)

Case 3.

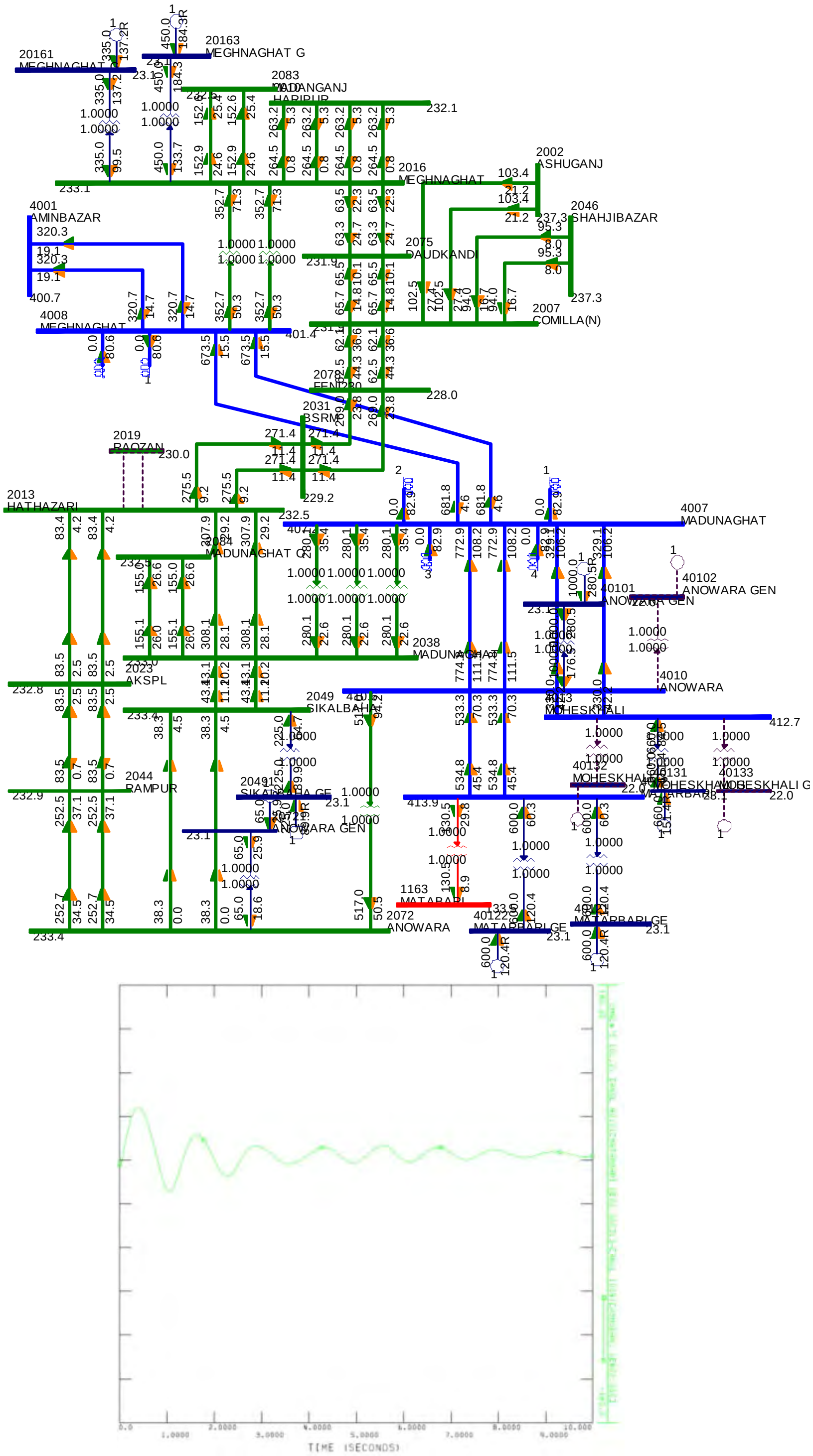
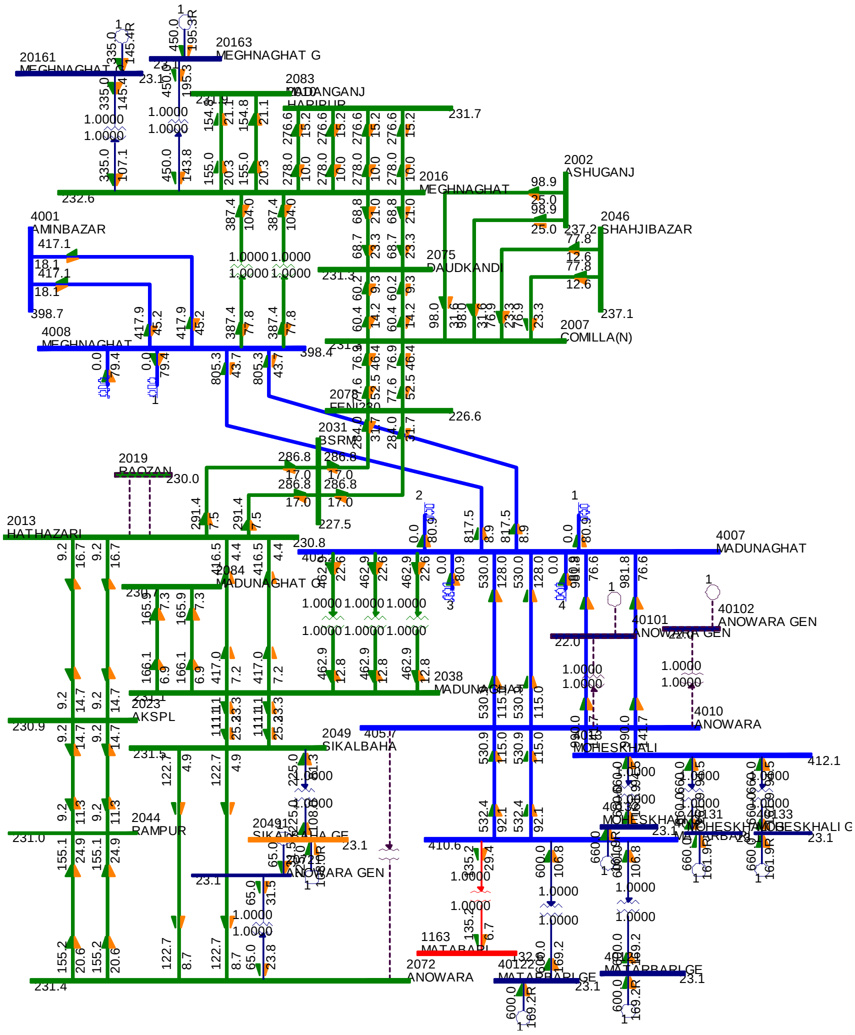


Figure 7.4-8 Power Angle Oscillation between Ashuganj-Matarbari when Madunaghat to Meghnaghat 400 kV 3LGO (Anowara 1,000 MW, Moheskhali 660 MW, Generation Pattern B)

Case 4.



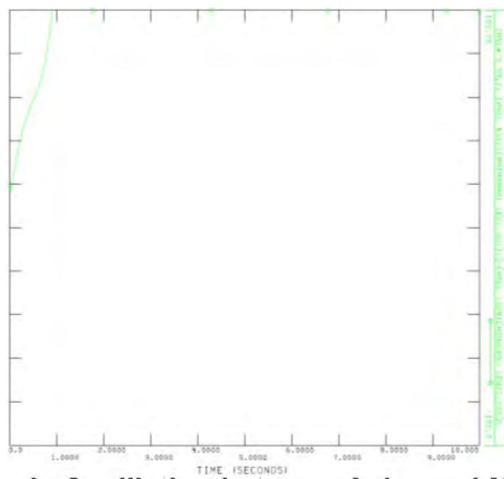


Figure 7.4-9 Power Angle Oscillation between Ashuganj-Matarbari when Madunaghat to Meghnaghat 400 kV 3LGO (Anowara Stopped, Moheskhali 1,980 MW, Generation Pattern B)

Case 5.

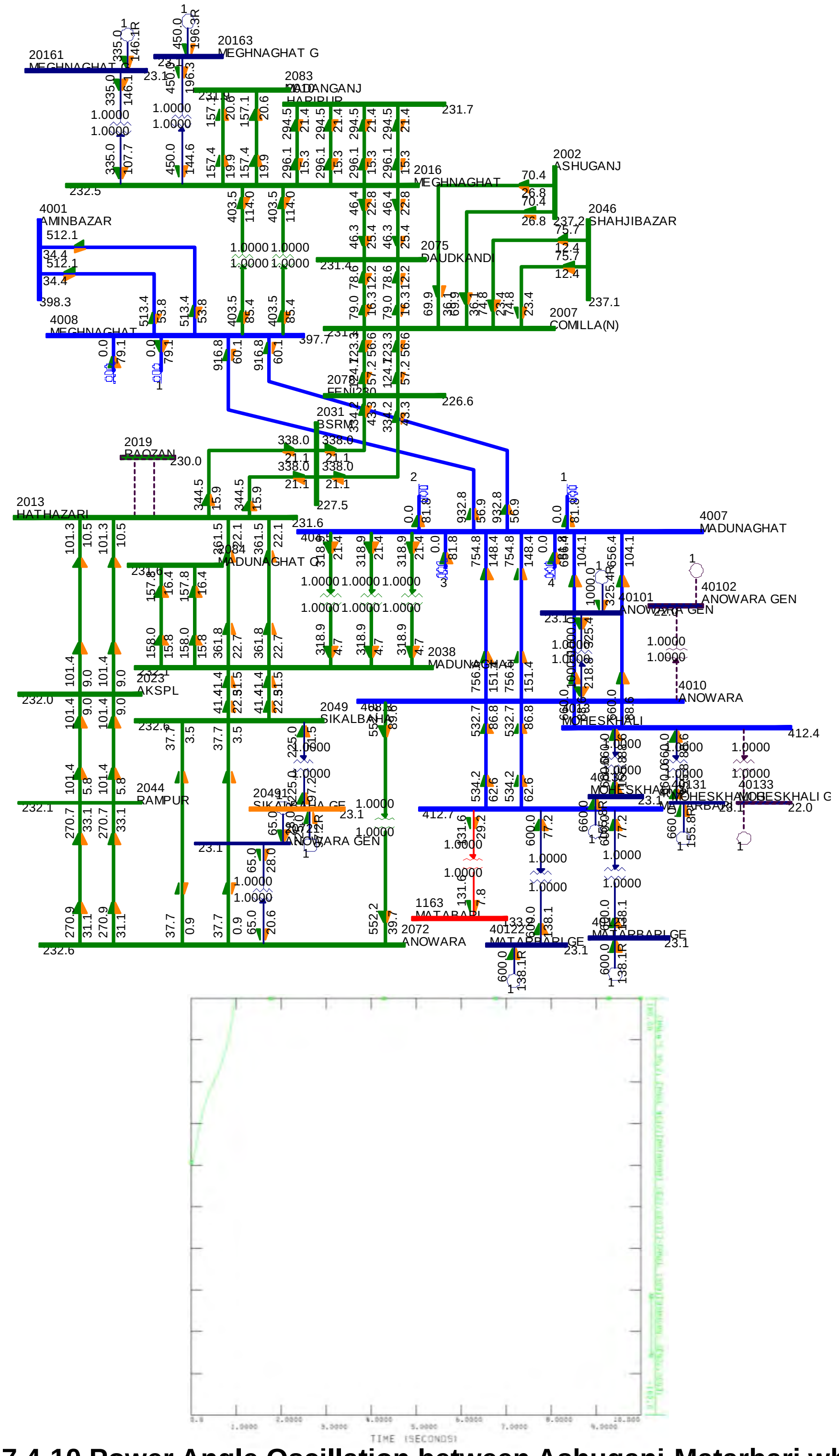


Figure 7.4-10 Power Angle Oscillation between Ashuganj-Matarbari when Madunaghat to Meghnaghat 400 kV 3LGO (Anowara 1,000 MW, Moheskhali 1,320 MW, Generation Pattern B)

Case 3-2.

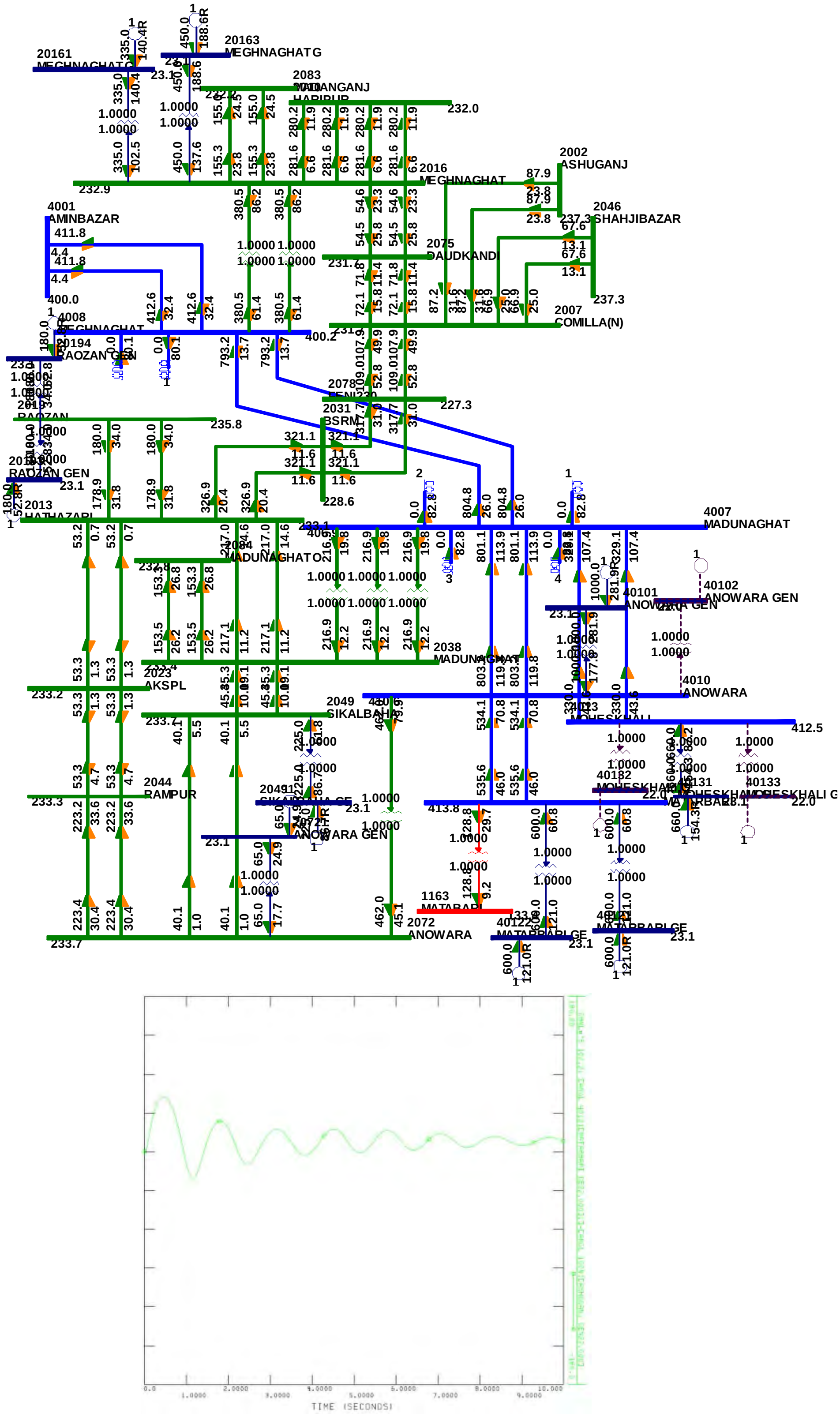


Figure 7.4-11 Power Angle Oscillation between Ashuganj-Matarbari when Madunaghat to Meghnaghat 400 kV 3LGO (Adding Raozan to Case 3)

Off Peak Case

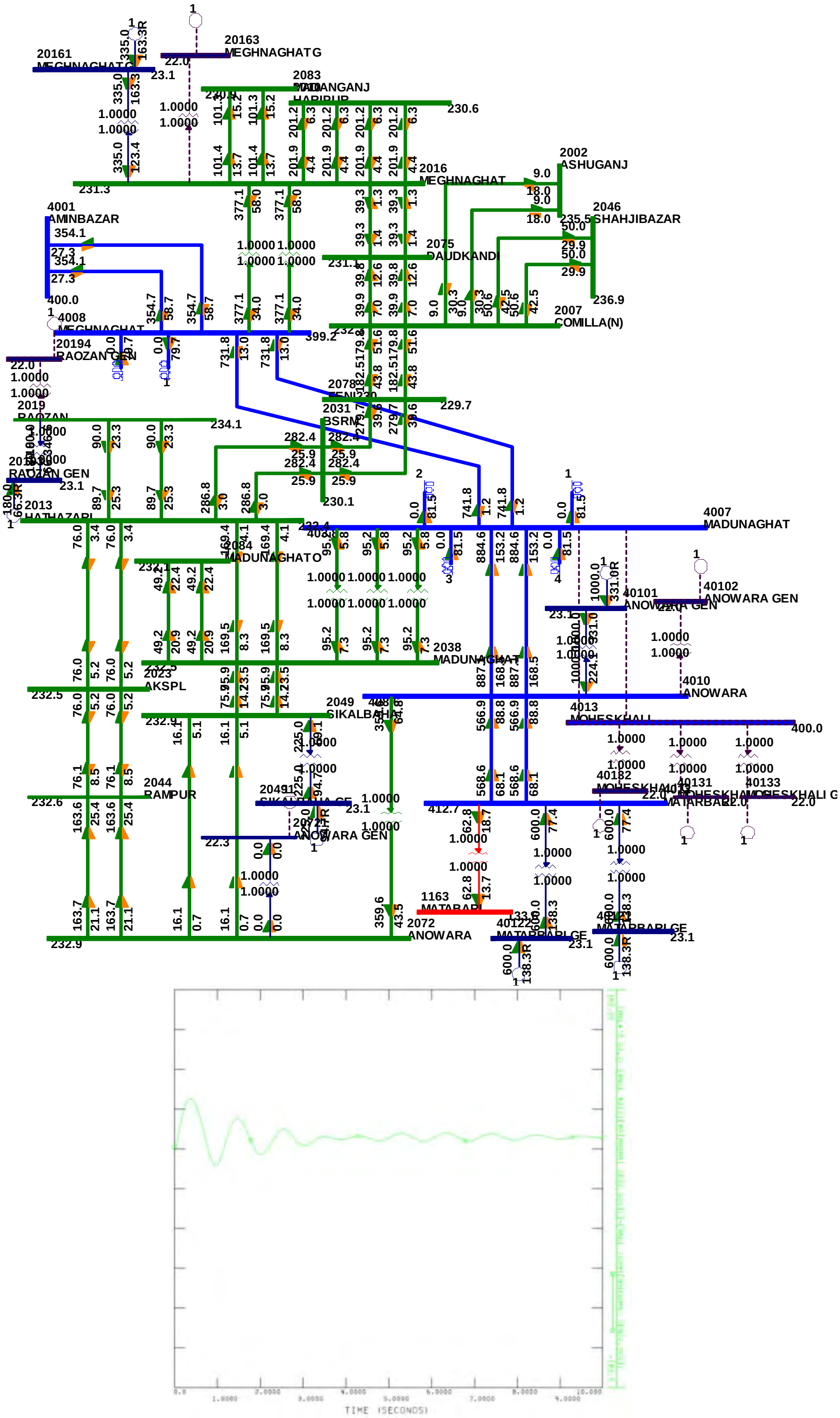


Figure 7.4-12 Power Angle Oscillation between Ashuganj-Matarbari when Madunaghat to Meghnaghat 400 kV 3LGO (Off Peak)

7.5 Conductor Selection

7.5.1 Comparison among the ACSRs

The target 400 kV transmission line is composed of the section between Meghnaghat SS and Anowara PP, which was studied in the World Bank's (WB's) Feasibility Study (F/S) in 2013, and the section between Anowara PP and Matarbari Coal Fired Power Plant (CFPP), studied in the "JICA Preparatory Survey on Chittagong Area Coal Fired Power Plant Development Project in Bangladesh". The conductor used for the section between Anowara PP and Matarbari CFPP has already been agreed as a low loss type between the Bangladesh side and JICA. The conductor to be used for the interval between Meghnaghat SS and Anowara PP was recommended as Finch in the WB's F/S in 2013. This section reviews and discusses the conductor that should be used for this interval.

Firstly, we compare the costs of ACSR type conductors by changing their sizes. If the larger size conductor is used, the loss of transmission line becomes small; however, its construction cost, including towers and foundations, becomes large. If the smaller size conductor is used, the loss becomes large; however, its construction cost can be reduced. Thus, there is an optimal point that minimizes the total cost including losses, towers, conductors and foundations.

The result shows that ACSR Finch stands at the optimal point among the three types of ACSR conductors; Martin, Finch, and Mallard all have enough capacity to transmit power between Dhaka and Chittagong as shown in the following table. The result is consistent with the WB's F/S.

Table 7.5-1 Cost Comparison among ACSRs

		ACSR Martin	ACSR Finch	ACSR Mallard
P max	MW	600	600	600
Voltage	kV	400	400	400
No. of Circuits		2	2	2
No. of Bundles per phase		4	4	4
Amp. per conductor	A	241	241	241
Resistance	ohm/km	0.04138	0.05144	0.07180
Resistance 70	ohm/km	0.04924	0.06121	0.08544
Loss per circuit	kW/km/cct	34.19597	42.50944	59.33472
Annual Loss Factor		0.4	0.4	0.4
Annual Loss per circuit	kWh/km/cct/year	119,823	148,953	207,909
kWh price	USD/kWh	0.06	0.06	0.06
Loss per year per circuit	mil.USD/km/cct/year	0.00719	0.00894	0.01247
years		20	20	20
Loss for life time per circuit	mil.USD/km	0.14379	0.17874	0.24949
Loss for life time per d. circuit		0.28757	0.35749	0.49898
Tower Weight	t	62.15142	57.84678	53.137
Tower cost per weight	USD/t	2100	2100	2100
No. of Tower per km for d. circuit		2.5	2.5	2.5
Tower Cost for d. circuit	mil. USD/km/2cct	0.32629	0.30370	0.27897
Conductor Cost(Japan)	USD/m	13.24	10.80	9.05
Conductor Cost(Korea)	USD/m	10.67	8.70	7.29
Conductor Cost(Used for compariso	USD/km	10,666	8,700	7,290
Line Cost	mil. USD/km/2cct	0.25597	0.20880	0.17497
(Assumed Manufacturer)		(Korea)	(Korea)	(Korea)
Foundation Cost per tower	USD/tower	53,721	50,000	45,929
Foundation Cost for d. circuit	mil. USD/km/2cct	0.13430	0.12500	0.11482
Insulator Cost per plate	mil. USD	0.00014	0.00014	0.00014
No. Insulator per phase	mil. USD	21	21	21
No. Insulator per tower	mil. USD	126	126	126
Insulator Cost for d. circuit	mil. USD/km/2cct	0.04500	0.04500	0.04500
Total Cost for d. circuit	mil. USD/km/2cct	1.04914	1.03998	1.11274
Meghnahat- Madunaghat	mil. USD for 20 years	224.5	222.6	238.1

7.5.2 Characteristics of Low Loss Type ACSR/AC

Apart from the usual conductor type of ACSR, Low Loss type ACSR/Aluminum-Clad Steel Wire (LL -ACSR/AC) that consists of trapezoidal (=non-cylindrical) aluminum conductor with strengthened core wire can be also considered as one of the appropriate candidates. It has the following characteristics.

- Trapezoidal (=non-cylindrical) shape with higher density aluminum than ACSR in a cross section
- Higher-tension steel core
- Anti-corrosion characteristic (<u>Usage of Aluminum Clad Steel Wire(=/AC)</u>)
  - AC type is usually employed to enhance a conductor’s anti-corrosion characteristics, which results in higher reliability & longer lifetime.
  - TEPCO revised its conductor design standard to employ /AC type in all new constructions. Formerly selected for heavily contaminated areas: e.g. Shore-side. Expect 1.5 times longer for conductor’s lifetime

There are two types of cost comparison methods for LL conductors.

<u>Application Case 1: Loss reduction</u>

If assuming the same conductor size, transmission loss can be reduced to 80% of conventional type. Usually, this method is taken for the cost comparison of cases with fixed tower design or fixed conductor sizes. Types of LL conductors corresponding to ACSR are selected to make the design conditions for towers and foundations fixed (that means the same tower and foundation can be applied). Thus, this method is usually applied for re-stringing cases or cases fixing the transmission tower design.

<u>Application Case 2: Initial cost reduction</u>

If assuming the same conductor loss, the diameter of LL-ACSR is 10% smaller than conventional ACSR, so the conductor weight can be reduced by 6.5% by utilizing high-tension steel core. Consequently, less wind-pressure, lighter load on towers, and streamlining of tower design can be achieved. This method can be applied in cases of new construction lines because conductor capacity (or its resistance that determines the electrical resistance) is usually designated to assure its electrical ability.

7.5.3 Cost Comparison of Low Loss Type Conductor with ACSR Finch

This Project has severe project conditions, such as strong wind velocity requiring strengthened tower design, which result in increased tower weight. If LL-ACSR is applied to the project in this particular case, LL-ACSR application can reduce tower construction cost from 101.4MUSD to 93.3MUSD. This conceptual figure is shown below.

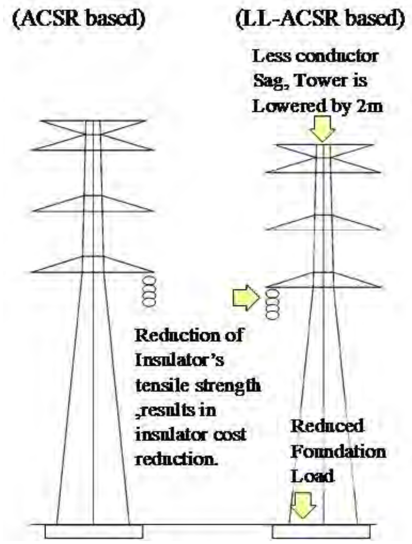


Figure 7.5-1 Concept of Saving Towers and Foundations

Consequently, the case using low loss type conductors would be more cost effective overall than ACSR Finch, as shown in the following table.

Table 7.5-2 Cost Comparison between Finch and ACSRs

		ACSR Finch	LL-ACSR/AS560mm2
P max	MW	600	600
Voltage	kV	400	400
No. of Circuits		2	2
No. of Bundles per phase		4	4
Amp. per conductor	A	241	241
Resistance	ohm/km	0.05144	0.0501
Resistance 70	ohm/km	0.06121	0.05962
Loss per circuit	kW/km/cct	42.50944	41.40208
Annual Loss Factor		0.4	0.4
Annual Loss per circuit	kWh/km/cct/year	148,953	145,073
kWh price	USD/kWh	0.06	0.06
Loss per year per circuit	mil.USD/km/cct/year	0.00894	0.00870
years		20	20
Loss for life time per circuit	mil.USD/km	0.17874	0.17409
Loss for life time per d. circuit		0.35749	0.34817
Tower Weight	t	57.84678	51.89866
Tower cost per weight	USD/t	2100	2100
No. of Tower per km for d. circuit		2.5	2.5
Tower Cost for d. circuit	mil. USD/km/2cct	0.30370	0.27247
Conductor Cost(Japan)	USD/m	10.80	10
Conductor Cost(Korea)	USD/m	8.70	-
Conductor Cost(Used for compariso	USD/km	8,700	10,000
Line Cost	mil. USD/km/2cct	0.20880	0.24000
(Assumed Manufacturer)		(Korea)	(Japan)
Foundation Cost per tower	USD/tower	50,000	44,859
Foundation Cost for d. circuit	mil. USD/km/2cct	0.12500	0.11215
Insulator Cost per plate	mil. USD	0.00014	0.00014
No. Insulator per phase	mil. USD	21	24
No. Insulator per tower	mil. USD	126	144
Insulator Cost for d. circuit	mil. USD/km/2cct	0.04500	0.05143
Total Cost for d. circuit	mil. USD/km/2cct	1.03998	1.02422
Meghnahat- Madunaghat	mil. USD for 20 years	222.6	219.2

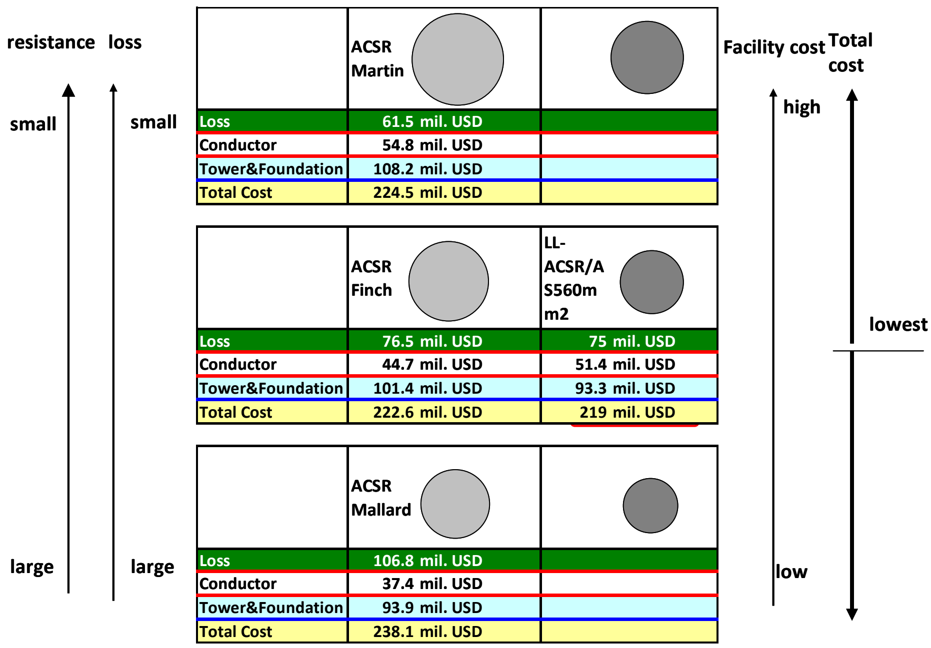


Figure 7.5-2 Concept of Cost Comparison among ACSR and LL type conductors

7.6 Necessity of Transpositions

When the negative sequence current flows into a turbine generator, the current with twice its nominal frequency occurs on the surface of the rotor and it causes heating of the rotor. Thus, it is necessary to reduce the negative sequence current in the power system.

The negative sequence current was calculated in the case without transpositions of the 400 kV transmission line between Matabari, Madunaghat and Meghnghat, modeling the system shown in the following figure when the positive sequence voltage was charged on the Matabari thermal power plants and one of the circuits of the transmission line was opened. The resultant ratio of the negative sequence current to the positive sequence current was 5%. This ratio is considered as a level that requires some of the countermeasures to reduce the negative sequence current flowing into the power plant with its large capacity.

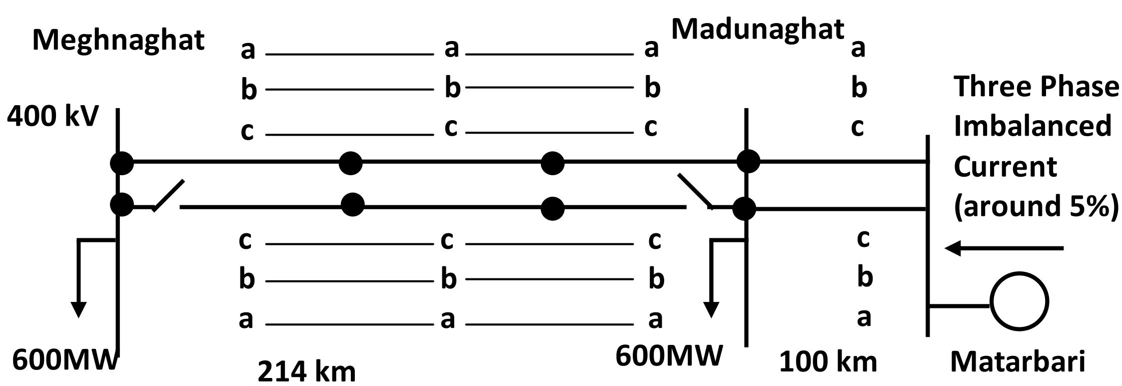


Figure 7.6-1 Case without transposition

Next, the negative sequence current was calculated in the case "with" transpositions of the 400 kV transmission line between Matabari, Madunaghat and Meghnghat, modeling the system shown in the following figure. The resultant ratio of the negative sequence current to the positive sequence current was less than 1%.

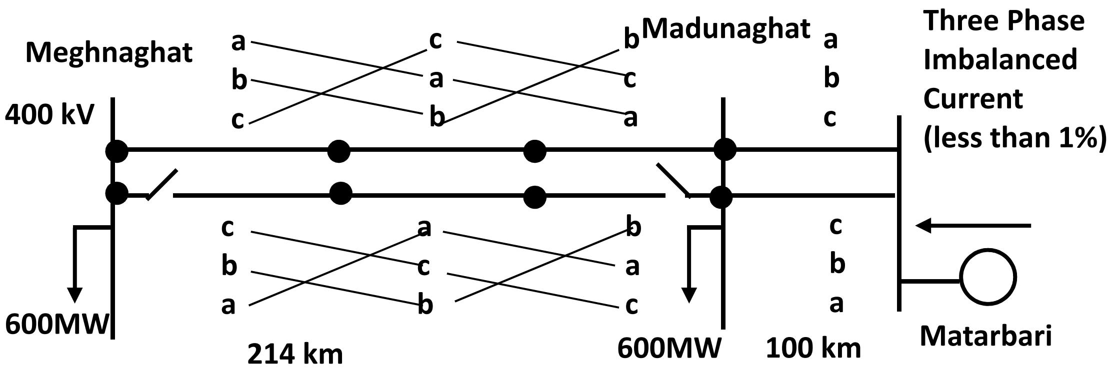


Figure 7.6-2 Case with transposition

If the 400 kV switch yard such as Feni is installed in the middle point between Meghnaghat and Matabari, the effects of the transposition remains around 1.5%.

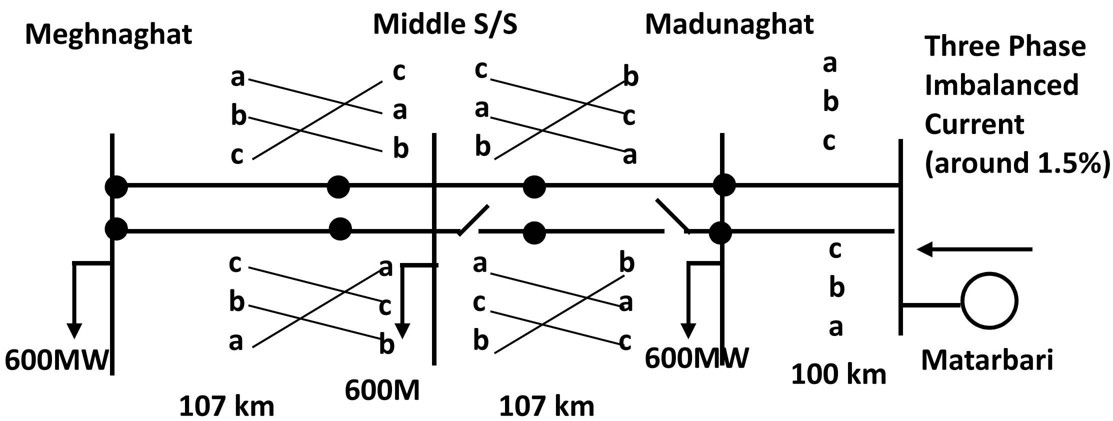


Figure 7.6-3 Case with transposition and middle point switch yard

It is recommended that the 400 kV transmission line between Meghnaghat – Madunaghat should have its two transposition towers.

7.7 Future System Configuration

The conductor used for the 400 kV transmission lines of this Project is Low Loss conductor equivalent to the four bundles of Finch and its current carrying capacity would be more than 2,000 MW. On the other hand, 2,000 MW can not be put on the interval of 400 kV lines with a distance of more than 100km due to the restriction by the power angle stability of the generators. Thus, the allowable amount of power flow on the long 400 kV transmission line is determined by the power angle stability of the connected generators to the system. In this section, the power system stability is analyzed for the severe cases and the required reinforcement of the power system between Dhaka and Chittagong is estimated in line with the power development scenarios. The power flow from Chittagong to Dhaka would be large during the off peak demand period of time and this causes a severe case from the viewpoint of system stability. In this section, all the cases were analyzed for the off-peak demand period of time in 2021 or 2025.

7.7.1 In the case of a 400 kV double circuit line between Dhaka and Chittagong (This Project's Scope)

The power flow in the case of two units of 600 MW of Matarbari and a unit of 700 MW of Singapore Power Plant during the off peak demand period of time in 2021 was calculated as shown in the following figure. Its stability was analyzed for the system during the off peak demand period of time and the system was found to be stable when a three phase short circuit fault occurs between Meghnaghat and Madunaghat. Full power outputs from two units of 600 MW of Matarbari and a unit of 700 MW of Singapore Power Plant can be sent by this system to Dhaka and Chittagong.

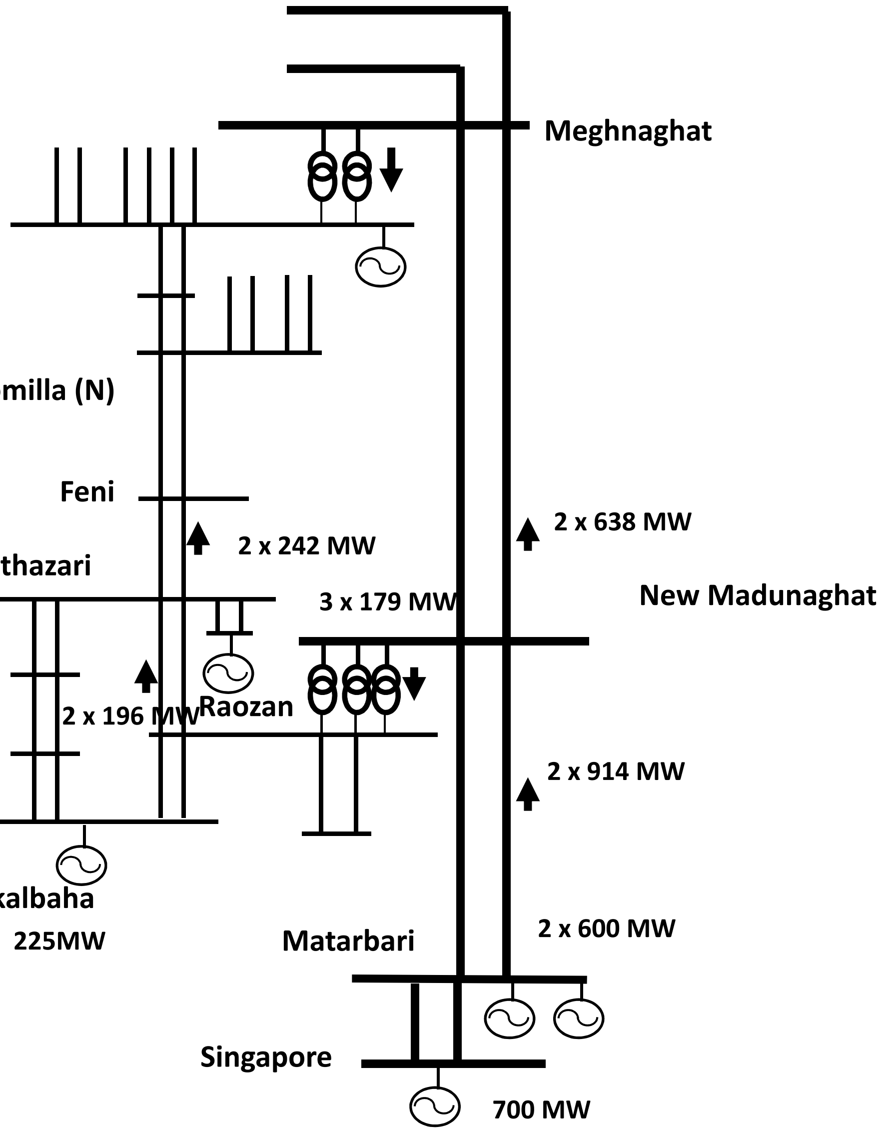


Figure 7.7-1 In the case of 400 kV double circuits between Meghnaghat and Madunaghat

7.7.2 In the case of a 400 kV double circuit line between Dhaka and Chittagong with more power units

The power flow in the case of two units of 600 MW of Matarbari, a unit of 700 MW of Singapore Power Plant and two units of 660 MW of Moheskhali during the off peak demand period of time in 2025 was calculated as shown in the following figure. New Feni substation was assumed at the middle point of the transmission line between Meghnaghat and Madunaghat to improve the system stability and additional 230 kV double circuits were assumed between Hathazari and Comilla with around 150 km to avoid an overloaded situation in this interval. Its stability was analyzed for the system during the off peak demand period of time and the system was found to be stable when a three phase short circuit fault occurs between Meghnaghat and Madunaghat. Full power outputs from two units of 600 MW of Matarbari, a unit of 700 MW of Singapore Power Plant and two units of 660 MW of Moheskhali can be sent by this system to Dhaka and Chittagong.

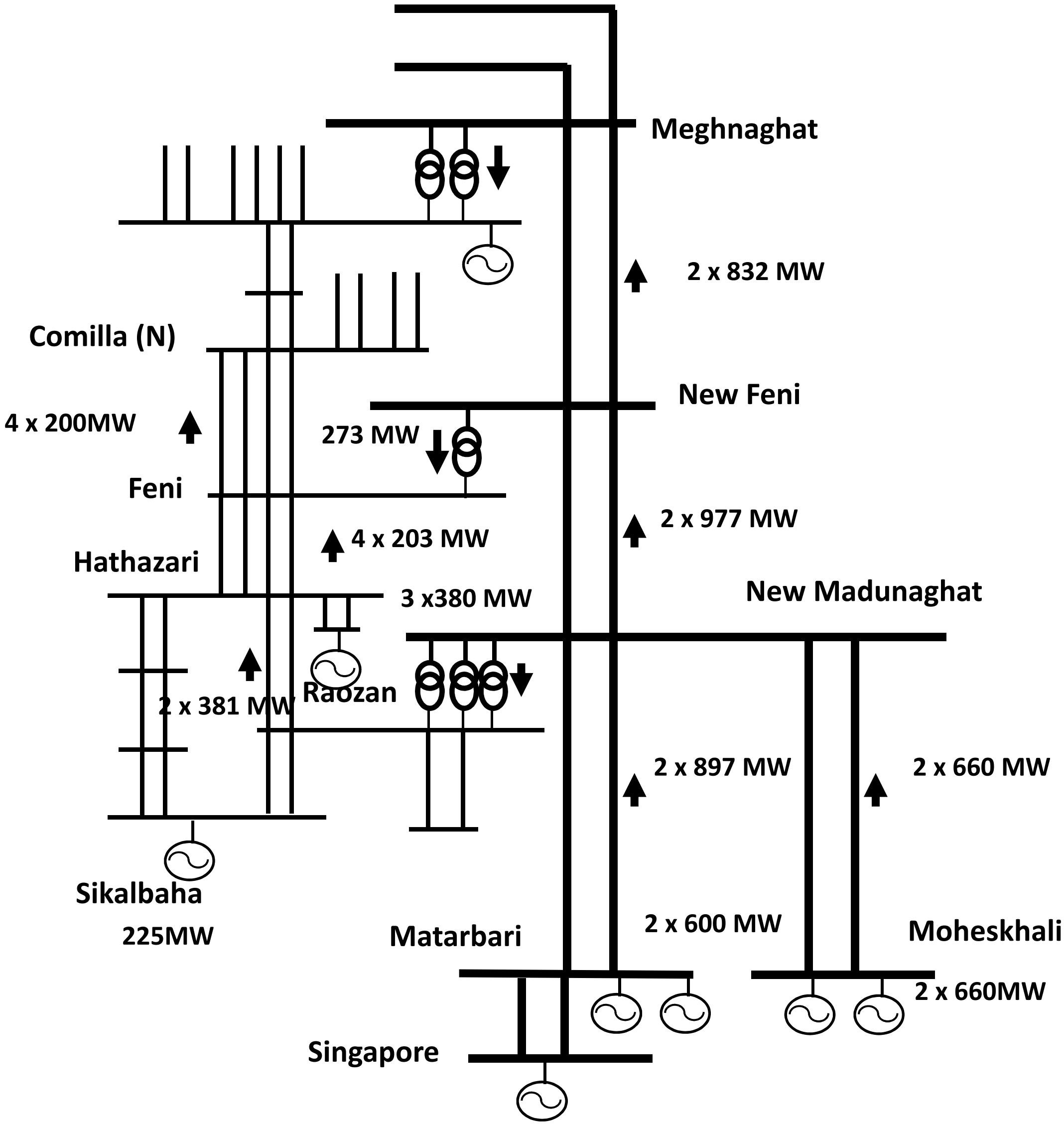


Figure 7.7-2 In the case of 400 kV double circuits between Meghnaghat and Madunaghat with additional 230 kV double circuits between Hathazari and Sikalbaha and a 400 kV New Feni Substation

7.7.3 In the case of a 400 kV four circuits between Dhaka and Chittagong

The power flow in the case of two units of 600 MW of Matarbari, a unit of 700 MW of Singapore Power Plant, a unit of 1,000 MW of Anowara and three units of 660 MW of Moheskhali during the off peak demand period of time in 2025 was calculated as shown in the following figure. Apart from the system reinforcement of additional 230 kV double circuits between Hathazari and Comilla and 400 kV New Feni Substation shown before, the 400 kV double circuit line from Comilla North to Dhaka and 400 kV New Comilla substation were also assumed. Its stability was analyzed for the system during the off peak demand period of time and the system was found to be stable when a three phase short circuit fault occurs between Meghnaghat and Madunaghat. Full power outputs from two units of 600 MW of Matarbari, a unit of 700 MW of Singapore Power Plant, a unit of 1,000 MW of Anowara and three units of 660 MW of Moheskhali can be sent by this system to Dhaka and Chittagong.

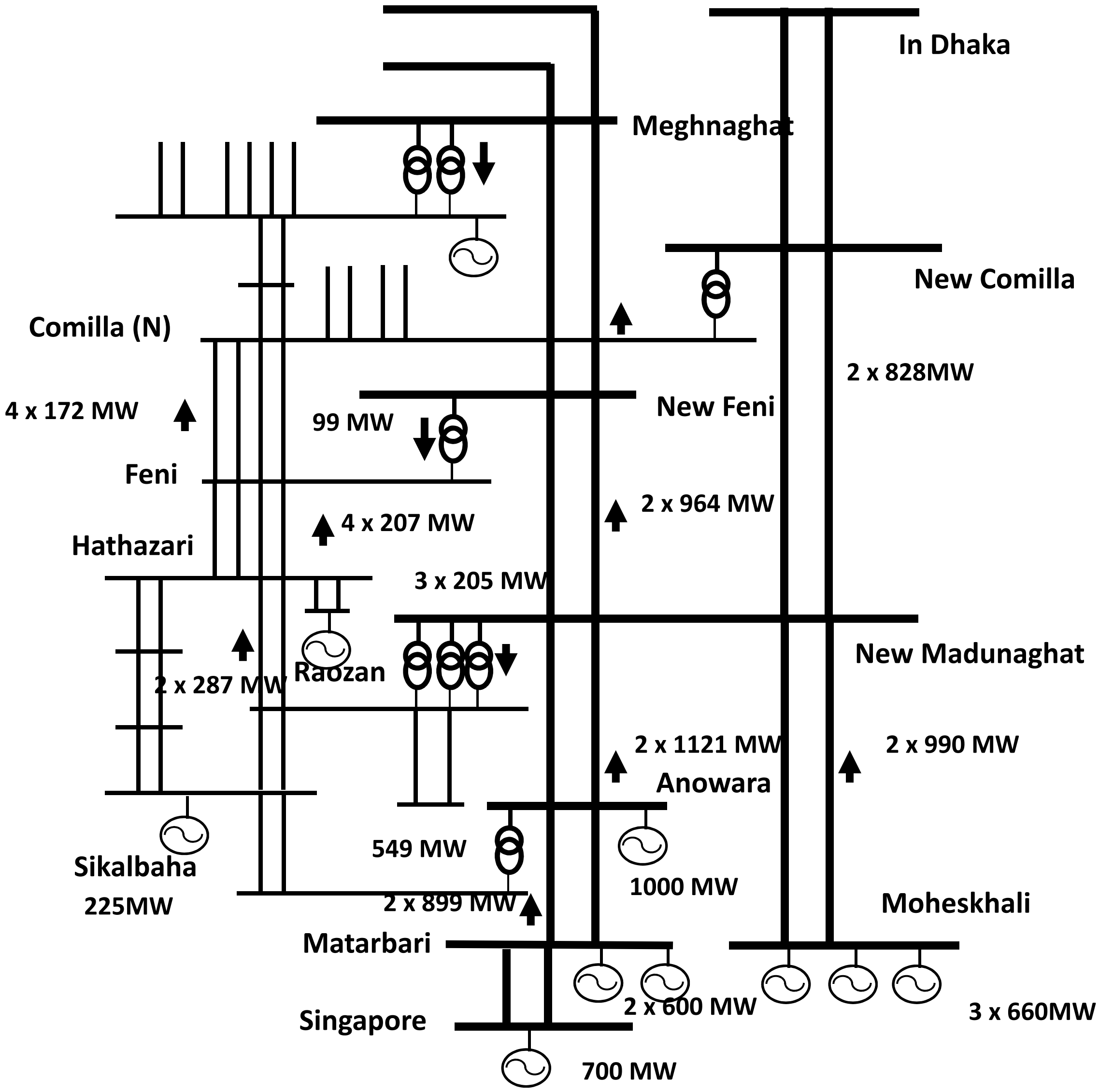


Figure 7.7-3 In the case of 400 kV four circuits between Dhaka and Chittagong

7.7.4 In the case of 765 kV double circuits between Dhaka and Chittagong

The 765 kV double circuits were assumed instead of 400 kV four circuits between Dhaka and Chittagong as show in the following figure. The power flow in the case of two units of 600 MW of Matarbari, a unit of 700 MW of Singapore Power Plant, a unit of 1,000 MW of Anowara and two units of 660 MW of Moheskhali during the off peak demand period of time in 2025 was calculated and the system was found to be stable when a three phase short circuit fault occurs between Meghnaghat and Madunaghat. Full power outputs from two units of 600 MW of Matarbari, a unit of 700 MW of Singapore Power Plant, a unit of 1,000 MW of Anowara and two units of 660 MW of Moheskhali can be sent by this system to Dhaka and Chittagong.

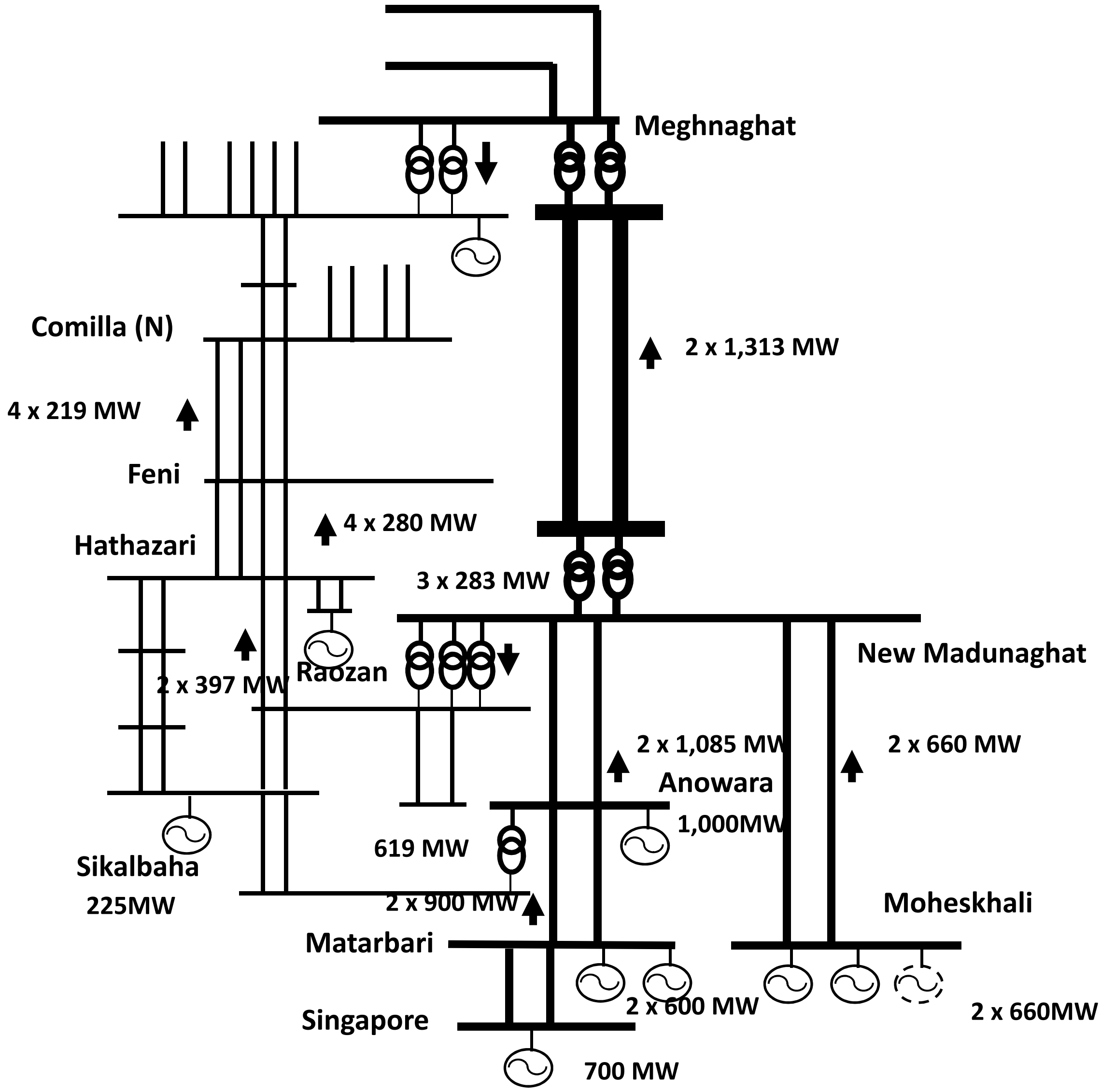


Figure 7.7-4 In the case of 765 kV double circuits between Meghnaghat and Madunaghat

7.7.5 Economical Option

When the ratios of the incremental cost of the transmission lines and substations to the incremental capable power outputs from the additional generators are compared among the options, the system composed of 400 kV double circuit tower lines is found to be the most economical option in comparison with the system composed of 400 kV four circuit tower lines and a system composed of a 765 kV line. The 765 kV transmission line costs a great deal due to its too short length from the economical point of view, requiring 765 kV substations both at Dhaka and Chittagong. The system with a 400 kV double circuit tower line between Dhaka and Chittagong would have enough capacity until the near future for three power generation units of 600 to 700 MW and still enough for five generation units of 600 to 1,000 MW by adding the installation of a middle point substation and the reinforcement of the 230 kV system in Chittagong.

Thus, the following steps for system reinforcement between Dhaka and Chittagong would be recommended for the power transmission from the large power plants installed in the south of Chittagong.

1. 400 kV double circuit line between Dhaka and Chittagong (This Project’s Scope)
2. The additional 230 kV double circuit line between Hathazari and Comilla and the installation of 400 kV New Feni Substation
3. The additional 400 kV double circuit line from Comilla North to Dhaka and the 400 kV New Comilla substation

7.8 Case of 400 kV designed Madunaghat – Meghnaghat transmission line operated at 230 kV

The power flow in the case of 400 kV designed Madunaghat - Meghnaghat transmission line operated at 230 kV is shown in the figure below. The figure illustrates the severest operating conditions in 2020 without Anwara power plant of 1,000 MW before operating the system at 400 kV, however, the power flow analysis confirmed that 230 kV system could supply enough power to Chittagong if a N-1 contingency is considered.

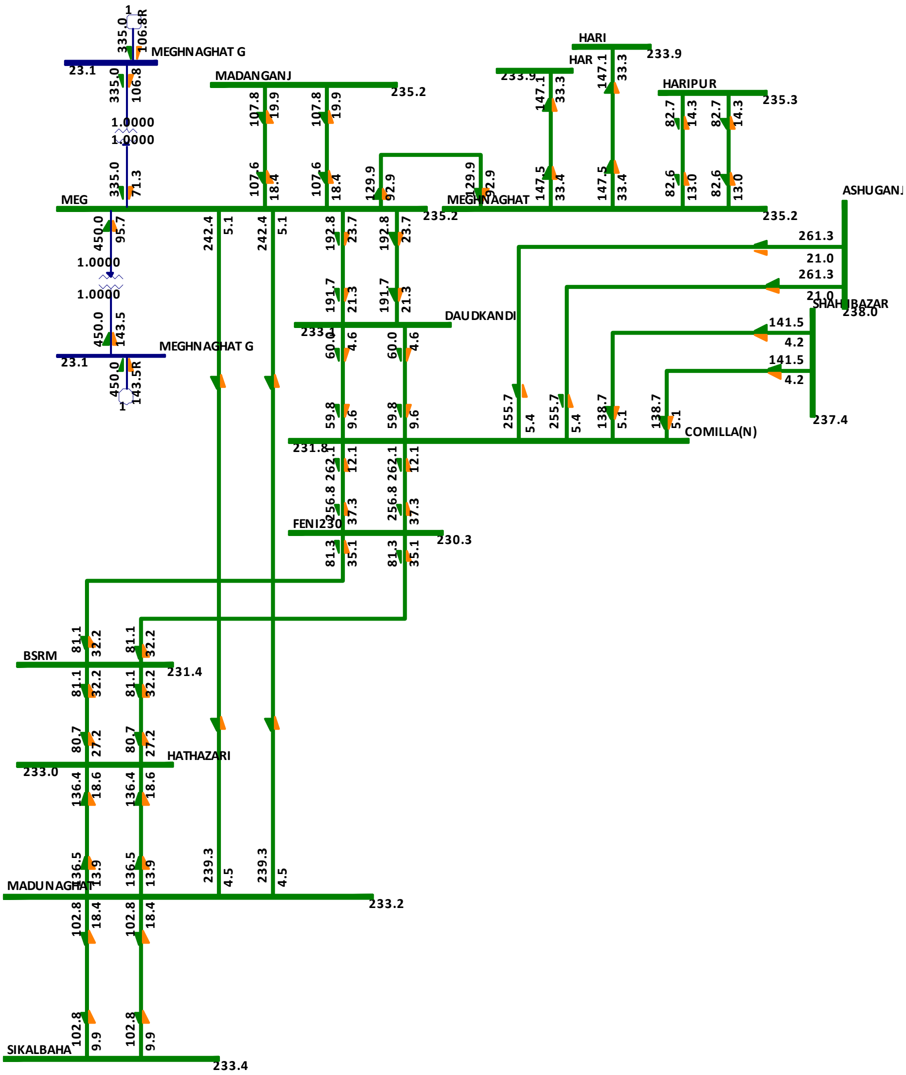


Figure 7.8-1 The power flow in the case of 400 kV designed Madunaghat - Meghnaghat transmission line operated at 230 kV

7.9 Recommended Power System Configuration

The scope of the Project was proposed as mentioned in Chapter 1. The following are recommended from the results of the power system analysis.

- It is reasonable to construct the future system by installing double circuit 400 kV lines.

- The transmission line between Dhaka and Chittagong will be urgently operated before 2021. Otherwise, quick rental power plants should be installed in the Chittagong area.

- Conductor for 400 kV lines between Meghnaghat, Madunaghat and Matarbari
LL-ACSR 560 mm^2 x 4 bundles whose resistance and tension strength are equivalent to those of ACSR Finch x 4 bundles.

- Conductor for 230kV Old Madunaghat
The same size as 230kV Hathazari-Sikalbaha should be applied.

- Impedance of 400 kV transformers
12.5 %

- Number and unit capacity of 400 kV transformers
Meghnaghat 750 MVA x2
Madunaghat 750 MVA x3

- Line Charge Compensating Shunt Reactors for Meghnaghat – Madunaghat
Meghnaghat: 80 MW x 2
Madunaghat: 80 MW x 2

-Line Charge Compensating Shunt Reactors for Matarbari – Madunaghat
Madunaghat: 80 MW x 2

- Fault Breaking Capacity of Circuit Breakers
Meghnaghat 400 kV: 40kA
Madunaghat 400 kV and 230 kV, Meghnaghat 230 kV: 50kA

- The 400 kV transmission line between Meghnaghat – Madunaghat should have its two transposition towers.

Chapter 8
Preliminary Transmission Line Design for the Project

Chapter 8 Preliminary Transmission Line Design for the Project

8.1 Target Transmission Lines of the Study

The basic design for the transmission lines listed below is implemented in the Survey.

	Voltage	Section
1	400 kV	Meghnaghat SS - Madunaghat SS - (Anowara PP) - Matarbari CFPP
2	230 kV	Madunaghat SS - Old Madunaghat SS
3	230 kV	LILO at Madunaghat SS from Hathazari - Sikalbaha T/L

8.2 Route Selection

8.2.1 Route Survey

Through the field survey, some typical points such as river crossings, hilly areas and so on were checked from the viewpoints of facility design, and social and environmental considerations.

It seems that no critical obstacle exists along the expected transmission line route but there are crossing points of wide rivers, national roads and the existing transmission lines.

(Source: Google Earth)

Figure 8.2-1 Surveyed Points

The current conditions of the surveyed points are shown below.

Planned 400 kV Meghnaghat SS site

Existing 230 kV Meghnaghat SS

230 kV Meghnaghat – Aminbazar T/L (400 kV designed)

River Crossing near the Meghnaghat SS (image)

Around Anowara PP Bypass Route

Existing 230 kV T/L Towers (left) River Crossing Tower, (right) Anchor Tower

Planned 400 kV Madunaghat SS site (site 2)

Existing 132 kV Transmission Line

Hilly Area (near Feni)

Existing 132 kV Madunaghat SS

Figure 8.2-2 Photos of the Field Survey Points

8.2.2 Outline of the 400 kV Transmission Line Route

The target 400 kV transmission line is composed of the section between Meghnaghat SS and Anowara PP, which was surveyed in the WB's F/S in 2013, and the section between Anowara PP and Matarbari CFPP studied in the "JICA Preparatory Survey on Chittagong Area Coal Fired Power Plant Development Project in Bangladesh". At this moment, the Anowara PP project is uncertain; therefore, the Anowara PP is bypassed to connect Madunaghat SS and Matarbari CFPP directly.

The 400 kV Matarbari – Meghnaghat T/L route drafted is shown below and it will be optimized through consultation with PGCB and the field survey conducted by the local consultant and then finalized.

(Source: Google Earth)

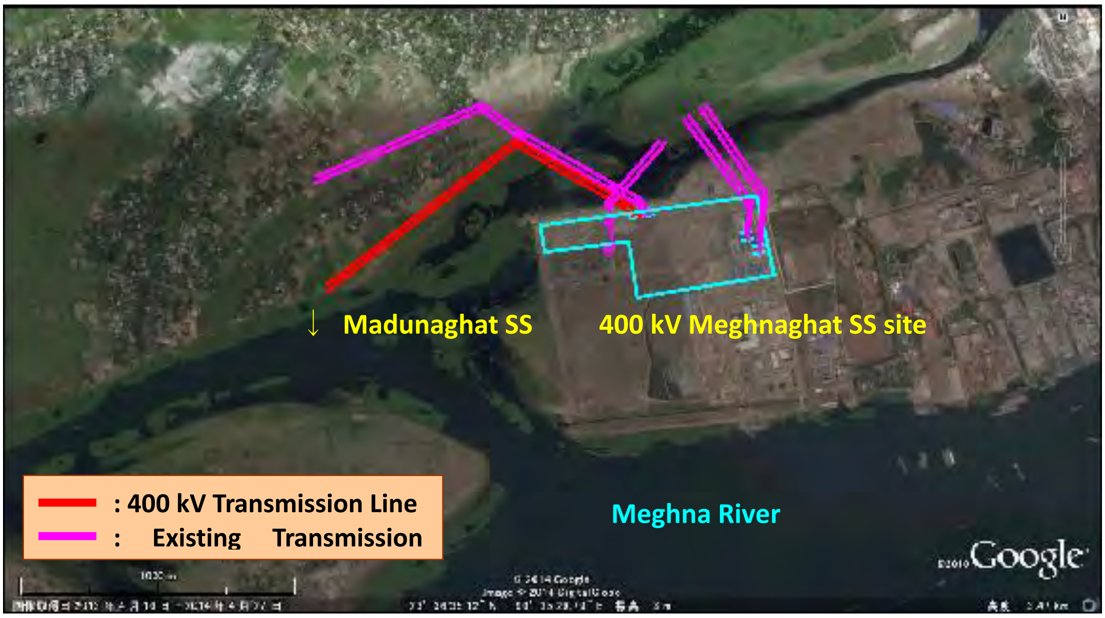
Figure 8.2-3 400 kV Transmission Line Route

The estimated total 400 kV transmission line route length is approximately 310 km.

The topographical characteristic of the route is generally flat terrain and there is a hilly area near Feni.

The outline of the whole route is as follows;

(a) The 400 kV Meghnaghat SS is planned to be located next to the existing 230/132 kV Meghnaghat SS which is at the north side of the Meghna River; the transmission line comes out from the north side of the Meghnaghat SS as shown in Figure 8.2-4.



(Source: Google Earth)

Figure 8.2-4 400 kV Transmission Line Paths around Meghnaghat SS

(b) The route crosses over the Meghna River, whose width is approx. 1 km, and then runs toward southeast passing the Gomti River, whose width is approx. 0.6 km, several extra high voltage transmission lines and railways on the way to the 400 kV Madunaghat SS.

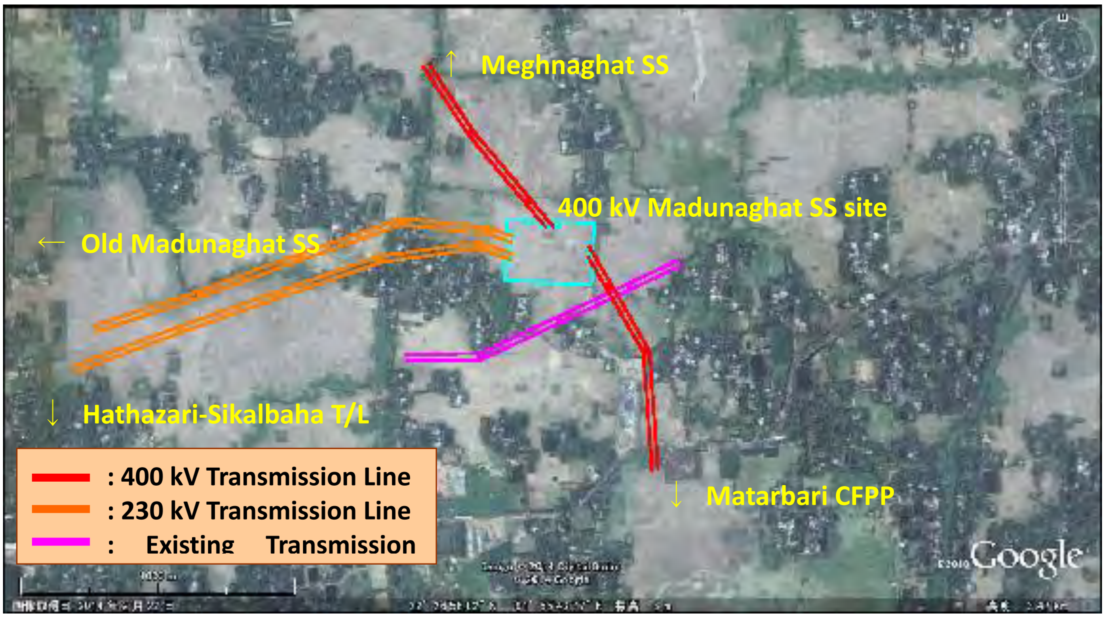
(Source: Google Earth)

Figure 8.2-5 Meghna River Crossing Point

(c) The topographical features of the passing through area are flat terrain and hills, and their land utilization is paddy/cultivated fields, residential zones and forests.

(d) The route was selected avoiding residential areas as much as possible but approximations of several towers to nearby residences were unavoidable.

(e) The transmission line enters the Madunaghat SS from the north side and then comes out from the east side of the Madunaghat SS as shown in Figure 8.2-6 and runs toward the south.



(Source: Google Earth)

Figure 8.2-6 400 kV & 230 kV Transmission Line Paths around Madunaghat SS

(f) The route passes over several extra high voltage transmission lines and a railway between Madunaghat SS and Matarbari CFPP and also crosses over the meandering part of the Sangu River.

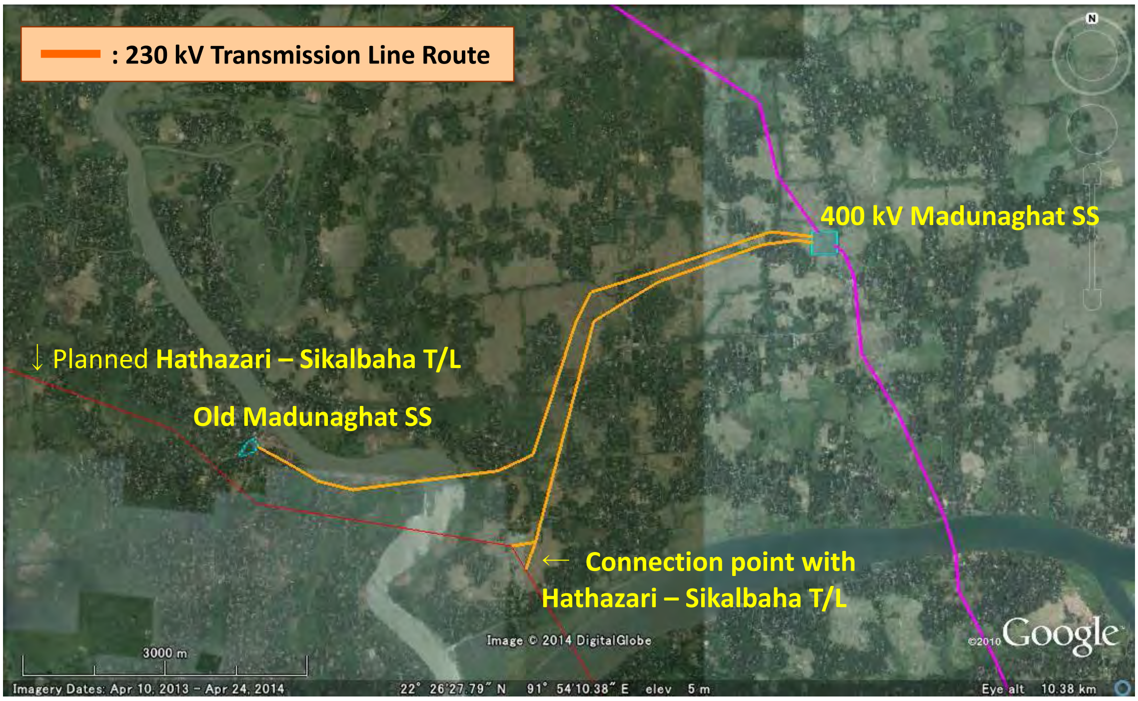
(Source: Google Earth)

Figure 8.2-7 Sangu River Crossing Point

(g) After that, the route runs south in parallel with the road "R170" and the coast.
(h) From the southeast side of the Anowara PP site, the selected route is almost same as the proposed route in the "JICA Preparatory Survey on Chittagong Area Coal Fired Power Plant Development Project in Bangladesh".

8.2.3 Outline of the 230 kV Transmission Line Route

The selected 230 kV Madunaghat – Old Madunaghat T/L and LILO at Madunaghat SS from Hathazari – Sikalbaha T/L routes are shown below.



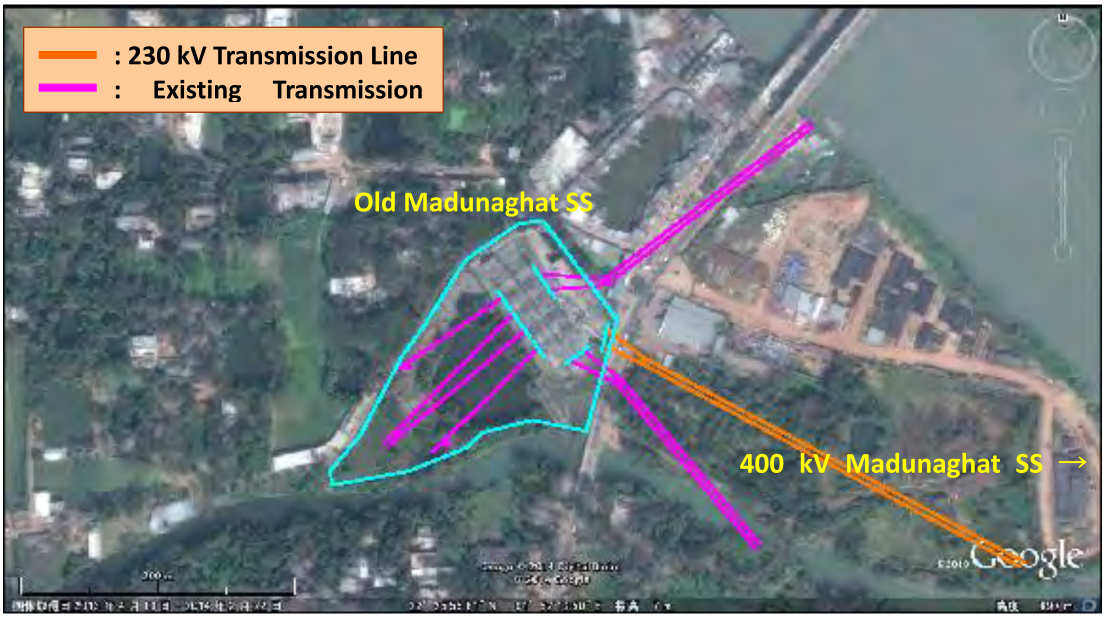
(Source: Google Earth)

Figure 8.2-8 230 kV Transmission Line Routes

And the estimated lengths of the 230 kV transmission line routes are as below.

Madunaghat SS – Old Madunaghat SS:	approx. 8 km
LILO at Madunaghat SS from Hathazari – Sikalbaha T/L:	approx. 5 km

The topographical characteristics of the routes are generally flat terrain. The 230 kV Madunaghat – Old Madunaghat T/L will cross over an existing 132 kV transmission line. The assumed incoming path to the Old Madunaghat SS is shown in Figure 8.2-9.



(Source: Google Earth)

Figure 8.2-9 230 kV Transmission Line Path around Old Madunaghat SS

8.3 Geological Features

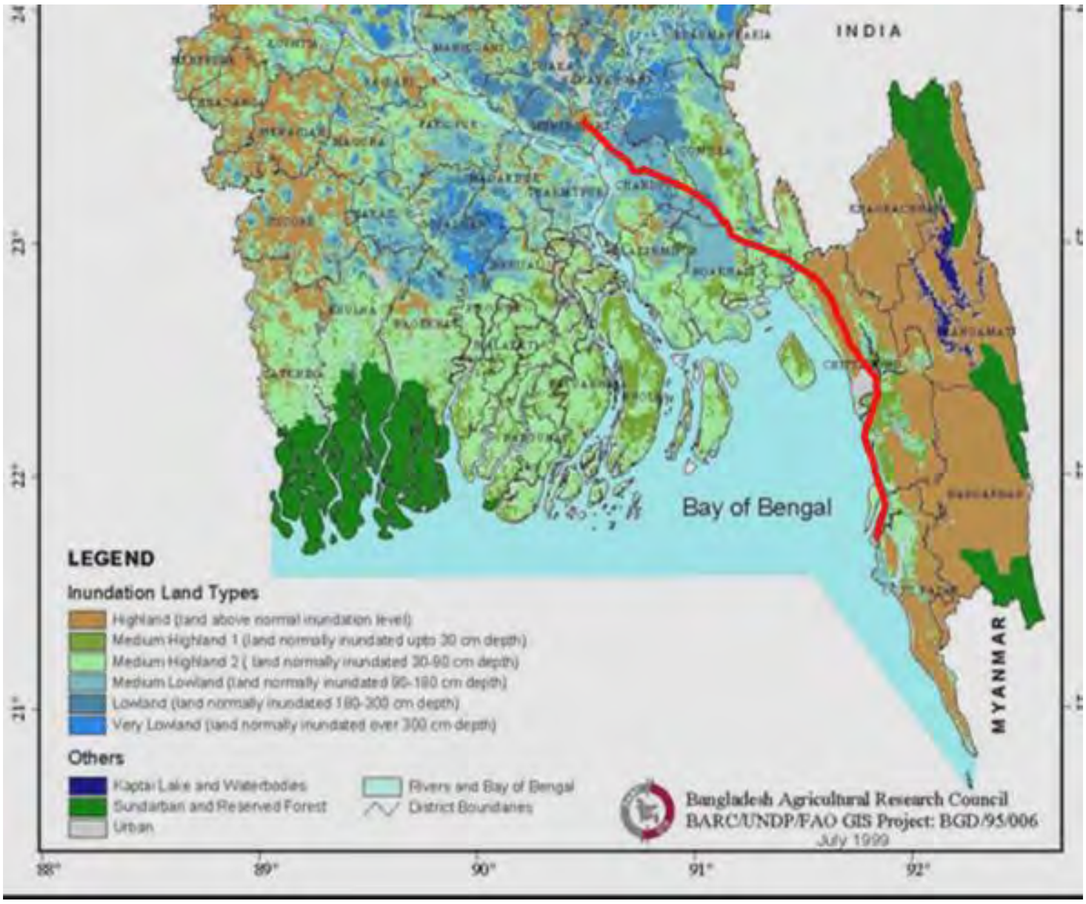
The 400 kV transmission line route between Madunaghat SS and Matarbari CFPP is drawn on the "inundation land type" map shown in Figure 8.3-1 below.

The route may be roughly categorized into the following three groups:

1) Northern lowland part which is colored light blue,

2) Middle part in highland and highland part in pale green and light brown, and

3) Southernmost coastal plain



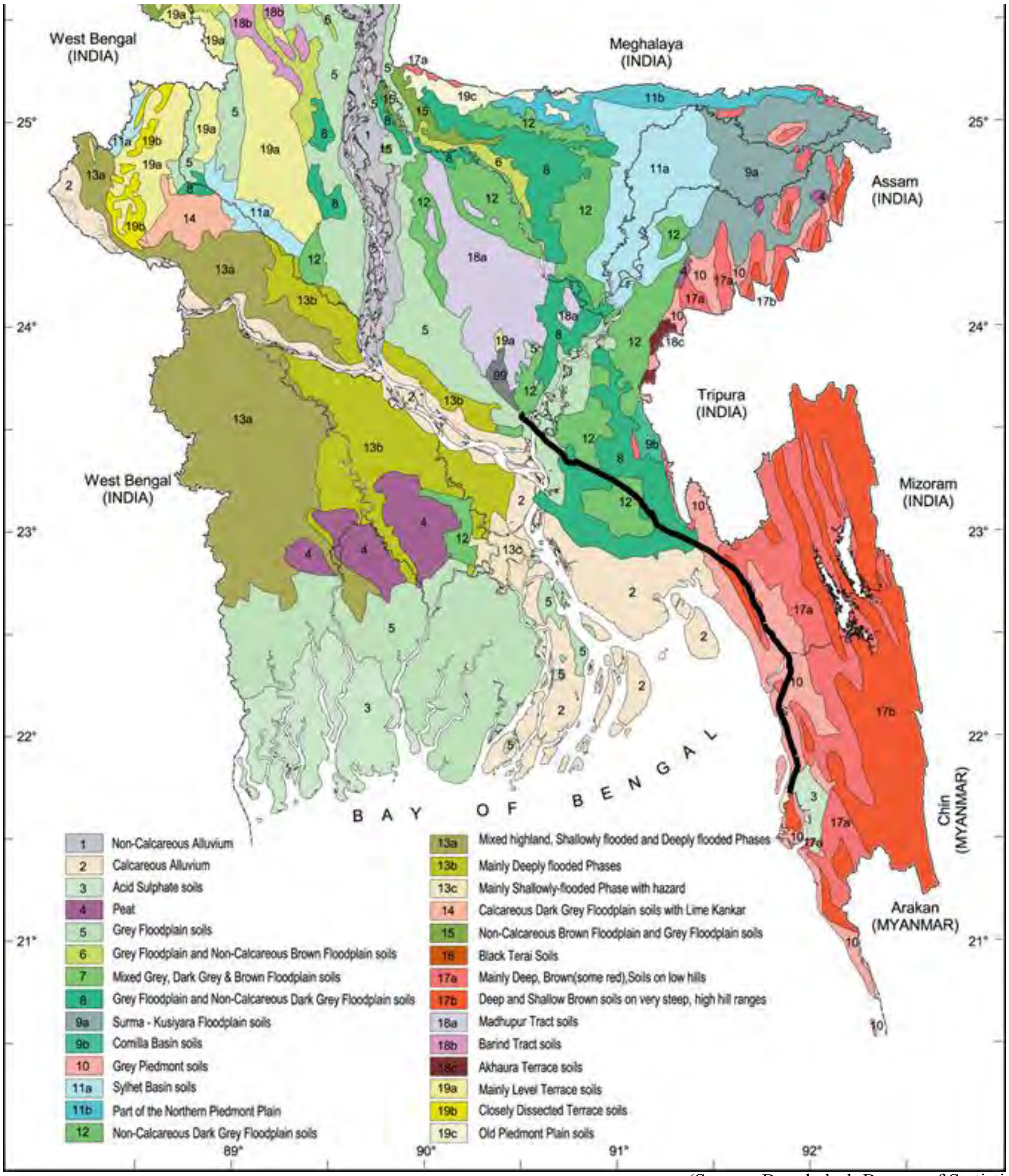
(Source: Bangladesh Agricultural Research Council (1999))

Figure 8.3-1 Inundation land type of Bangladesh and the 400 kV T/L route

Soil distributed along the route is shown in Figure 8.3-2. The above three groups in the inundation lands are roughly summarized as below;

1) The Northern lowland part has "Grey Floodplain - Grey Floodplain and Non-Calcareous dark Grey Floodplain soils", and

2) Middle part in highland and medium highland and 3) Southernmost coastal plain, are in "Grey Piedmont soils, Mainly Deep, Brown (some red) soils on low hills, and "Deep and shallow Brown soils on very steep, high hill ranges" in some parts of 2) area.



(Source: Bangladesh Bureau of Statistics (2011))

Figure 8.3-2 the 400 kV T/L route on the General Soil Map

Boring along the 400 kV Meghnaghat – Matarbari T/L route was implemented at 13 points shown in Figure 8.3-3, from Dhaka (left) to Matarbari (right). The profile is lined by the consecutive plots of every boring point read from the GOOGLE EARTH image.

Blue arrowed plates show the location of actual major rivers and Lined plates show the boring points on the profile.

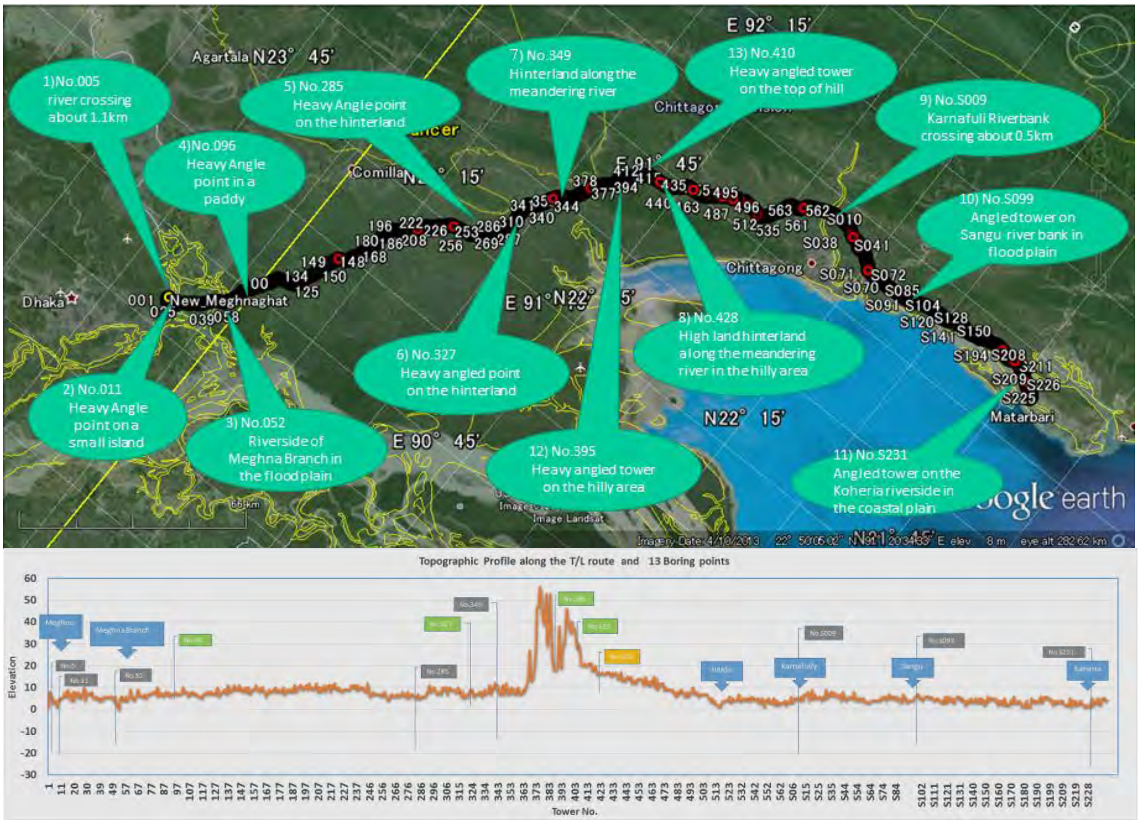


Figure 8.3-3 T/L route and proposed boring points

These boring works combined with in-situ tests were carried out at the temporary Tower Numbers in the process of being examined (refer to Figure 8.3-1). 5 locations of Tower No.285, 349, 395, 410 and 428 are different from the final Tower Number, and BH-6 strays off the course of the final route.

Actual boring depths vary from 23 m to 32 m, in which each hole was finished after 3 consecutive times of N-value≧50.

Their coordinates and the other related conditions are summarized in the table shown below.

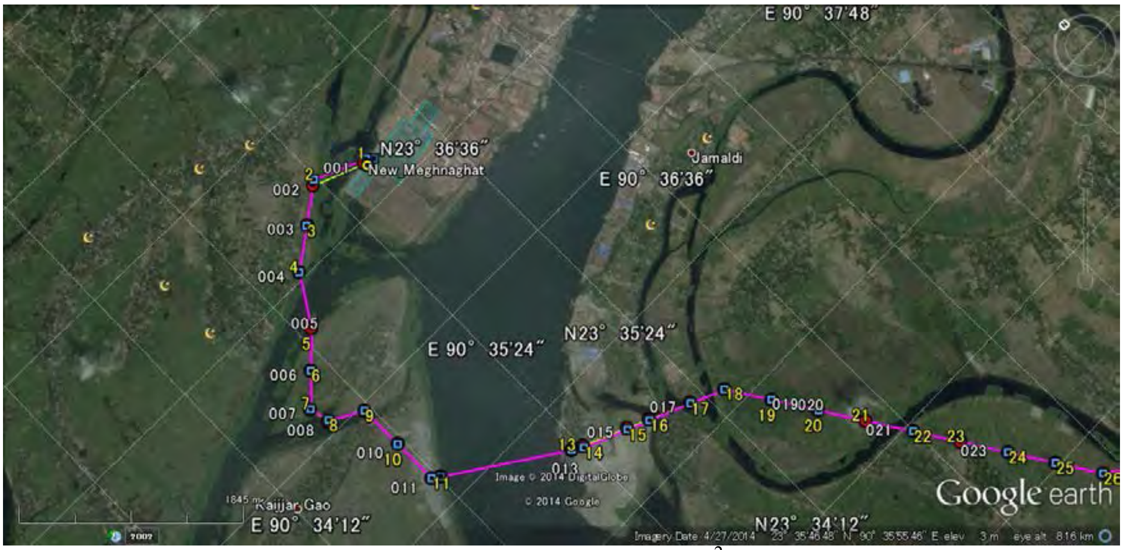
Table 8.3-1 Boring details and environment of each Tower Location

Bore-hole No	Tower No.		Boring Depth (m)	Boring Location		Environment
	Temporary	Final		Easting	Northing	
BH-1	05	05	32	90^0-34'-52.18"	23^0-36'-23.66"	char of Meghna River side
BH-2	11	11	30	90^0-34'-45.68"	23^0-35'-32.80"	Meghna River bank
BH-3	52	52	32	90^0-40'-59.76"	23^0-29'-26.93"	point bar on Meghna branch River bank
BH-4	96	96	24	90^0-49'-47.02"	23^0-25'-16.03"	old flood-plain
BH-5	285	284	31	91^0-18'-42.23"	23^0-03'-26.59"	old flood-plain on the hinterland
BH-6	327	faraway 325	30	91^0-26'-35.84"	23^0-01'-27.03"	hinterland on the hill side

BH-7	349	346	30	91^0-30'-18.89"	22^0-59'-6.43"	hinterland along the river
BH-12	395	392	27	91^0-37'-45.58"	22^0-53'-36.85"	mountain stream in the hilly area
BH-13	410	406	27	91^0-40'-19.51"	22^0-52'-13.54"	hilltop in the hilly area
BH-8	428	424	23	91^0-42'-48.74"	22^0-49'-40.53"	hinterland among hills
BH-9	S-09	S-09	30	91^0-56'-28.69"	22^0-25'-30.82"	flood-plain of Karnafuli river bank
BH-10	S-99	S-99	32	91^0-53'-17.6"	22^0-08'-18.0"	intertidal zone on the estuary of Sangu river
BH-11	S-231	S-229	32	91^0-54'-26.88"	21^0-43'-21.22"	intertidal zone in the estuary of Koheria river bank

Laboratory tests for sampled soil from each hole were also carried out, and their results were reflected for revised N-value of sandy soil. For silty fine sand, where SPT is more than 15, the SPT values are revised using the following equation: N = 15 + 0.5 (N-15)

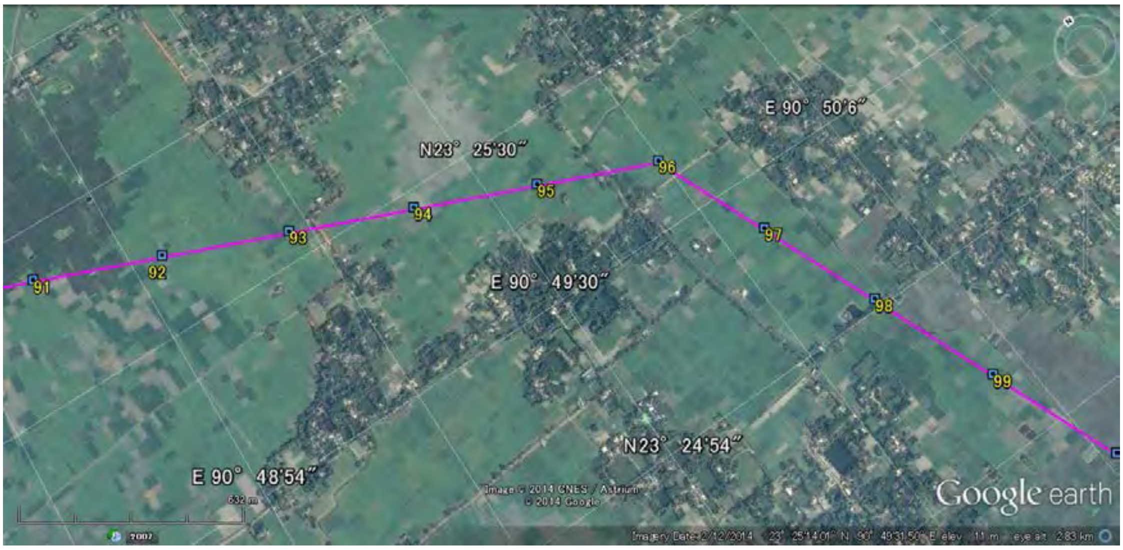
Boring points on the T/L route are in the following circumstances.



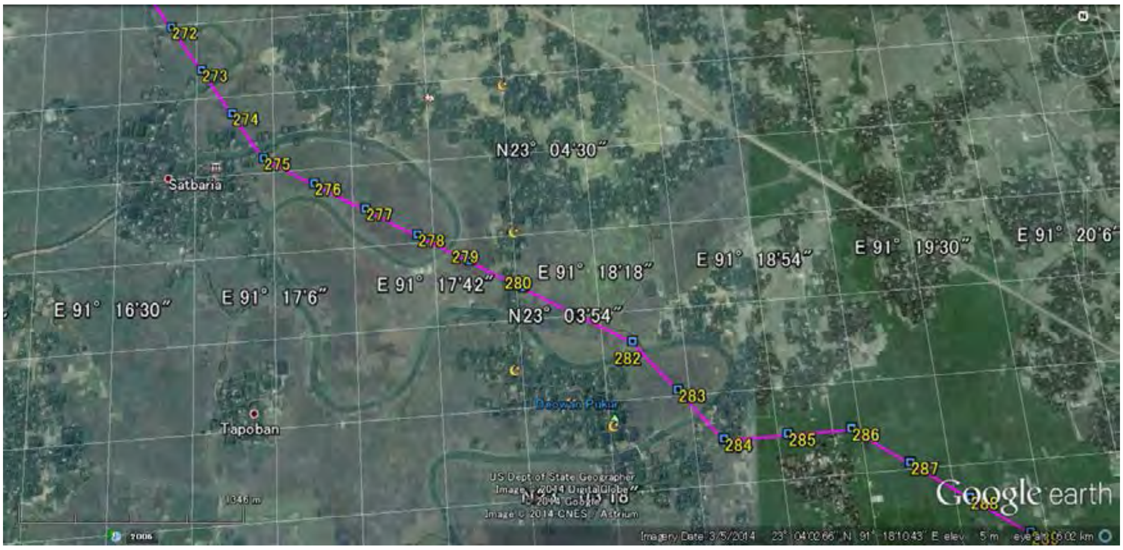
BH-No.1; at the Tower No.005, as a representative on a char[2] on Meghna river side,
BH-No.2; at the Tower No.011 (heavy angled), as a representative of riverbank of wide river on the natural levee deposit. The span between No.12 and 13 is 1.1km.
Both borings are planned to ascertain the geotechnical condition on such an alluvial plain.

[2] 'char' is applied to a newly formed alluvial tract or flood-plain island formed of silt and sand deposited in the bed of a deltaic river (Source: Glossary of Geology fourth edition by American Geological Institute)

BH-No.3; at the Tower No.052, just on a point bar in the flood-plain of Meghna River Branch. It is planned to ascertain the geotechnical characteristics of the slip off slope of the river.

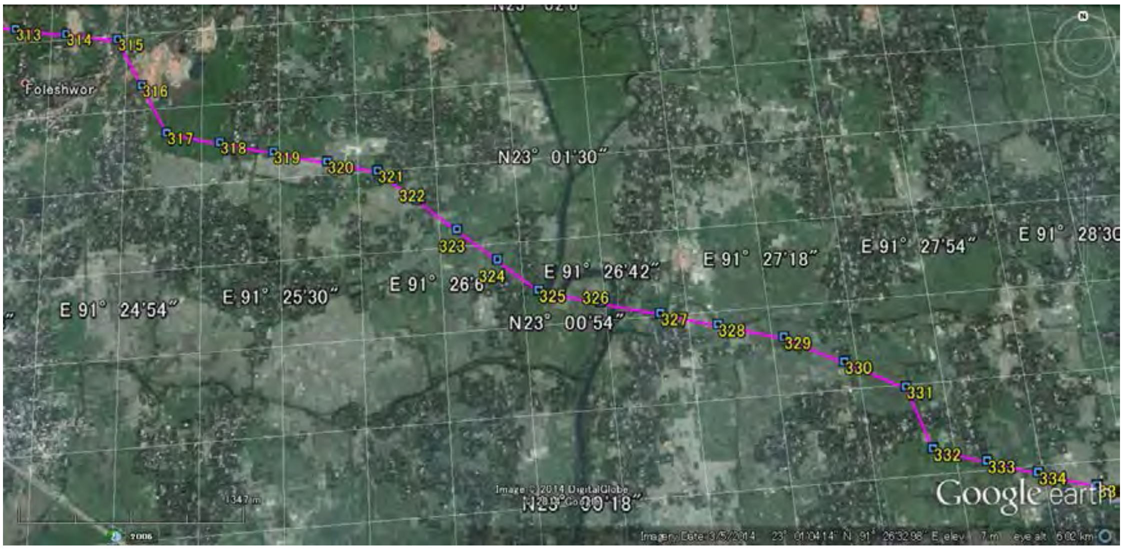


BH-No.4; at the Tower No.096 (angled), It is planned as a representative of old flood-plain.



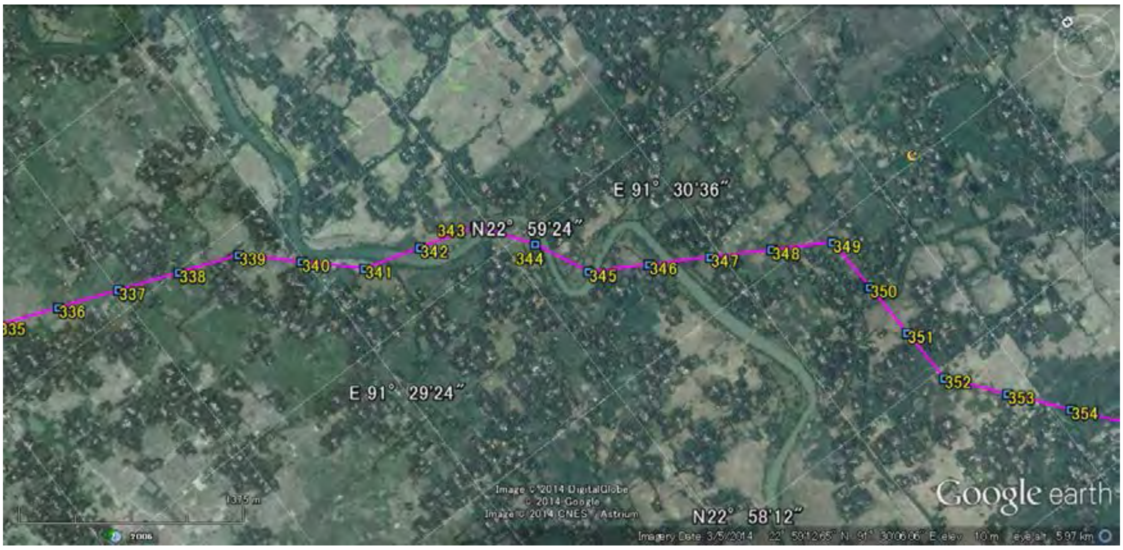
BH-No.5; at the Tower No.284 (angled).

Boring on this point is planned as a representative of old flood-plain on the hinterland along the meandering river.

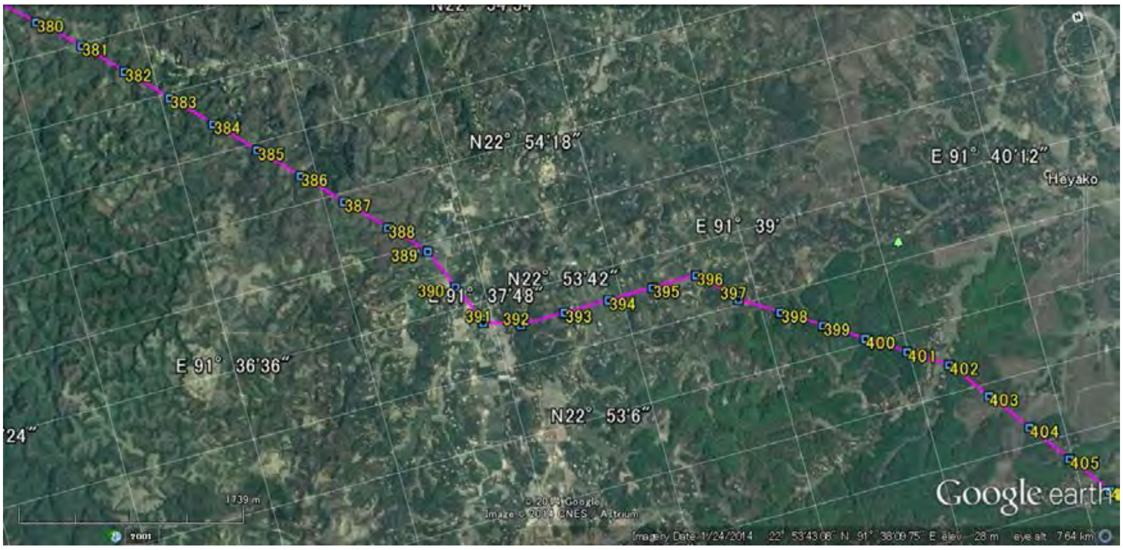


BH-No.6; at around 0.8 km north from the Tower No.32, which is just beside the creek.

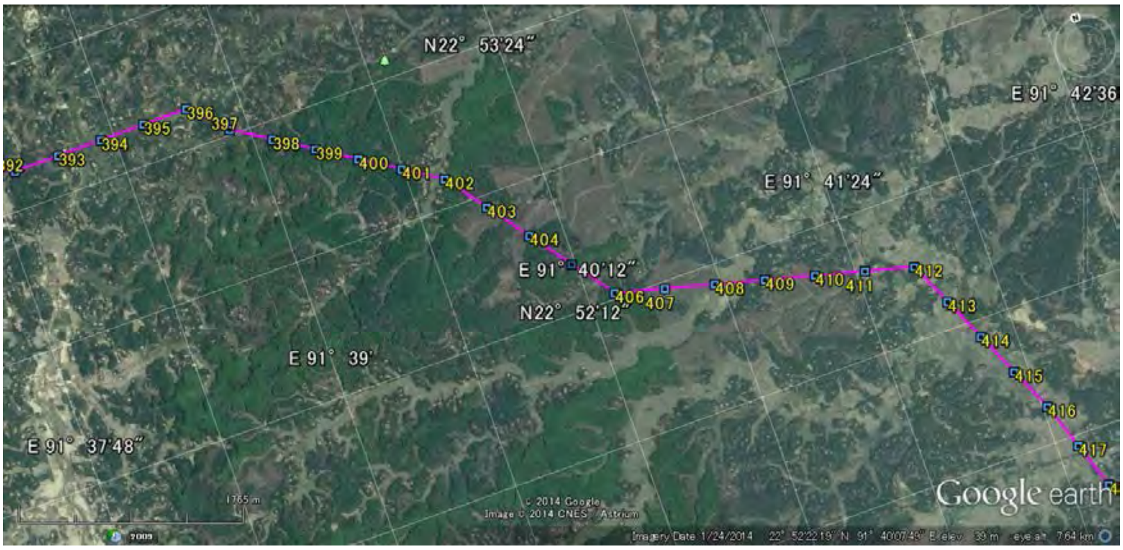
Boring in this area aims to ascertain the riverside deposit of an old flood-plain in the hinterland on the hill side.



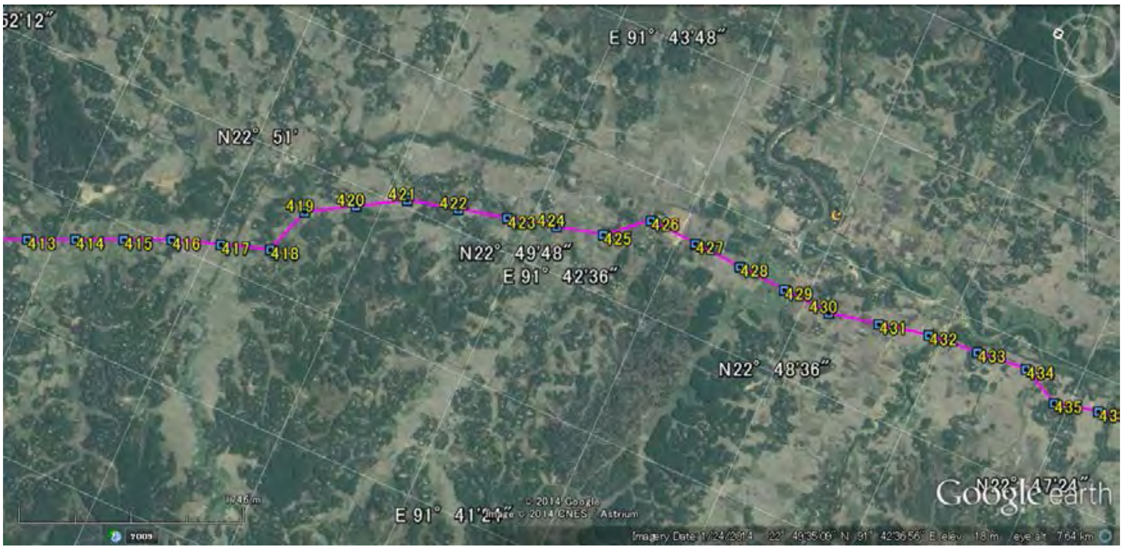
BH-No.7; at the Tower No.346, as a representative of the hinterland along the meandering river



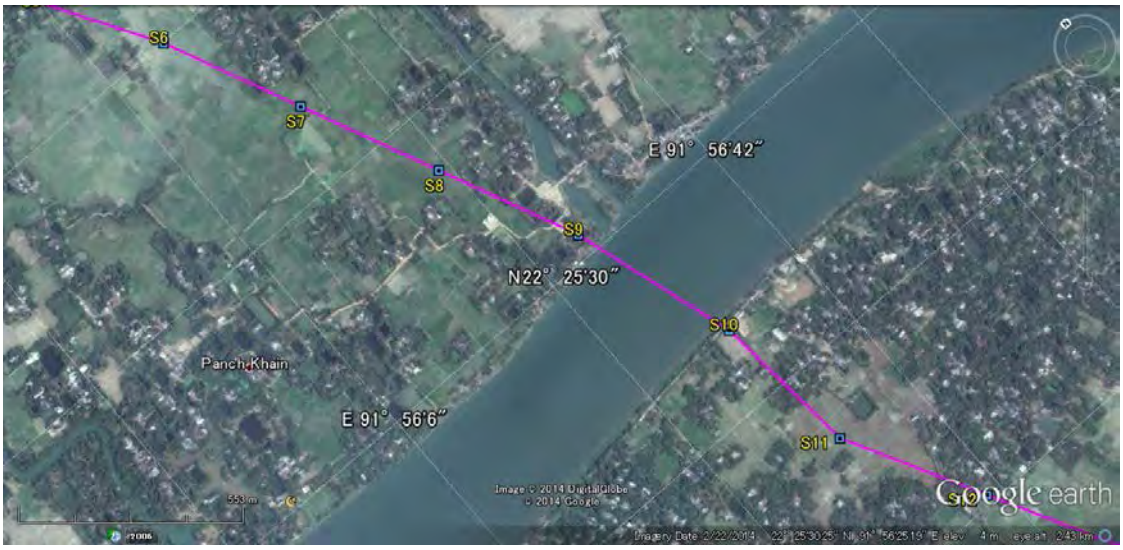
BH-No.12; at the Tower No.392 (heavy angled), as a representative of the mountain stream side in the hilly area.



BH-No.13; at the Tower No.406 (heavy angled), planned on the top of a hill as a representative of the hilly area.



BH-No.8; at the Tower No.424, planned as a representative along the meandering stream in the hinterland among hills.



BH-No.9; at the Tower No.S-09, planned to ascertain the geotechnical condition of topographically unique point on the undercut slope on the flood-plain of Karnafuli river bank.

BH-No.10; at the Tower No.S-99, is planned as a representative of the Intertidal zone on the estuary of Sangu river on the coastal plain.

BH-No.11; at the Tower No.S-229 (angled), planned on the Intertidal zone in the estuary of Koheria river as a representative of the southernmost coastal plain area.

Consecutive N-value profile on each boring point is one of the most important hints. Figure 8.3-4 **s**hows the representative SPT profile on each topographic circumstance. Foundation type of the tower is examined from its trend.

The depth of N-value more than 50 is 20 to 30 m. Bearing layer for the Tower should be chosen based on the designed function and weight of each tower. However, in most cases except BH-8, long pile will be required for the foundation of 400 kV T/L towers.

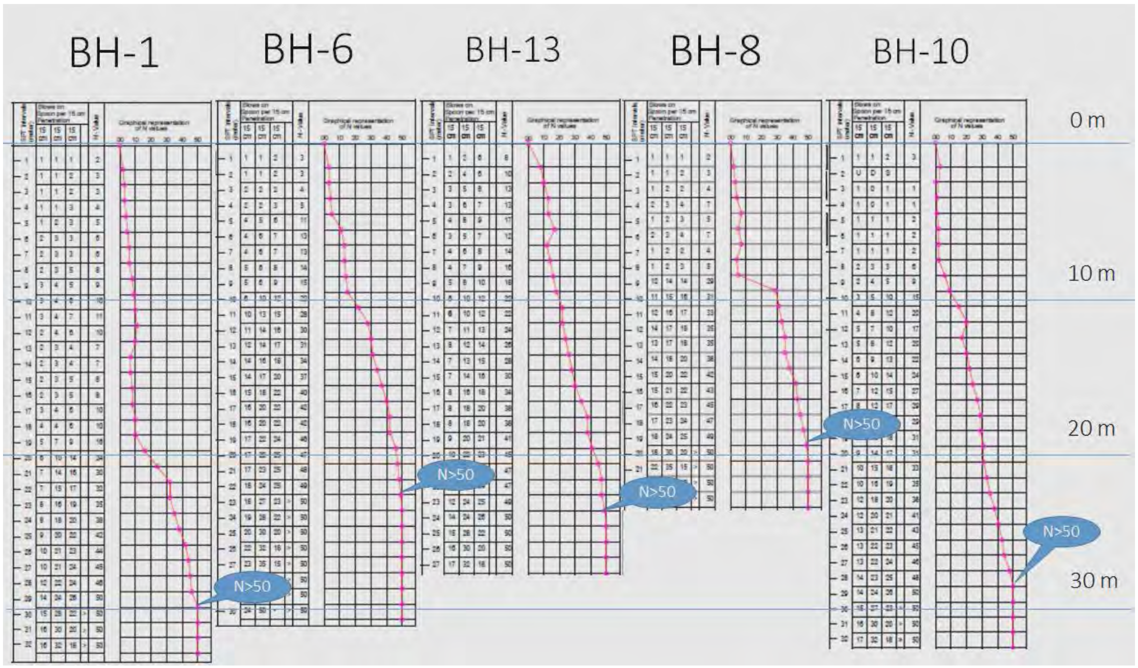
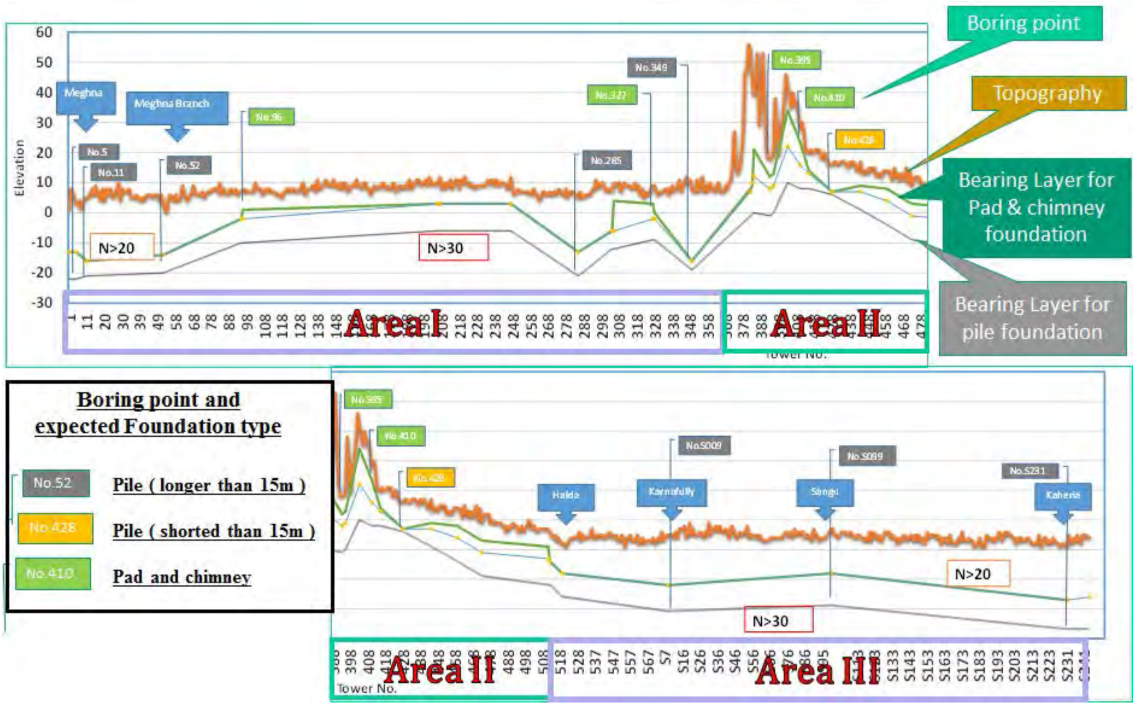


Figure 8.3-4 Representative SPT profiles along the T/L route

Table 8.3-2 shows the summary of the survey results, which are drawn in Figure 8.3-5.

Table 8.3-2 Geotechnical Investigation result (on the process of examining the T/L route)

Area	Bore-Hole No.	Tower No.	Ground Elevation (m)	Depth of Bearing Layer (-m) N >20	Depth of Bearing Layer (-m) N >30	N-value at 6m below GL	actual GWL (-m)	physiographic feature surrounding the tower / land use	Considerable foundation type
I	1	5	3	16	25	6.03	0	Meghna river bank / flood-plain / Vacant land	pile longer than 15m
	2	11	5	21	26	3.03	0.45	Meghna river bank / Proposed Power Plant site	pile longer than 15m
	3	52	3	17	23	4.00	0.3	Meghna branch river bank / Crop land	pile longer than 15m
	4	96	7	9	17	13.15	0.47	old flood-plain /Crop land	pile longer than 15m
	5	285	5	18	26	5.89	0.31	hinterland along the meandering river Bank of Canal /Crop land	pile longer than 15m
	6	327	9	11	18	12.99	0	hinterland on the hill side / Crop land	Pad & Chimney or shorter pile
	7	349	8	24	27	5.99	0	hinterland along the river / Crop land	pile longer than 15m
II	12	395	19	10	19	15.49	0	stream in the hilly area	pile shorter than 15m
	13	410	28	12	20	12.0	4.5	hilltop in the hilly area	pile shorter than 15m
	8	428	16	9	10	6.97	0	hinterland among hills / Crop land	pile shorter than 15m
III	9	S9	5	17	26	2.00	0	Bank of Karnafuli River / Vacant land	pile longer than 15m
	10	S99	7	15	26	1.98	0.3	Intertidal zone on the estuary of Sangu river / Char	pile longer than 15m
	11	S231	1	18	28	2.97	0	Intertidal zone in the estuary of Koheria river bank / Crop land	pile longer than 15m



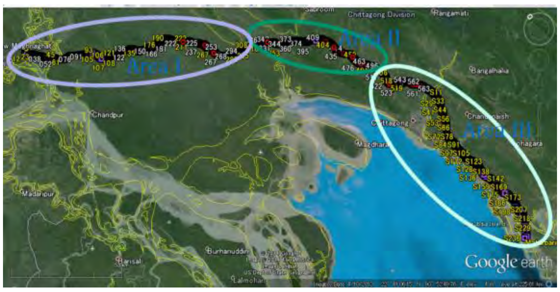
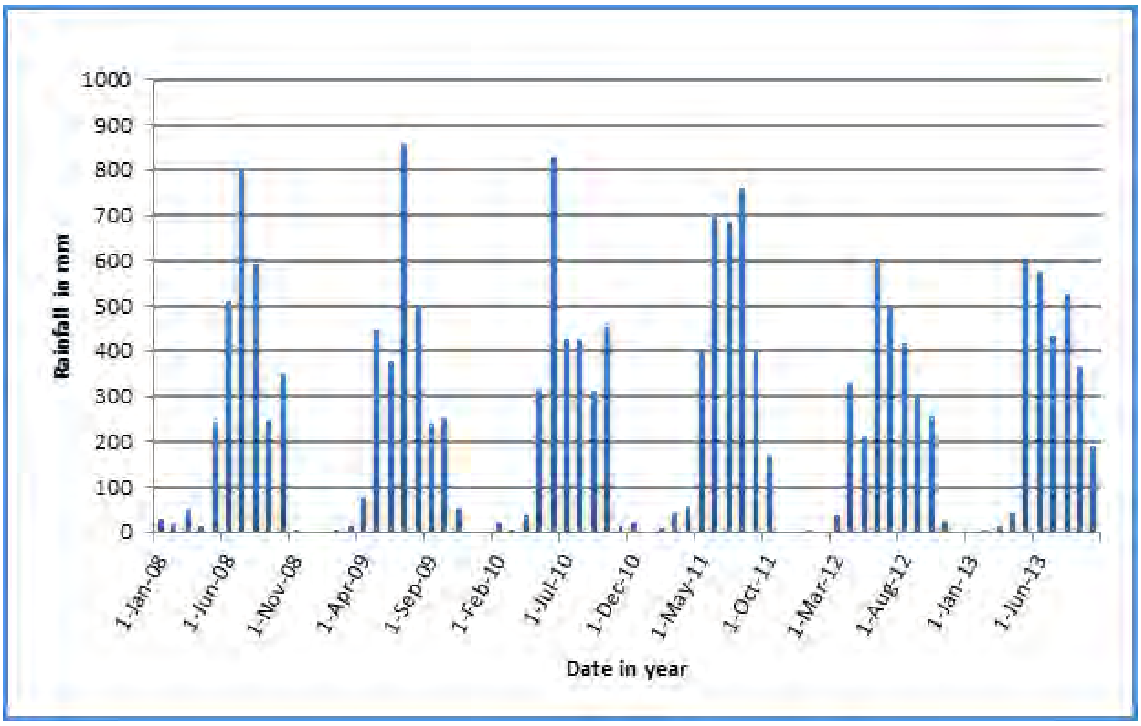


Figure 8.3-5 Summary of the Geotechnical Investigation Results Along the T/L Route

- Lined plates with green color show the boring points which are considerable for Pad & Chimney type foundation, and grey and orange might be pile foundation.
- There are two alternative bearing layers: N＞30 and N＞20. Exact bearing layer should be examined based on the designed tower load.
- Most of the GWL are almost near the ground surface, which was measured in the bore-holes of the flood-plain area during the survey period, but in the case that the GWL is several meters below the ground surface, Pad & Chimney type foundations may be applicable at some zones between No.96 and No.323.
- In the case that the required N-value is larger than 30 for pile foundations, the pile lengths vary from 10 to 28 m.

Basically, Pad & chimney type foundation might be preferable in the case that the bearing layer is shallow and GWL is deep. They will be applied at most of the hilly areas. Pile foundation should be chosen at most parts of the flood-plain area (see Table 8.3-3).

Total numbers of pad & chimney foundation would be applied to approx. 40 through the 400 kV T/L (however, it has a possibility of being more than 200 towers depending on the water level due to the seasonal environmental conditions.) If some heavy machinery is available for excavation, it will be applicable to about 6 m maximum even in the saturated condition. However, some treatment for access routes and working space would be required during construction, especially in the rainy season (from June to October). The average rainfall during the rainy season of the most recent 6 years varies from 200 to 600 mm per month (see Figure 8.3-6**).**



(Source:; Bangladesh Meteorological Department, Station No. 11805)

Figure 8.3-6 Monthly average rainfall distribution of Feni (2008 to 2013)

Table 8.3-3 Expected Foundation Type along the T/L (on the previous route)

Area		Tower No.		expected foundation type				Remarks
		from	to	longer pile	shorter pile	pile or P&C	Pad & chimney	
I	NW flood-plain -1	1	95	95				pile longer than 15m
	NW flood-plain -2	96	245		39	(111)		shorter pile (or Pad & Chimney)
	NW flood-plain -3	246	289	45				pile longer than 15m
	NW flood-plain -4	290	322		13	(20)		shorter pile (or Pad & Chimney)
	NW flood-plain -5	323	345	23				pile longer than 15m
II	NW foothill	346	366		21			shorter pile
	hilly area	367	418		14		41	Pad & Chimney (and Shorter pile)
	SE foothill -1	419	434		16			shorter pile
	SE foothill -2	435	502		21	(47)		shorter pile (or Pad & Chimney)
III	S flood-plain	507	S239	299				pile longer than 15m
total number of each foudation type				462	124	(178)	41	*(number) may change depend on the seasonal condition*

Regarding the section between Meghnaghat and Madunaghat, approximately 20 % of the tower foundation is assumed to be pad & chimney type and the rest is assumed to be pile. But through further study, pad & chimney type foundation might be applied for more towers in some parts of the flood plain on the northern side of the hilly area due to environmental conditions such as ground water level and trafficability of the field.

As for the section between Madunaghat and Matarbari, all of the towers' foundations are assumed to be pile.

8.4 Design Procedure

Design of the transmission line is carried out via the following flow.

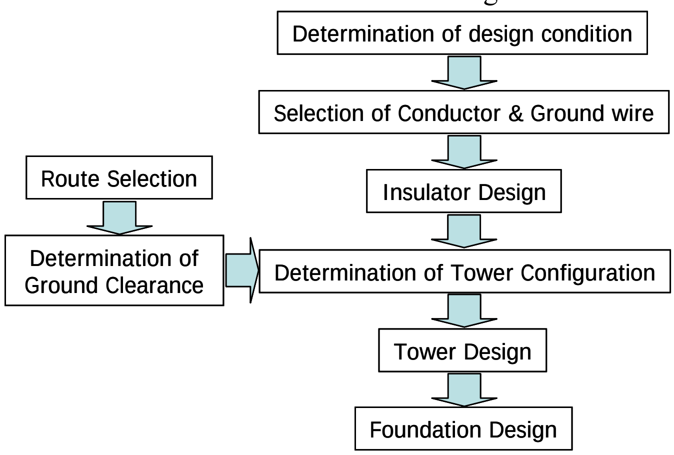


Figure 8.4-1 Design Flow of the Transmission Line

8.5 Design Conditions

The basic design conditions for the Project are as below.

(1) Ambient Temperature

Maximum air temperature: 45 ºC
Minimum air temperature: 5 ºC
Annual mean air temperature: 35 ºC

(2) Wind Velocity

The basic wind speed at each location is as below.

Dhaka: 210 km/h
Chittagong & Cox's Bazar: 260 km/h

Therefore, the basic wind (gust wind) speed for 400 kV Meghnaghat - Madunaghat T/L is assumed to be 210 km/h, and 400 kV Madunaghat - Matarbari T/L and 230 kV transmission lines is assumed to be 260 km/h, and they are converted to approximately 45.0 m/s and 53.5 m/s as 10 minutes' mean wind velocity at 10 m height respectively.

(3) Wind Pressure

The wind pressure for conductor, insulator string and tower are assumed to be as follows.

[400 kV Meghnaghat – Madunaghat T/L]

Conductor & Ground wire:	1,190 Pa
Insulator:	1,670 Pa
Tower:	3,430 Pa

[400 kV Madunaghat – Matarbari T/L and 230 kV transmission lines]

Conductor & Ground wire:	1,680 Pa
Insulator:	2,360 Pa
Tower:	4,850 Pa

(4) Stringent (the most severe design) Condition and EDS (Every Day Stress) Condition

The conditions were determined as follows.

[400 kV Meghnaghat – Madunaghat T/L]

Condition	Temperature	Wind
Stringent	5 ºC	45.0 m/s
EDS	35 ºC	Still air

[400 kV Madunaghat – Matarbari T/L and 230 kV transmission lines]

Condition	Temperature	Wind
Stringent	5 ºC	53.5 m/s
EDS	35 ºC	Still air

(5) Pollution Level

Medium, International Electrotechinical Commission (IEC)
(400 kV Meghnaghat – Madunaghat T/L & 230 kV transmission lines)

Heavy, IEC
(400 kV Madunaghat – Matarbari T/L)

(6) Maximum Annual Rainfall: 2,500 mm

(7) Isokeraunic Level (IKL): 80 days

(8) Other conditions assumed

Maximum humidity:	100 %
Average humidity:	80 %

(9) Safety Factors

Required minimum safety factors for the facilities of the transmission line are as below.

(a) Conductor/Ground wire

2.5 to Ultimate Tensile Strength (UTS) for stringent condition (65 % of UTS at river crossing)
5.0 to UTS for Every Day Stress (EDS) condition

(b) Insulator string

2.5 to RUS (Rated Ultimate Strength) for maximum working tension at supporting point

(c) Tower

1.25 to yield strength of material under normal condition (= stringent condition)

1.05 to yield strength of material under broken-wire condition (= normal condition + one ground wire & half a phase (two out of four) conductors' breakage or two half a phase conductors' breakage)

(d) Foundation

Tower type / Loading case	4DL	4D1, 4D25, 4D45, 4DT60
Normal condition	1.33	1.60
Broken wire condition	1.60	1.90

(10) Standard span length

The standard span length between towers for both 400 kV and 230 kV transmission lines is assumed to be 400 m.

(11) Right of Way (ROW)

400 kV transmission lines: 23 m for each side from the center (46 m in total)
230 kV transmission lines: 20 m for each side from the center (40 m in total)

(12) Ground clearance

The most severe state for the ground clearance of the conductors will occur when the conductor's temperature rises to 80 ºC under still air conditions. The minimum heights of the conductors above the ground at 400 kV and 230 kV level are determined as below.

Table 8.5-1 Minimum Height of Conductor above Ground

Applied area/objects	400 kV	230 kV
Ground	11.0 m	8.0 m
Roads	14.0 m	14.0 m
Buildings and structures, etc.	7.0 m	7.0 m
Trees	5.5 m	5.5 m
Shrubs	5.5 m	5.5 m
Railways	18.0 m	18.0 m
River Crossing	25.0 m	25.0 m

8.6 Conductor and Ground Wire Design

8.6.1 400 kV Transmission Line

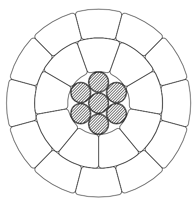
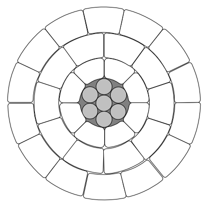
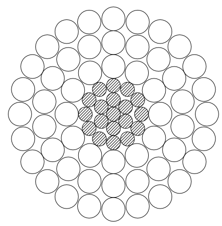
(1) Conductor and ground wire

As mentioned in section 7.7, the system analysis and cost comparison proved that 4-bundled low loss type ACSR 560 mm^2, which has the same electrical resistance as the conventional ACSR Finch, is appropriate for the Project.

In comparison with the conventional ACSR conductor, the low loss type conductor (LL-ACSR) is more compact and lighter; therefore, it makes the tower and the foundation smaller than those for the conventional ACSR conductor. This advantage leads to a reduction in the necessary material costs.

The technical characteristics of the LL-ACSR conductors are shown in the following table.

Table 8.6-1 Technical Characteristics of the Low Loss Conductors

Type		LL-ACSR/AC (Finch equivalent)	LL-ACSR/Ultra-High Strength Galvanized Steel Wire (UGS) (Finch equivalent)	(reference) ACSR Finch
Cross sectional area		624.0 mm^2	641.93 mm^2	636.9 mm^2
Sectional area	Aluminum	564.1 mm^2	594.08 mm^2	564.0 mm^2
	Steel core	59.87 mm^2	47.85 mm^2	71.5 mm^2
Overall diameter		29.5 mm	30.0 mm	32.83 mm
Nominal weight		1,994 kg/km	2,028 kg/km (with grease)	2,131 kg/km
Ultimate tensile strength		176.9 kN	174.0 kN	174.6 kN
Modulus of elasticity		72.2 GPa	72.5 GPa	78.0 GPa
Coefficient of linear expansion		20.5×10^{-6} /ºC	20.6×10^{-6} /ºC	19.6×10^{-6} /ºC
DC resistance at 20 ºC		0.0501 Ω/km	0.0488 Ω/km	0.05144 Ω/km
Cross sectional view				

Regarding the steel core, both the galvanized steel wire (GSW/UGS) and the aluminum-clad steel wire (AC) would be applicable to the Project. In particular, the AC core, which can provide better anti-corrosion performance than GSW, would be appropriate for the transmission lines passing through coastal areas.

As for the ground wires, ACSR Dorking 153 mm^2 and OPGW 158 mm^2 are applied, the same as the 400 kV Bibiyana – Kaliakoir T/L.
The technical characteristics of the ground wires are shown in the following table.

Table 8.6-2 Technical Characteristics of the Ground Wires

Type	ACSR Dorking 153 mm^2	OPGW 158 mm^2
Cross sectional area	153.1 mm^2	158 mm^2
Overall diameter	16.02 mm	16.7 mm
Nominal Weight	708.9 kg/km	860 kg/km
Ultimate tensile strength	83.3 kN	98.1 kN
Modulus of elasticity	105.0 GPa	120.6 GPa
Coefficient of linear expansion	15.3×10^{-6} /ºC	14.4×10^{-6} /ºC
DC resistance at 20 ºC	0.2986 Ω/km	0.3230 Ω/km
Number of optical fibers	-	48

(Source: PGCB)

(2) Maximum working tension and EDS

The standard span length is assumed to be 400 m and the values of the maximum working tension and the EDS of both the conductor and the ground wires satisfy the determined safety factors as shown in the following table.

Table 8.6-3 Maximum Working Tension and EDS

Type of Conductor/GW	UTS	Tension		Safety Factors
Meghnaghat SS – Madunaghat SS				
4-bundled LL-ACSR 560	176.9 kN	Max. tension	69.0 kN	2.56 > 2.5
		EDS	34.8 kN	5.08 > 5.0
ACSR Dorking 153 mm^2	83.3 kN	Max. tension	22.0 kN	3.78 > 2.5
		EDS	14.7 kN	5.66 > 5.0
OPGW 158 mm^2	98.1 kN	Max. tension	26.0 kN	3.77 > 2.5
		EDS	19.0 kN	5.16 > 5.0
Madunaghat SS – Matarbari CFPP				
4-bundled LL-ACSR 560	176.9 kN	Max. tension	69.0 kN	2.56 > 2.5
		EDS	26.5 kN	6.67 > 5.0
ACSR Dorking 153 mm^2	83.3 kN	Max. tension	24.0 kN	3.47 > 2.5
		EDS	12.4 kN	6.71 > 5.0
OPGW 158 mm^2	98.1 kN	Max. tension	27.0 kN	3.63 > 2.5
		EDS	15.3 kN	6.41 > 5.0

(3) Sags and tensions of the ground wires

The sags of the ground wires under EDS condition must be smaller than the conductors' sag at the standard span length to avoid a reverse flashover from the ground wires to the conductors and direct lightning stroke to the conductors. The tensions of the ground wires are determined to satisfy the safe separation of conductors and ground wires in the mid-span.

8.6.2 230 kV Transmission Line

(1) Conductor and ground wire

The 4-bundled LL-ACSR equivalent to Finch was selected for the conductor of the 230 kV Hathazari – Sikalbaha T/L in the "National Power Transmission Line Development Project". Therefore, the 4-bundled LL-ACSR equivalent to Finch is assumed to be applied to the conductor for LILO at Madunaghat SS from Hathazari – Sikalbaha T/L, the same as the conductor of the 230 kV Hathazari – Sikalbaha T/L. Considering the power flow, the same size conductor with above section should be applied to the conductor between Madunaghat SS and the existing Madunaghat SS.

Regarding the ground wires, AC 90 mm^2 as well as OPGW 90 mm^2 would be applied to both transmission lines. The characteristics of the conductor and ground wires are shown in the following table. (The characteristics of LL-ACSR equivalent to Finch are shown in Table 8.6-1.)

Table 8.6-4 Technical Characteristics of the Conductor and Ground Wire

Type	AC 90 mm^2		OPGW 90 mm^2	
Cross sectional area	93.09	mm^2	87.99	mm^2
Overall diameter	12.34	mm	13.2	mm
Nominal weight	619.5	kg/km	641.3	kg/km
Ultimate tensile strength	101.1	kN	98.0	kN
Modulus of elasticity	162.2	GPa	149.3	GPa
Coefficient of linear expansion	12.9×10^{-6}	/ºC	13.2×10^{-6}	/ºC
DC resistance at 20 ºC	0.370	Ω/km	0.708	Ω/km

(2) Maximum working tension and EDS

The standard span length is assumed to be 400 m and the values of the maximum working tension and the EDS of both the conductor and the ground wire satisfy the determined safety factors as shown in the following table.

Table 8.6-5 Maximum Working Tension and EDS

Type of Conductor/GW	UTS	Tension		Safety Factors
4-bundled LL-ACSR 560	176.9 kN	Max. tension	69.0 kN	2.56 > 2.5
		EDS	34.8 kN	5.08 > 5.0
AC 90 mm^2	101.1 kN	Max. tension	32.0 kN	3.15 > 2.5
		EDS	11.1 kN	9.10 > 5.0
OPGW 90 mm^2	98.0 kN	Max. tension	32.0 kN	3.06 > 2.5
		EDS	10.9 kN	8.99 > 5.0

8.7 Insulator Design

8.7.1 400 kV Transmission Line

(1) Insulator type

The insulator unit applied to the Project is a standard disc type porcelain insulator with ball and socket, complying with IEC 60305. The 210 kN size insulator can be applied to the suspension strings and several sizes of insulator, such as 210 kN, 300 kN and 400 kN can be applied to the tension strings. The technical characteristics of these insulators are shown in the following table.

Table 8.7-1 Technical Characteristics of the Insulators

Rated Ultimate Strength	210 kN	300 kN	400 kN
IEC Designation	U210B	U300B	U400B
Shell Diameter	280 mm	320 mm	340 mm
Unit Spacing	170 mm	195 mm	205 mm
Nominal Creepage Distance	405 mm	505 mm	550 mm
Ball & Socket Coupling	20 mm	24 mm	28 mm

(Source: Suspension Insulator Catalog, NGK INSULATORS, LTD.)

(2) Number of insulator discs and the number of strings

The pollution level of Meghnaghat SS – Madunaghat SS section is assumed as medium of the IEC standard and Madunaghat SS – Matarbari CFPP section is assumed as heavy.

The applicable insulator size, the number of insulator strings and the number of insulator discs are shown in the following table. By applying the low loss conductor, the insulator size for suspension string can be downsized. As for the tension string, the 300 kN size insulator would be suitable in consideration of the cost and maintenance.

Table 8.7-2 Number of Insulator Discs and Strings

Type of String	Conductor	Electro-mechanical strength of insulator disc [kN]	Number of discs	Maximum Tension [kN]	Mechanical strength of insulator string [kN]	Safety Factors
Meghnaghat SS – Madunaghat SS						
Suspension	4-bundled LL-ACSR 560	210	2x24	420 (210x2)	140.4	2.99 > 2.5
Tension		300	3x21	900 (300x3)	276.0 (69x4)	3.26 > 2.5
Madunaghat SS – Matarbari CFPP						
Suspension	4-bundled LL-ACSR 560	210	2x26	420 (210x2)	162.6	2.58 > 2.5
Tension		300	3x21	900 (300x3)	276.0 (69x4)	3.26 > 2.5

It is assumed the suspension string as normal suspension string in the Survey, but the application of "V" type suspension string would be considered in the next detailed design stage.

8.7.2 230 kV Transmission Line

Regarding the 230 kV transmission lines, 210 kN and 300 kN normal disc type porcelain insulator with ball and socket is applied to the suspension string and the tension string respectively, the same as the 400 kV transmission line, whose conductor is 4-bundled LL-ACSR 560.

The applicable insulator size, the number of insulator strings and the number of insulator discs are shown in the following table.

Table 8.7-3 Number of Insulator Discs and Strings

Type of String	Conductor	Electro-mechanical strength of insulator disc [kN]	Number of discs	Maximum Tension [kN]	Mechanical strength of insulator string [kN]	Safety Factors
Suspension	4-bundled LL-ACSR 560	210	2x15	420 (210x2)	153.6	2.73 > 2.5
Tension		300	3x13	900 (300x3)	276.0 (69x4)	3.26 > 2.5

8.8 Tower Configuration

8.8.1 400 kV Transmission Line

(1) Clearance Design

The clearance design is applied using the same values as the Bibiyana – Kaliakoir T/L.

Table 8.8-1 Values of Clearance Diagram for Tower

Tower type	Swinging angle of conductor	Clearance value
Suspension	0 deg.	3,100 mm
	10 deg.	3,100 mm
	30 deg.	2,800 mm
	50 deg.	1,830 mm
Tension	10 deg.	3,100 mm
	15 deg.	2,800 mm
	40 deg.	1,830 mm

(2) Insulation design of the ground wires

Number and shielding angle of the ground wires are determined as below:
Number of ground wires: 2
Maximum shielding angle: 0 deg.

(3) Tower configurations

The towers shall normally be the following 6 standard types.

Table 8.8-2 Tower Types and the Applied Conditions

Tower Type	Position of Use	Angle of Deviation/Entry	Insulator String Type
4DL	Straight line	0 – 1 deg.	Suspension
4D1	Straight line	0 – 3 deg.	Heavy Suspension
4DR	River crossing	0 – 3 deg.	Heavy Suspension
4D25	Angle	5 – 25 deg.	Tension
4D45	Angle	25 – 45 deg.	Tension
4DT60	Angle Terminal	45 – 60 deg. 0 – 30 deg.	Tension

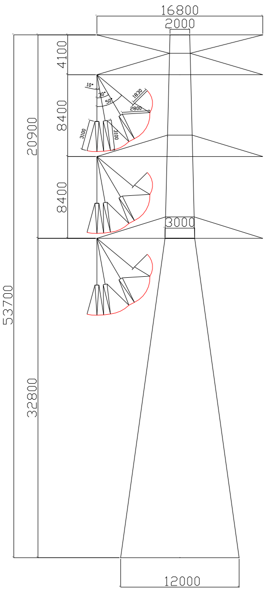


Figure 8.8-1 Suspension Tower (+3 m)

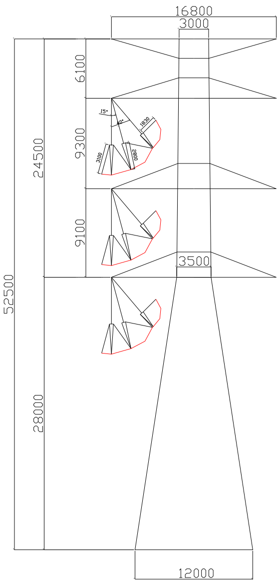


Figure 8.8-2 Tension Tower (+3 m)

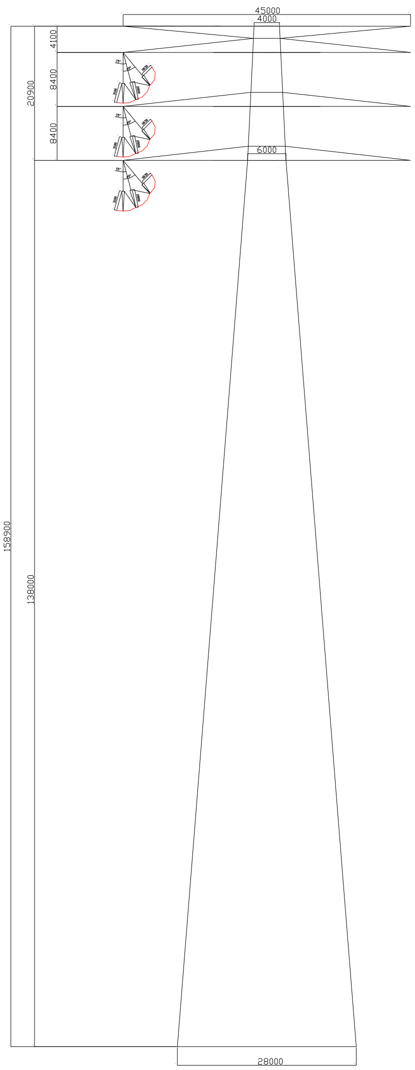


Figure 8.8-3 Meghna River Crossing Tower (Span: 1,200 m)

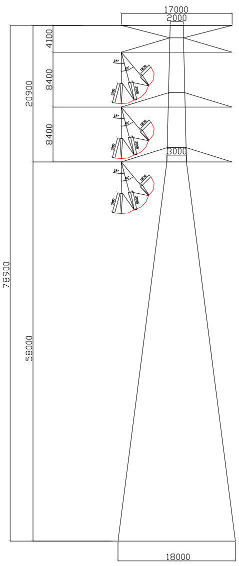


Figure 8.8-4 Sangu River Crossing Tower (Span: 600 m)

8.8.2 230 kV Transmission Line

(1) Clearance Design

The clearance design is applied using the existing 230 kV transmission line.

Table 8.8-3 Values of Clearance Diagram for Tower

Tower type	Swinging angle of conductor	Clearance value
Suspension	0 deg.	2,300 mm
	10 deg.	2,300 mm
	45 deg.	1,630 mm
Tension	0 deg.	2,300 mm
	10 deg.	2,300 mm
	25 deg.	1,630 mm

(2) Insulation design of the ground wires

Number and shielding angle of the ground wires are determined as below:
Number of ground wires: 2
Maximum shielding angle: 0 deg.

(3) Tower configurations

The double-circuit towers shall normally be the following 4 standard types.

Table 8.8-4 Tower Types and the Applied Conditions

Tower Type	Position of Use	Angle of Deviation/Entry	Insulator String Type
2DL	Straight line	0 – 1 deg.	Suspension
2D1	Straight line	1 – 10 deg.	Suspension
2D25	Angle/Section	0 – 25 deg.	Tension
2DT6	Angle Terminal	25 – 60 deg. 0 – 30 deg.	Tension

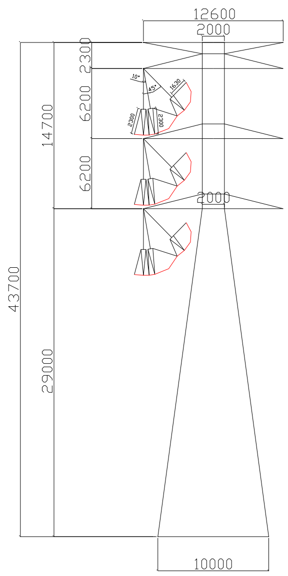


Figure 8.8-5 Suspension Tower (+ 0)

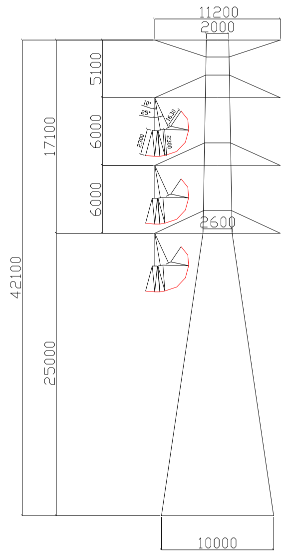


Figure 8.8-6 Tension Tower (+ 0)

And the four-circuit towers shall normally be the following 5 standard types.

Table 8.8-5 Tower Types and the Applied Conditions

Tower Type	Position of Use	Angle of Deviation/Entry	Insulator String Type
2QL	Straight line	0 – 1 deg.	Suspension
2Q15	Angle	0 – 15 deg.	Tension
2Q30	Angle	0 – 30 deg.	Tension
2QT6	Angle Terminal	30 – 60 deg. 0 – 30 deg.	Tension

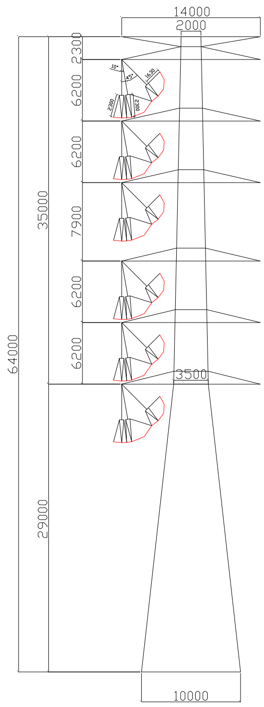


Figure 8.8-7 Suspension Tower (+ 0)

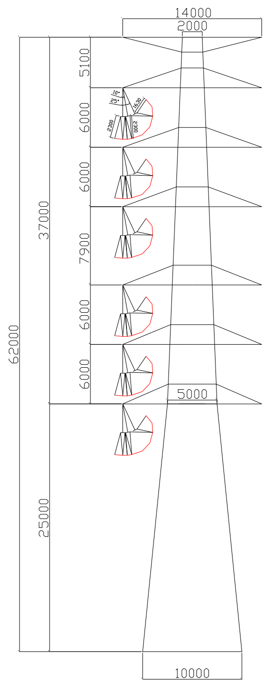


Figure 8.8-8 Tension Tower (+ 0)

8.9 Foundation Configuration

8.9.1 400 kV Transmission Line

According to the result of the SPT described in Chapter 8.3, pile type foundation would be applied through the whole route mainly and spread (pad and chimney) type foundation would be applied to the section passing through the hilly area. The assumed foundation loads that are transmitted from each tower type are shown in the following table.

Actual foundation type at each tower as well as pile length shall be examined by results of more detailed boring in the detailed design stage.

Table 8.9-1 Assumed Foundation Loads (400 kV Meghnaghat – Madunaghat T/L)

Tower type (extension: +0)	Compressive load	Tensile load
4DL	1,234 kN	925 kN
4D1	1,344 kN	1,030 kN
4DR (Meghna Riv.)	6,807 kN	3,812 kN
4D25	2,368 kN	1,978 kN
4D45	3,283 kN	2,849 kN
4DT60	3,942 kN	3,459 kN

Table 8.9-2 Assumed Foundation Loads (400 kV Madunaghat – Matarbari T/L)

Tower type (extension: +0)	Compressive load	Tensile load
4DL	1,673 kN	1,326 kN
4D1	1,782 kN	1,432 kN
4DR (Sangu Riv.)	2,834 kN	2,196 kN
4D25	2,799 kN	2,371 kN
4D45	3,732 kN	3,253 kN
4DT60	4,404 kN	3,883 kN

8.9.2 230 kV Transmission Line

According to the result of the SPT described in Chapter 8.3, pile type foundation would be applied to the 230 kV transmission lines of the Project. The assumed foundation loads that are transmitted from each tower type are shown in the following table.

Actual pile length at each tower including the possibility of application of pad and chimney type foundation shall be examined in the detailed design stage.

Table 8.9-3 Assumed Foundation Loads (230 kV Madunaghat – Old Madunaghat T/L)

Tower type (extension: +0)	Compressive load	Tensile load
2DL	904 kN	727 kN
2D1	1,165 kN	977 kN
2D25	1,451 kN	1,241 kN
2DT6	2,291 kN	2,041 kN

Table 8.9-4 Assumed Foundation Loads (230 kV LILO at Madunaghat SS from Hathazari – Sikalbaha T/L)

Tower type (extension: +0)	Compressive load	Tensile load
2QL	3,972 kN	3,292 kN
2Q15	5,733 kN	4,702 kN
2Q30	7,793 kN	6,407 kN
2QT6	11,417 kN	9,694 kN

8.10 Quantities of the Transmission Line Materials

8.10.1 400 kV Transmission Line

(1) Number of Towers and Weight of Towers

The assumed tower weight and the number of towers of the 400 kV transmission line are summarized in the following tables.

Table 8.10-1 Assumed Tower Weight and Number of Towers (400 kV Meghnaghat – Madunaghat T/L)

Tower type	Extension [m]	Unit weight [ton]	No. of towers [unit]	Total weight [ton]
4DL: Suspension (Horizontal angle: 0-1 deg.)	0	30.9	377	11,649
	+3	32.1	6	193
	+6	34.8	3	104
	+9	37.6	1	38
Sub total			387	11,984
4D1: Heavy Suspension (Horizontal angle: 0-3 deg.)	0	31.9	1	32
	+3	34.0	0	0
	+6	36.5	0	0
	+9	40.0	0	0
Sub total			1	32
4DR: Heavy Suspension (River crossing)	Meghna Riv.	556.3	2	1,113
	Gomoti Riv.	67.4	2	135
Sub total			4	1,247
4D25: Tension (Horizontal angle: 5-25 deg.)	0	42.8	56	2,397
	+3	44.8	1	45
	+6	50.0	2	100
	+9	52.7	0	0
Sub total			59	2,542
4D45: Tension (Horizontal angle: 25-45 deg.)	0	51.5	71	3,657
	+3	55.4	3	166
	+6	59.4	1	59
	+9	63.7	0	0
Sub total			75	3,882
4DT60: Tension/Dead-end	0	61.5	35	2,153
	+3	65.2	3	196
	+6	69.7	0	0
	+9	76.1	1	76
Sub total			39	2,424
Total			565	22,111

Table 8.10-2 Assumed Tower Weight and Number of Towers (400 kV Madunaghat – Matarbari T/L)

Tower type	Extension [m]	Unit weight [ton]	No. of towers [unit]	Total weight [ton]
4DL: Suspension	0	38.3	149	5,707
(Horizontal angle: 0-1 deg.)	+3	40.8	0	0
	+6	44.9	1	35
	+9	48.2	0	0
Sub total			150	5,742
4D1: Heavy Suspension	0	39.1	1	39
(Horizontal angle: 0-3 deg.)	+3	41.4	0	0
	+6	45.8	0	0
	+9	48.9	0	0
Sub total			1	39
4DR: Heavy Suspension	Sangu Riv.	92.8	4	371
(River crossing)				0
Sub total			4	371
4D25: Tension	0	50.2	41	2,058
(Horizontal angle: 5-25 deg.)	+3	53.8	1	45
	+6	59.1	1	50
	+9	62.7	0	0
Sub total			43	2,153
4D45: Tension	0	60.6	30	1,818
(Horizontal angle: 25-45 deg.)	+3	64.8	0	0
	+6	70.9	0	0
	+9	74.6	0	0
Sub total			30	1,818
4DT60: Tension/Dead-end	0	69.2	8	554
	+3	74.2	1	65
	+6	80.6	2	139
	+9	84.7	0	0
Sub total			11	758
Total			239	10,881

(2) Quantities of Conductor and Ground Wires

Quantities of conductor and ground wires for the transmission line are calculated by multiplying the number of conductors or ground wires by the route length, and multiplying that number by 1.05 (1.10 for OPGW) for the sag allowance and margin for stringing work.

Table 8.10-3 Quantities of Conductor and GW (400 kV Meghnaghat – Madunaghat T/L)

Conductor/Ground wire type	No. of bundles	No. of phases	No. of circuits	Route length [km]	Total [km]
Low Loss ACSR (Finch equivalent)	4	3	2	214	5,393
OPGW 158 mm^2	1	-	1	214	236
ACSR Dorking 153 mm^2	1	-	1	214	225

Table 8.10-4 Quantities of Conductor and GW (400 kV Madunaghat – Matarbari T/L)

Conductor/Ground wire type	No. of bundles	No. of phases	No. of circuits	Route length [km]	Total [km]
Low Loss ACSR (Finch equivalent)	4	3	2	92	2,319
OPGW 158 mm^2	1	-	1	92	102
ACSR Dorking 153 mm^2	1	-	1	92	97

(3) Quantities of Insulators

Quantities of insulator and insulator assemblies for the transmission line are calculated from the number of suspension and tension towers considering number of strings.

Table 8.10-5 Quantities of Insulator and Insulator Assemblies (400 kV Meghnaghat – Madunaghat T/L)

Tower type	Assembly type	Insulator size	No. of insulators per string [pcs]	No. of strings per tower [set]	No. of towers [unit]	Sub total of strings [set]	Sub total of insulators [pcs]
Suspension	Double	210 kN	48	6	392	2,352	112,896
Tension	Triple	300 kN	63	12	173	2,076	130,788
(Jumper support)	Single	210 kN	24	6	173	1,038	24,912
Total						210 KN	137,808
						300 kN	130,788

Table 8.10-6 Quantities of Insulator and Insulator Assemblies (400 kV Madunaghat – Matarbari T/L)

Tower type	Assembly type	Insulator size	No. of insulators per string [pcs]	No. of strings per tower [set]	No. of towers [unit]	Sub total of strings [set]	Sub total of insulators [pcs]
Suspension	Double	210 kN	52	6	155	930	48,360
Tension	Triple	300 kN	63	12	84	1,008	63,504
(Jumper support)	Single	210 kN	26	6	84	504	13,104
Total						210 KN	61,464
						300 kN	63,504

(4) Quantities of Tower Foundation

Regarding the section between Meghnaghat and Madunaghat, approximately 20 % of the tower foundation is assumed to be pad and chimney type and the rest is assumed to be pile at present. But through further study, pad and chimney type foundation might be applied for more towers in some parts of the flood plain on the north side of the hilly area due to geological conditions such as ground water level.

As for the section between Madunaghat and Matarbari, all tower foundations are assumed to be pile.

8.10.2 230 kV Transmission Line

(1) Number of Towers and Weight of Towers

The assumed tower weight and the number of towers of the 230 kV transmission lines are summarized in the following tables.

Table 8.10-7 Assumed Tower Weight and Number of Towers (230 kV Madunaghat – Old Madunaghat T/L)

Tower type	Extension [m]	Unit weight [ton]	No. of towers [unit]	Total weight [ton]
2DL: Suspension (Horizontal angle: 0-1 deg.)	0	28.0	8	224
	+3	32.8	0	0
	+6	38.2	0	0
	+9	55.3	1	55
Sub total			9	279
2D1: Suspension (Horizontal angle: 1-10 deg.)	0	30.1	3	90
	+3	35.0	0	0
	+6	40.7	0	0
	+9	58.8	0	0
Sub total			3	90
2D25: Tension (Horizontal angle: 0-25 deg.)	0	32.8	1	33
	+3	39.0	2	78
	+6	45.9	0	0
	+9	65.8	0	0
Sub total			3	111
2DT6: Tension/Dead-end (Horizontal angle: 25-60 deg.)	0	35.6	4	142
	+3	41.2	0	0
	+6	49.4	0	0
	+9	69.9	1	70
Sub total			5	212
Total			20	693

Table 8.10-8 Assumed Tower Weight and Number of Towers (230 kV LILO at Madunaghat SS from Hathazari – Sikalbaha T/L)

Tower type	Extension [m]	Unit weight [ton]	No. of towers [unit]	Total weight [ton]
2QL: Suspension (Horizontal angle: 0-1 deg.)	0	75.9	8	607
	+3	80.3	0	0
	+6	84.0	0	0
	+9	87.9	0	0
Sub total			8	607
2Q15: Tension (Horizontal angle: 0-15 deg.)	0	138.9	2	278
	+3	147.2	0	0
	+6	167.7	0	0
	+9	175.9	0	0
Sub total			2	278
2Q30: Tension (Horizontal angle: 0-30 deg.)	0	211.4	0	0
	+3	222.2	0	0
	+6	240.9	0	0
	+9	251.9	0	0
Sub total			0	0
2QT6: Tension/Dead-end (Horizontal angle: 30-60 deg.)	0	280.1	3	840
	+3	291.7	0	0
	+6	311.2	0	0
	+9	322.9	0	0
Sub total			3	840
Total			13	1,725

(2) Quantities of Conductor and Ground Wires

Quantities of conductor and ground wires for the transmission line are calculated by multiplying the number of conductors or ground wires by the route length, and multiplying that number by 1.05 (1.10 for OPGW) for the sag allowance and margin for stringing work.

Table 8.10-9 Quantities of Conductor and GW (230 kV Madunaghat – Old Madunaghat T/L)

Conductor/Ground wire type	No. of bundles	No. of phases	No. of circuits	Route length [km]	Total [km]
LL-ACSR equivalent to Finch	4	3	2	8	202
OPGW 90 mm^2	1	-	1	8	9
AC 90 mm^2	1	-	1	8	9

Table 8.10-10 Quantities of Conductor and GW (230 kV LILO at Madunaghat SS from Hathazari – Sikalbaha T/L)

Conductor/Ground wire type	No. of bundles	No. of phases	No. of circuits	Route length [km]	Total [km]
LL-ACSR equivalent to Finch	4	3	4	5	252
OPGW 90 mm^2	1	-	1	5	6
AC 90 mm^2	1	-	1	5	6

(3) Quantities of Insulators

Quantities of insulator and insulator assemblies for the transmission line are calculated from the number of suspension and tension towers considering the number of strings.

Table 8.10-11 Quantities of Insulator and Insulator Assemblies (230 kV Madunaghat – Old Madunaghat T/L)

Tower type	Assembly type	Insulator size	No. of insulators per string [pcs]	No. of strings per tower [set]	No. of towers [unit]	Sub total of strings [set]	Sub total of insulators [pcs]
Suspension	Double	210 kN	30	6	12	72	2,160
Tension	Double	300 kN	39	12	8	96	3,744
(Jumper support)	Single	210 kN	15	6	8	48	720
Total						210 KN (Suspension & Jumper)	2,880
						300 kN (Tension)	3,744

Table 8.10-12 Quantities of Insulator and Insulator Assemblies (230 kV LILO at Madunaghat SS from Hathazari – Sikalbaha T/L)

Tower type	Assembly type	Insulator size	No. of insulators per string [pcs]	No. of strings per tower [set]	No. of towers [unit]	Sub total of strings [set]	Sub total of insulators [pcs]
Suspension	Double	210 kN	30	12	8	96	2,880
Tension	Double	300 kN	39	24	5	120	4,680
(Jumper support)	Single	210 kN	15	12	5	60	900
Total						210 KN (Suspension & Jumper)	3,780
						300 kN (Tension)	4,680

(4) Quantities of Tower Foundation

All of the tower foundations for the 230 kV transmission lines of the Project are assumed to be pile.

8.10.3 Spare Parts, Tools and Measuring Devices

Since maintenance work for the transmission line after completion of the Project will be carried out by PGCB's maintenance offices, it is necessary to provide spare parts, maintenance tools and measuring devices considering common stock among the maintenance offices. Although items and their quantities will be determined in the detailed design stage of the Project, it is assumed that the principal items for maintenance are as follows:

(a) Transmission line materials for maintenance:

Complete set of standard towers, galvanized steel materials and bolts for replacement of damaged tower members, spares for conductors, ground wires and their fittings, insulators and their fittings, etc.

(b) Tools and measuring devices:

Insulator replacing devices, repair work tools, insulated earthing rods, insulation resistance testers, equipment for maintenance staff, vehicles for transmission line patrol and inspection, etc.

It is assumed that the cost of spare parts, tools and measuring devices for the Project would be approximately 5% of the total costs of the transmission line materials.

Chapter 9
Preliminary Substation Design for the Project

Chapter 9 Preliminary Substation Design for the Project

9.1 Preliminary Design for the Project's Substations

To define design policy, fundamental substation design, and technical requirements for this 400 kV transmission system project, the JICA and PGCB's C/Ps held some technical discussions, and mutually agreed on the following basic designs:

9.1.1 New 400 kV Madunaghat SS

✧ Future extensions of transmission lines and transformers should be considered in the initial design.

Table 9.1-1 The Development Plan for New 400 kV Madunaghat SS

Item	Initial	Final
400 kV Transmission Line	4 cct (2: to Meghnaghat) (2: to Matarbari)	8 cct (2: to Aminbazar) (2: to Moheskhali)
400 kV Transformer	750 MVA x 3 banks	750 MVA x 4 banks
230 kV Transmission Line	6 cct (2: to Madunaghat) (2: to Sikalbanai) (2: to Hathazari)	12 cct (2: to Raozan) (4: for future)

(Source: Interview with PGCB)

✧ GIS form is selected to construct the substations in the limited spaces planned, and to pursue the highest operational reliability of 400 kV bulk power system, which is the most important component of Bangladesh's power grid
✧ Due to GIS's higher reliability, double bus-bar scheme with four bus couplers will be applied to both 400 kV and 230 kV bus-bars.

The capacity of individual transformers is selected as 750 MVA to satisfy the projected loading of the new Madunaghat Substation, which is 1300 MVA in 2021 with the N-1 criteria. Also, the number of transformers in the final stage is set to 4 banks, with which the lower side bus-bar can be separately operated to reduce the short circuit current rating for lower voltage side switching gears including circuit breakers.

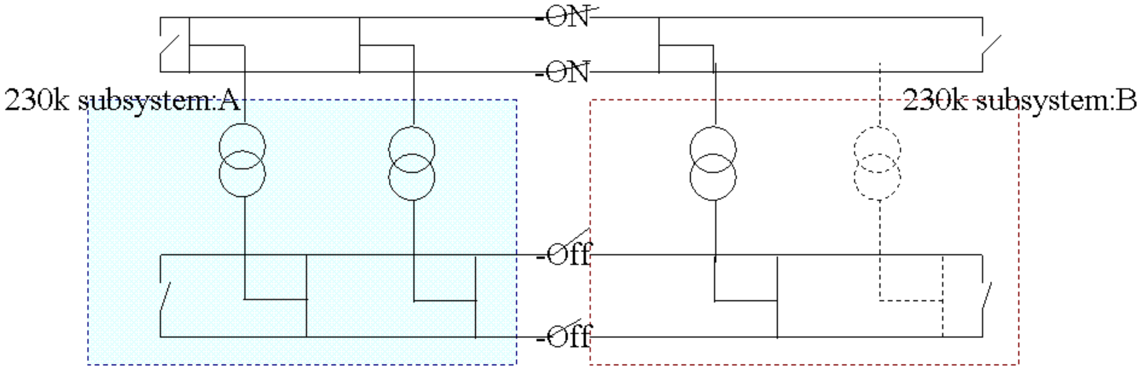


Figure 9.1-1 Image of 230kV side separation with 3(4) transformer configuration

For reference, a Single Line Diagram at the current stage is shown on the next page.

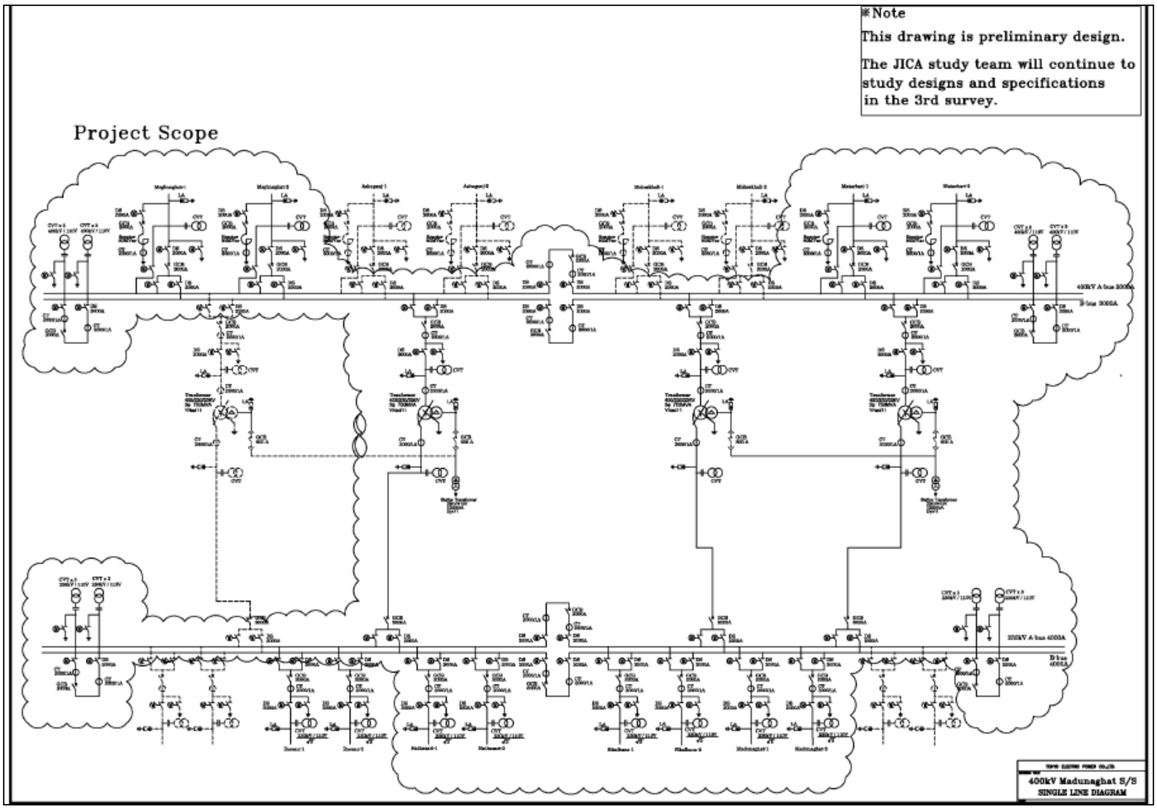


Figure 9.1-2 Single Line Diagram of Madunaghat SS (See Appendix for details)

✧ GIS type should be outdoor-type to provide some advantages. One is cost-effectiveness as per the below table. Another advantage is shorter construction period because it's unnecessary to install buildings for outdoor-type GIS. Yet another is simpler work for construction and assembly work of outdoor-type GIS because it is possible to use cranes for lifting GIS parts. On the other hand, indoor-type GIS needs extra facilities for lifting, such as hoists and hooks. Hence, building cost for indoor-type GIS is higher than for outdoor-type.

Table 9.1-2 Cost Comparison: Outdoor GIS vs Indoor GIS

	Indoor GIS	Outdoor GIS
Equipment cost	(Base)	+Slightly higher
Building cost	+Higher	(Base)
Land cost	Same	Same
Total	++	+

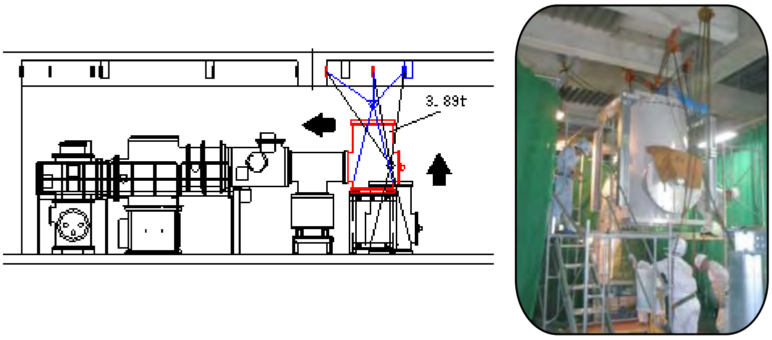
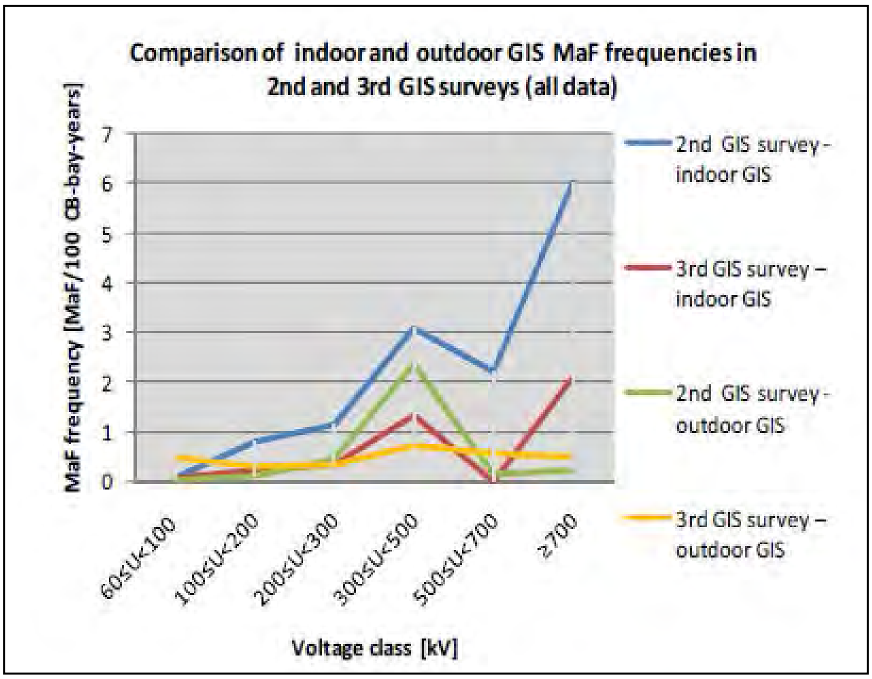


Figure 9.1-3 Image of GIS Assembly Work for Indoor-type GIS

✧ 400 kV reactors for compensating transmission line charging could be directly connected to each 400 kV transmission line.

In this project, PGCB will introduce the first 400 kV-class GIS in Bangladesh, and the 400 kV grids will play an important role in supplying a large amount of electricity in a stable manner for a long period. Thus, higher reliability compared to the current 230 kV system is necessary to ensure its expected role in the whole power grid. Also, the CIGRE study reports an increase in failure frequency in higher voltage class equipment as shown below. Therefore, the new 400 kV GIS should achieve higher operational reliability by procuring machines with some technical qualification of the suppliers, and Bangladesh's particular necessary functions, such as pre-inserted resistance, and open-phase synchronizer. The necessary functions will be studied in the Basic design stage.



(Source: CIGRE WG A3.06, 2012 October "Final Report of the 2004 – 2007 International Enquiry on Reliability of High Voltage Equipment – Gas Insulated Switchgear")

Figure 9.1-4 Comparison of GIS failure frequencies of each voltage class

9.1.2 Existing 230kV Meghnaghat Switch Station

✧ Future extensions of transmission lines and transformers should be considered in the initial design.

Table 9.1-3 The development plan for existing 230 kV Meghnaghat Switch Station

Item	Initial	Final
400 kV Transmission Line	4 cct (2: to Madunaghat 2: to Aminbazar)	4 cct
400kV Transformer	750 MVA x 2 banks	750 MVA x 3 banks

(Source: Interview with PGCB)

✧ Existing 230 kV Meghnaghat Switch Station will be upgraded to 400/230 kV substation.
✧ Substation type should be outdoor-type for its cost efficiency.
✧ 400 kV Bus-bar system should be one and a half scheme with air-insulated switchgears.
✧ Existing 230 kV Bus-bar is AIS, so it isn’t necessary to change this scheme.
✧ By upgrading to a 400 kV substation, the power flow to the existing equipment will be increased. Separating the 230 kV bus-bar into two can make the existing 230 kV bus-bar meet the capacity after the Project.

For reference, a Single Line Diagram at the current stage is shown below.

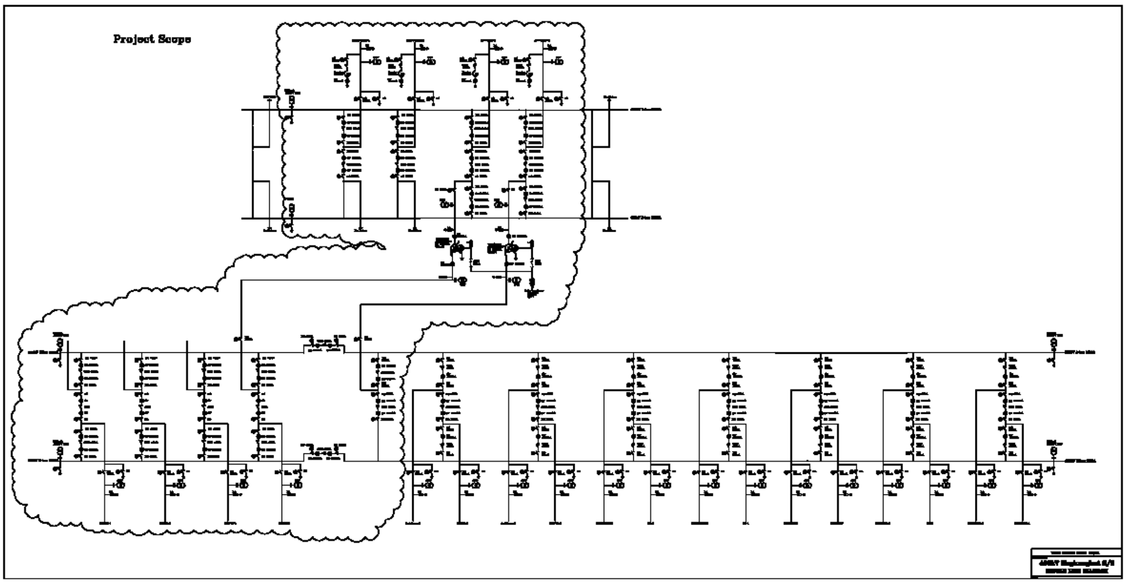


Figure 9.1-5 Single Line Diagram of 230 kV Meghnaghat SS (See Appendix III for details)

9.1.3 Existing 132kV Madunaghat SS

✧ Future extensions of transmission lines and transformers should be considered in the initial design as below.

Table 9.1-4 The Development Plan for Existing 132 kV Madunaghat SS

Item	Initial	Final
230 kV Transmission Line	2 cct (2: to Madunaghat)	4 cct (2: for future)
230 kV Transformer	300 MVA x 3 banks	300 MVA x 3 banks

✧ Old Madunaghat SS will be upgraded to 230/132 kV substation.
✧ Substation type could be outdoor-type for cost efficiency
✧ All construction will be carried out on the premises. Considering the existing dimensions, the upgraded substation should be compact.
✧ 230 kV Bus-bar scheme is double bus-bar scheme with one bus coupler.
✧ 132 kV Bus-bar is GIS with double bus-bar scheme with four bus coupler.
✧ The design for removal of the existing 132kV AIS and installation of the new 132 kV GIS will be done by PGCB. However, as of F/S, the position of new 132 kV GIS isn't determined.

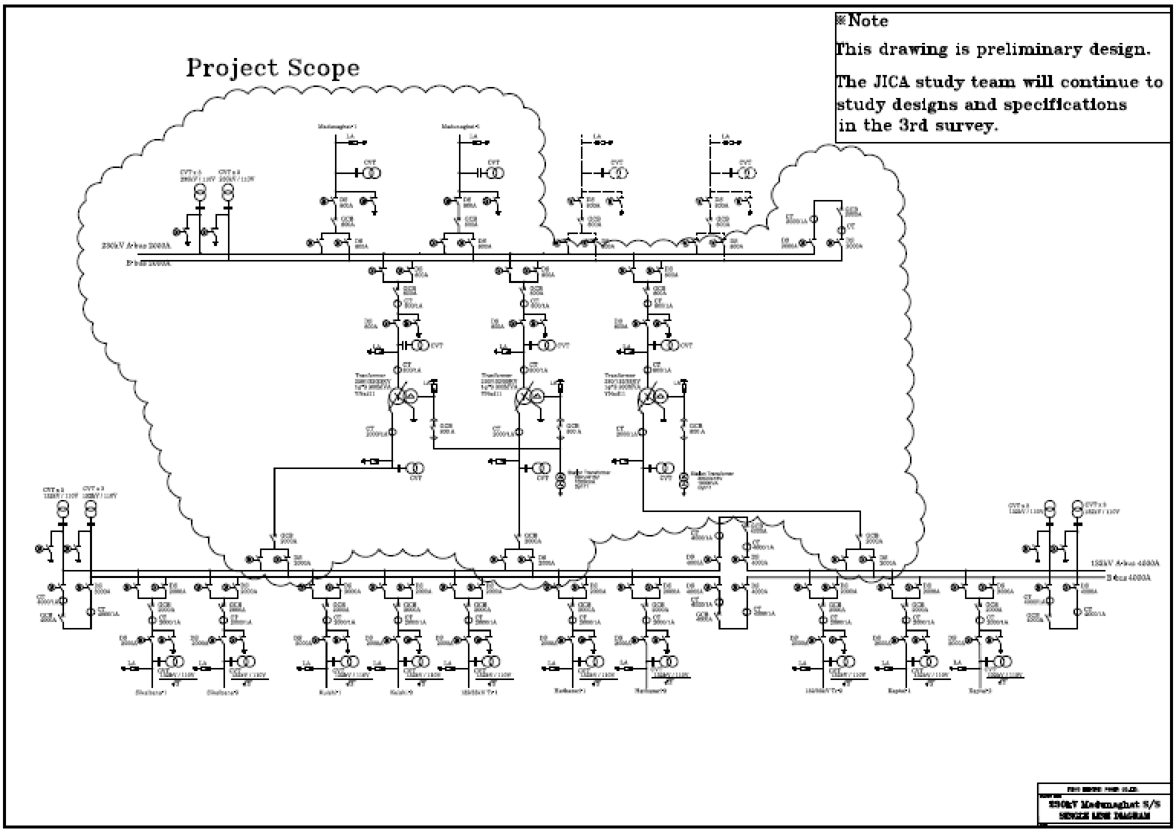


Figure 9.1-6 Single Line Diagram of 132 kV Madunaghat SS

9.2 Location of the Substations

As described, three substations are subject to the Project. The determined locations of the three substations are shown below.

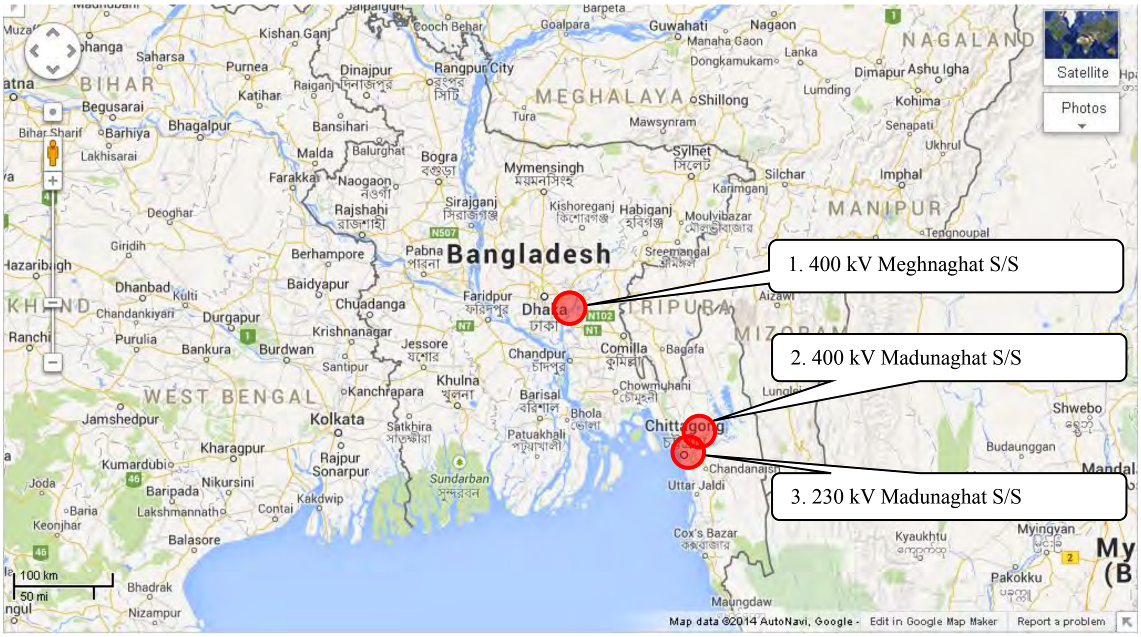


Figure 9.2-1 The Substations' Locations for the Project

The situations of each substation are described in the following sections.

9.2.1 New 400 kV Madunaghat SS

PGCB and JICA selected site #2 for the new 400 kV Madunaghat SS in which the substation will be built in GIS form.

Figure 9.2-2 The Four Locations for New 400 kV Madunaghat SS

Pictures of each location are shown below.

(a) Planned space in Site-1

(b) Planned space in Site-2

(c) Planned space in Site-3

(d) Planned space in Site-4

(Note): To avoid unnecessary disturbance for further land acquisition, some sites are inspected from a distance.

Figure 9.2-3 Pictures of Each Location for New 400 kV Madunaghat SS

PGCB has already compared the four locations based on several criteria as shown in the following table. Based on this comparison, PGCB concluded that Site-1/2/3 could only accommodate a GIS substation due to its limited land availability, while Site-4 can be any form of substation.

Table 9.2-1 Comparison for Site Selection

Site/Location		Site-1		Site-2		Site-3		Site-4	
Location/Mouza Name		Kalu Miyar Tag		Dakhin Islam Nagar		Pahartoli		Gachi	
No.	Items	Description	Points	Description	Points	Description	Points	Description	Points
1	Availability of Required Land	Yes	10	Yes	10	Yes	10	Yes	10
2	Availability of Right of Way (RoW)	Hard	6	Easy	10	Easy	9	Easy	9
3	Length of Connecting T/L (km)	230kV=20 400kV=714	10	230kV=18 400kV=714	10	230kV=25 400kV=725	9	230kV=27 400kV=725	9
4	Complexity Level of Acquiring	Moderate	8	Low	10	Moderate	8	Moderate	8
5	Height of Required Land Filling (Meter)	3.5	8	2	10	3.5	8	4	7
6	Connecting Road (Required/Not Required)	Not Required	10	0.7km road renovation required	8	Not Required	10	0.5km new road & one 50m bridge required	7
7	Load Centre (Comparative position)	Good	10	Good	10	Fair	9	Fair	9
8	Scope of Future Expansion	Yes	10	Yes	10	Yes	10	Yes	10
9	Communication System (Road/Water/Train)	Road	10	Road	10	Road	10	Road	10
10	Owner of Land (Govt./Private)	Private	5	Private	5	Private	5	Private	5
11	Type of Land (Cultivated/Barren)	Cultivated	5	Cultivated	5	Cultivated	5	Cultivated	5
12	Land Cost (Comparative)	High	7	Moderate	8	High	7	Moderate	8
Total			**99**		**106**		**100**		**97**

Since PGCB showed their willingness to include substation cost study in their preliminary on-site study, the substation costs are evaluated and compared each other between GIS case in Site-2 and AIS case in Site-4 as below. In addition, the case of adoption of Hybrid Gas Insulated Switchgear in Site-4 is studied and it was concluded that Hybrid Gas Insulated Switchgear (H-GIS) is not the best solution for this project because the construction cost is expensive compared to AIS form.

Table 9.2-2 Comparison of Rough Estimations for New 400 kV Madunaghat SS

Unit: million USD

	Case 1 (400kV AIS - 230kV AIS)	Case 2 (400kV HGIS - 230kV AIS)	Case 3 (400kV GIS - 230kV GIS)
	site 4 (50Acres)	site 4 (50Acres)	site 2 (20Acres)
400kV Switchgear	13.66	16.50	20.42
230kV Switchgear	2.65	6.00	7.61
Transformer	22.59	22.59	22.59
SCADA, Ry, Aux	10.11	10.11	9.63
Civil and Erection (25% for AIS, 23% for H-GIS 20% for Full GIS)	12.25	12.70	12.05
Construction Cost	**61.26**	**67.90**	**72.30**
Land Acquisition	for 50 Acres	for 50 Acres	for 20 Acres
TL Construction Cost	10	10	0
	+3km LILO, 3km OLD-NEW Madunaghat additional 3km 400KV TL	+3km LILO, 3km OLD-NEW Madunaghat additional 3km 401KV TL	(8Mil)
Technical Loss Increase of line length (for 40 years)	0.7	0.7	0
TOTAL	**72.0+(Land Acquisition)**	**77.90**	**72.3+(Land Acquisition)**

* not so compact for 20 Acres

As per the above table, the cost difference between GIS in Site-2 and AIS in Site-4 is marginal. In addition, from the viewpoint of reliability, GIS form in Site-2 is better than AIS because GIS is enclosed by metal and free from external disturbances in the case of a hurricane. Hence, the location of the new 400 kV Madunaghat SS was selected as a GIS substation in Site-2.

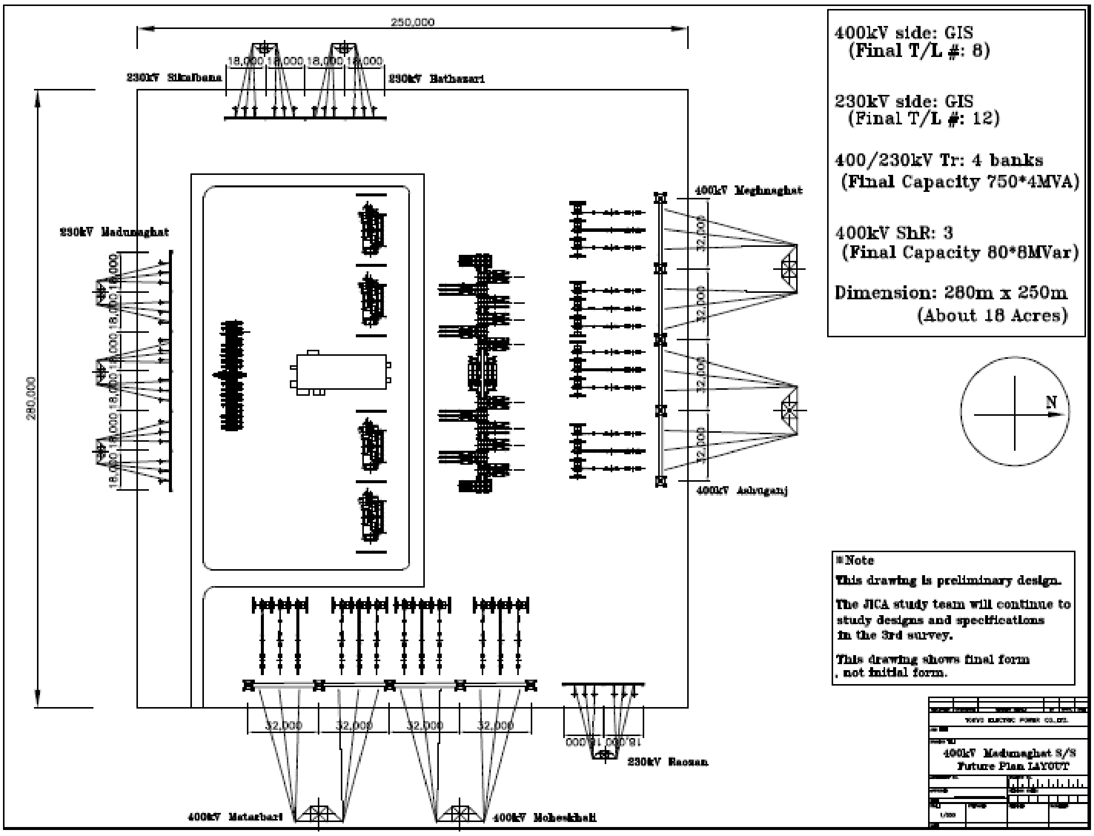


Figure 9.2-4 The Preliminary Layout of Madunaghat SS with GIS Form

As a result of the survey, a mosque is known to be next to the new Madunaghat SS. Hence, green area should be installed in the adjacent area to the mosque on the premises in order to minimize the influence on it. Also, a dormitory for the substation operators will be accommodated in the substation site.

9.2.2 Existing 230kV Meghnaghat Switch Station

New 400 kV units, such as 400 kV Switchgears and Transformers, are installed in the vicinity of the existing Meghnaghat Switch Station. The conditions of the site are nearly flat; hence, it is unlikely to raise any problem of excessive civil cost. The owner of the candidate site is BPDB, so PGCB will acquire the land through exchange with other land.

Figure 9.2-5 Pictures of Candidate Site for New 400 kV unit Meghnaghat Switch Station

AIS type will be used for its cost efficiency as the connection method between the new 400 kV unit and existing 230 kV unit, not Cross Linked Polyethylene (XLPE) cable and Gas Insulated Bus-bar (GIB).
For reference, it is necessary to design the layout avoiding the gas pipelines buried for nearby IPPs.

The existing access road will be used to transport the new equipment for this project. In addition, shipping for heavy and large equipment will be used as well. The unloading work from the river is carried out at a nearby temporary jetty.

(Source: Google Map)

Figure 9.2-6 Site Location for Existing 230 kV Meghnaghat Switch Station

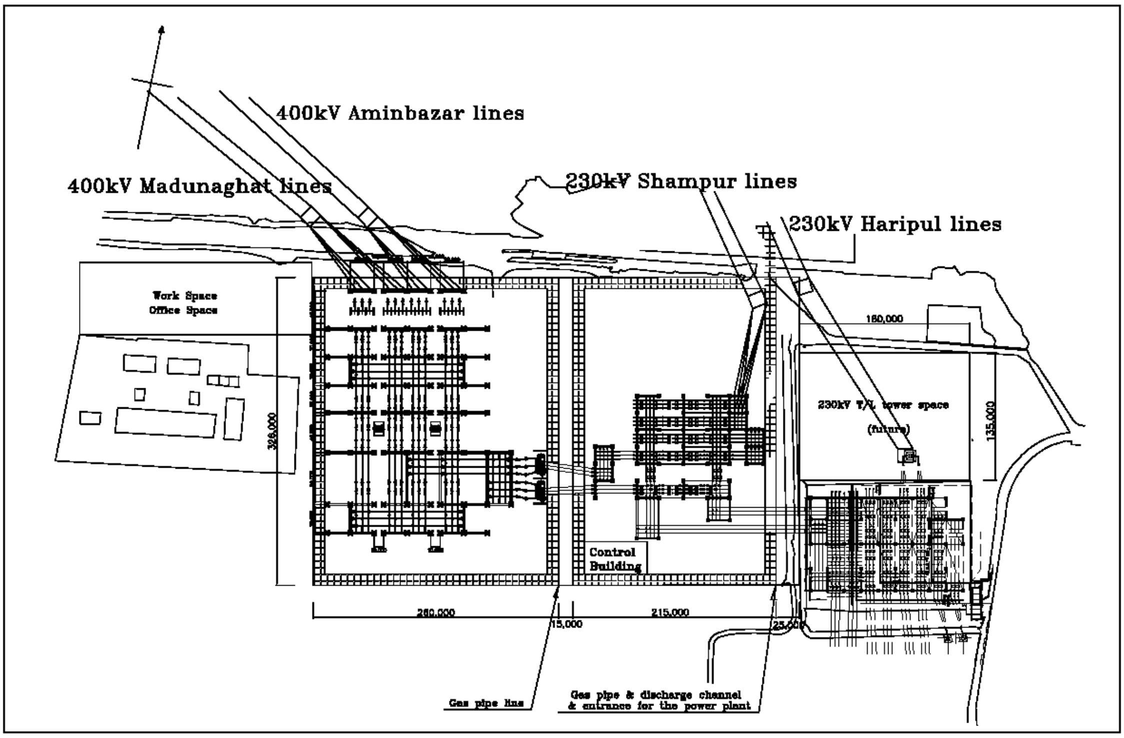
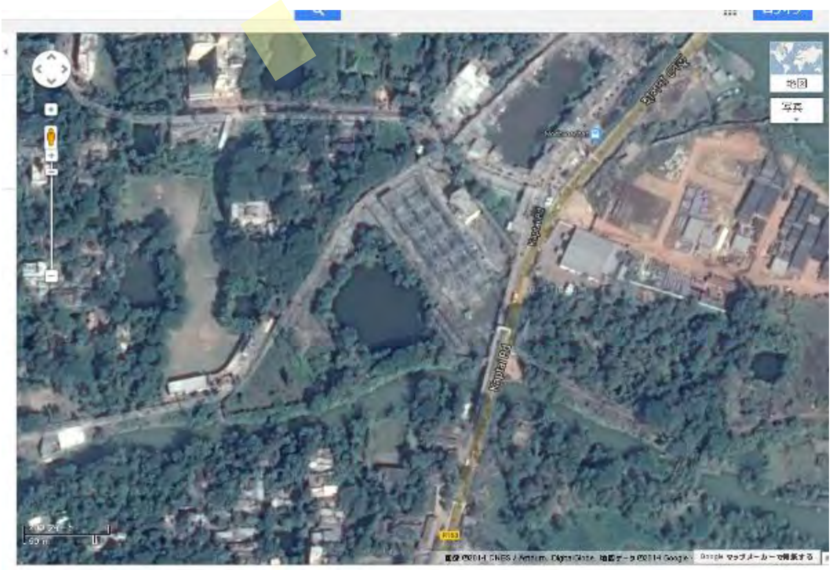


Figure 9.2-7 Tentative Layout of Developed 400 kV Meghnaghat SS

9.2.3 Existing 132 kV Madunaghat SS

The existing 132 kV Madunaghat SS is located in the north-eastern Chittagong area and faces Kaptai Road. Kaptai road will be used to transport the new equipment for this project. However, it is necessary to check if it is possible to transport the new equipment for this project via only Kaptai Road.



(Source: Google Map)

Figure 9.2-8 Site Location of Existing 132 kV Madunaghat SS

The preliminary substation layout is developed as shown below.

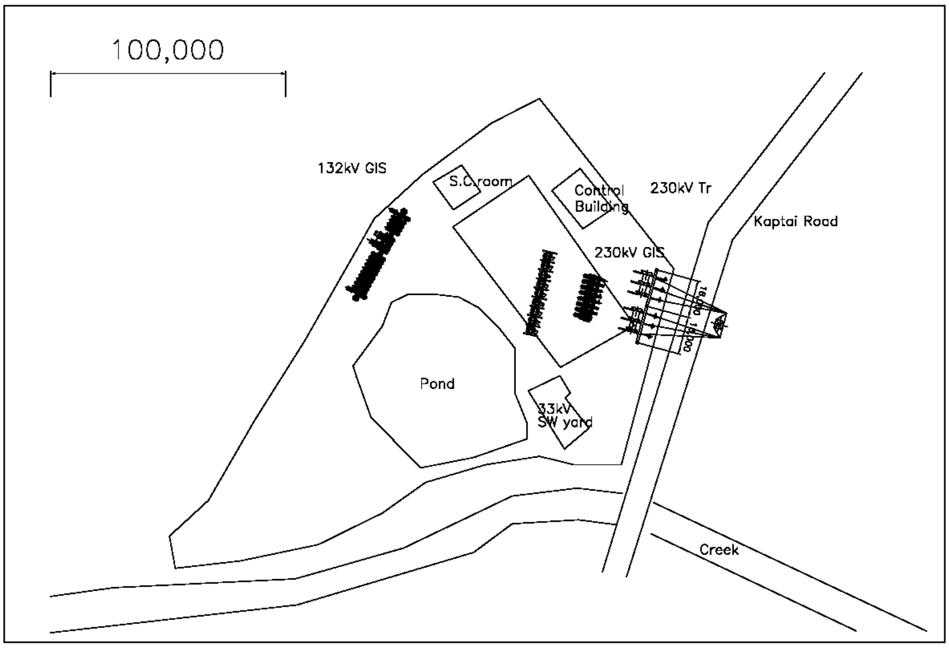


Figure 9.2-9 Tentative Layout of Developed 230 kV Madunaghat SS

9.3 Specifications for the Project's Substations

9.3.1 New 400 kV Madunaghat SS

The specifications of the main equipment for the new Madunaghat SS are shown below as of F/S. The below designs will be studied in the Basic design stage.

Table 9.3-1 Specification for the main equipment for New Madunaghat SS

Name	Specification	Note
Main Transformer	Type: 3-phase or single-phase Rated Voltage: 400/230kV Rated Capacity: 750MVA	Type should be finalized based on the route survey result
Shunt Reactor	Type: single-phase Rated Voltage: 400kV Rated Capacity: 80MVar	Type should be finalized based on the route survey result
400kV Circuit Breaker (Line)	Rated current: 4000A Rated short circuit current: 50kA	GIS Form
400kV Disconnector (Line)	Rated current: 4000A Rated short circuit current: 50kA	GIS Form
400kV Busbar	Rated current: 6000A	GIS Form
230kV Circuit Breaker (Line)	Rated current: 4000A Rated short circuit current: 50kA	GIS Form
230kV Disconnector (Line)	Rated current: 4000A Rated short circuit current: 50kA	GIS Form
230kV Busbar	Rated current: 6000A	GIS Form
Communication Method	Optical Fibre, PLC	
Protection Relay for T/L	[Main] PCM	Backup is under consideration
Protection Relay for Tr	[Main] Current Differential	Backup is under consideration
Protection Relay for Busbar	[Main] Current Differential	Backup is under consideration

As of F/S stage, it is not apparent whether it is possible to transport a 3-phase transformer from the viewpoint of transportation route conditions, such as the width and load capacity. Hence, based on the further route survey, the type of transformer should be finalized in the basic stage.

In terms of 400 kV circuit breaker's specifications, special functions, such as Pre-Insert Resistor and Point-on-Wave Control, may be necessary to limit the switching surges. The details of the specifications will be determined by clarifying advantageous technologies in the basic design stage.

9.3.2 230kV Meghnaghat Switching Station (to be expanded to a 400kV Substation)

The specifications of the main equipment for the existing 230 kV Meghnaghat SS are shown below as of F/S. The basic designs must be reviewed in the Basic design stage so that substation design and construction scheduling can be optimized among multiple construction entities.

Table 9.3-2 Specification for the main equipment for Meghnaghat SS

Name	Specification	Note
Main Transformer	Type: 3-phase or single-phase Rated Voltage: 400/230kV Rated Capacity: 750MVA	Type should be finalized based on the route survey result
Shunt Reactor	Type: single-phase Rated Voltage: 400kV Rated Capacity: 80MVar	Type should be finalized based on the route survey result
400kV Circuit Breaker (Line)	Rated current: 4000A Rated short circuit current: 40kA	GIS Form
400kV Disconnector (Line)	Rated current: 4000A Rated short circuit current: 40kA	GIS Form
400kV Busbar	Rated current: 6000A	GIS Form
230kV Circuit Breaker (Line)	Rated current: 3000A Rated short circuit current: 50kA	GIS Form
230kV Disconnector (Line)	Rated current: 3000A Rated short circuit current: 50kA	GIS Form
230kV Busbar	Rated current: 6000A	GIS Form
Communication Method	Optical Fibre, PLC	
Protection Relay for T/L	[Main] PCM	Backup is under consideration
Protection Relay for Tr	[Main] Current Differential	Backup is under consideration
Protection Relay for Busbar	[Main] Current Differential	Backup is under consideration

As per Section 9.3.1, the transformer type and circuit breaker’s function will be studied in the basic design stage.

9.3.3 Existing 132 kV Madunaghat SS (to be converted to 230kV Madunaghat SS)

The specifications of the main equipment for the existing 132kV Madunaghat SS are shown below as of F/S. The below designs will be studied in the Basic design stage.

Table 9.3-3 Specification for the main equipment for Existing Madunaghat SS

Name	Specification	Note
Main Transformer	Type: 3-phase or single-phase Rated Voltage: 230/132kV Rated Capacity: 300MVA	Type should be finalized based on the route survey result
230kV Circuit Breaker	Rated current: 1200A Rated short circuit current: 50kA	GIS Form
230kV Disconnector	Rated current: 1200A Rated short circuit current: 50kA	GIS Form
230kV Busbar	Rated current: 1200A	GIS Form
132kV Circuit Breaker	Rated current: 2000A Rated short circuit current: 50kA	GIS Form
132kV Disconnector	Rated current: 2000A Rated short circuit current: 50kA	GIS Form
Communication Method	Optical Fibre, PLC	
Protection Relay for T/L	[Main] Distance	Backup is under consideration
Protection Relay for Tr	[Main] Current Differential	Backup is under consideration
Protection Relay for Busbar	[Main] Current Differential	Backup is under consideration

9.4 Services provided by telecommunication system and required equipment

Substation needs the following telecommunication services:

- Telephony (Voice)
- Data acquisition (Supervision)
- Tele-operation (Supervisory Control)
- Tele-protection (Communication Aided Protection)

Based on PGCB design philosophy of telecommunication systems, the new substation and neighboring substations need the following equipment.

- Tele-protection
- Optical Multiplexer (SDH, PDH)
- PLC
- PAX (Private Automatic Exchange)
- Power Source: for Telecommunication equipment

The cores of OPGW are 48, based on PGCB design philosophy. SDH and PDH are to be installed as the transmission system and connected to Meghnaghat, Madunaghat and Matarbari PS. PLC is to be installed for the backup line of the tele-protection system of more than 400kV transmission line. (i.e. Meghnaghat–New Madunaghat–Matarbari PS).

Meghnaghat SS and the existing Madunaghat SS are built, owned and operated by PGCB while the same is carried out by CPGCBL for Matarbari Power Station.

Thus, the telecommunication facilities at Matarbari Power Station should be built by CPGCBL in the same manner. However, the telecommunication facilities at both sides of New Madunaghat and Matarbari should operate on the same protocol and specification, or those facilities will not work.

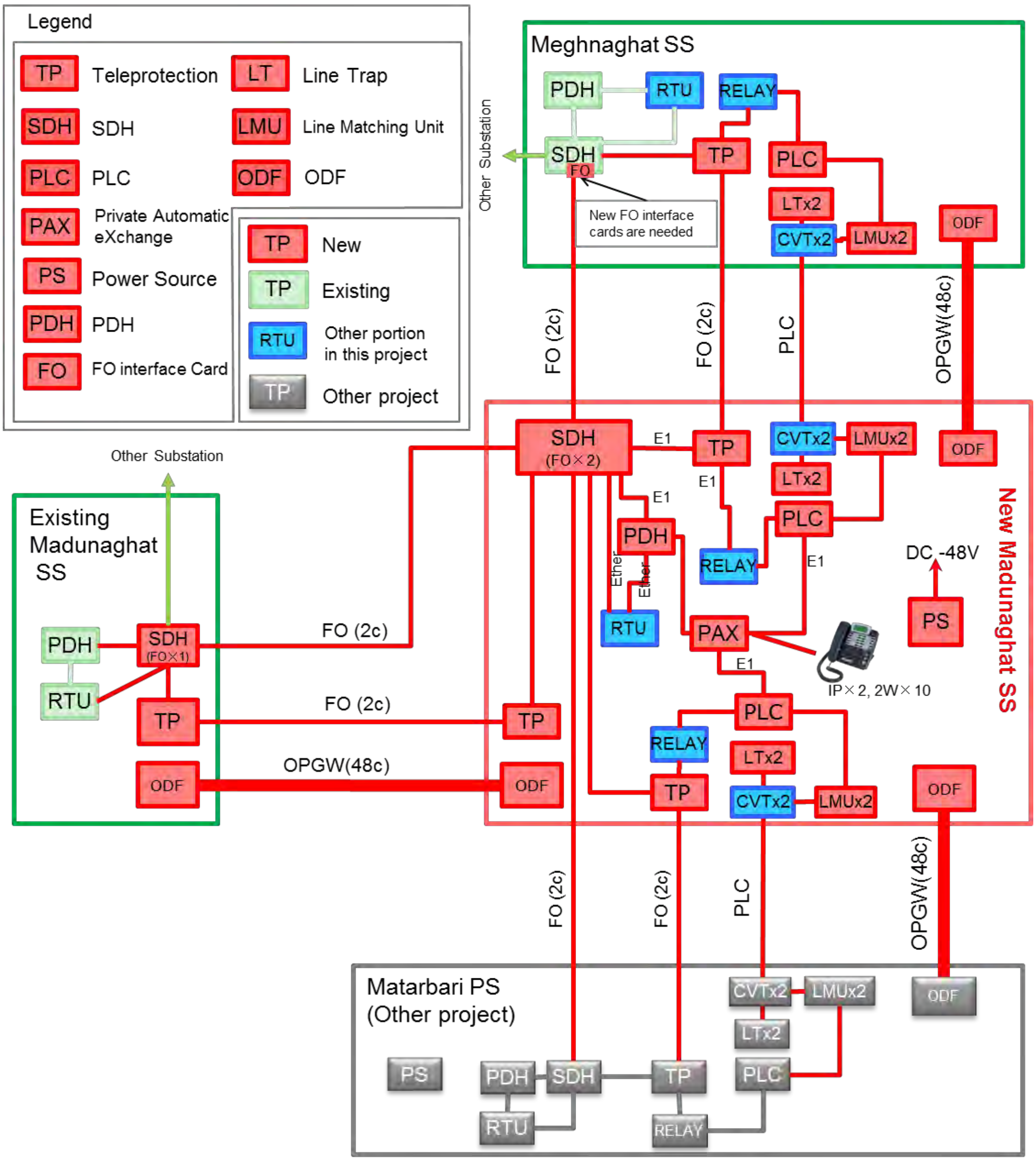


Figure 9.4-1 Outline Design of Telecommunication System for New Substation

Chapter 10

Proposed Maintenance/Replacement of NLDC

Chapter 10 Proposed Maintenance/Replacement of NLDC

10.1 The Repair Proposal of an Existing NLDC System

10.1.1 Maintenance of an existing NLDC system

Most components of the existing NLDC system has expired its maintenance end, or are reaching the maintenance end, except Front End Server 3 and 4, which was extended in recent years. Hardware life prolongation will become impossible in the near future, and it is inevitable. When the server of a NLDC system breaks down, it will be replaced with same type server by taking out the healthy server from the backup system. To renew the system, it is recommended for NLDC operator to make arrangements with a system vendor periodically to discuss the maintenance and renewal method.

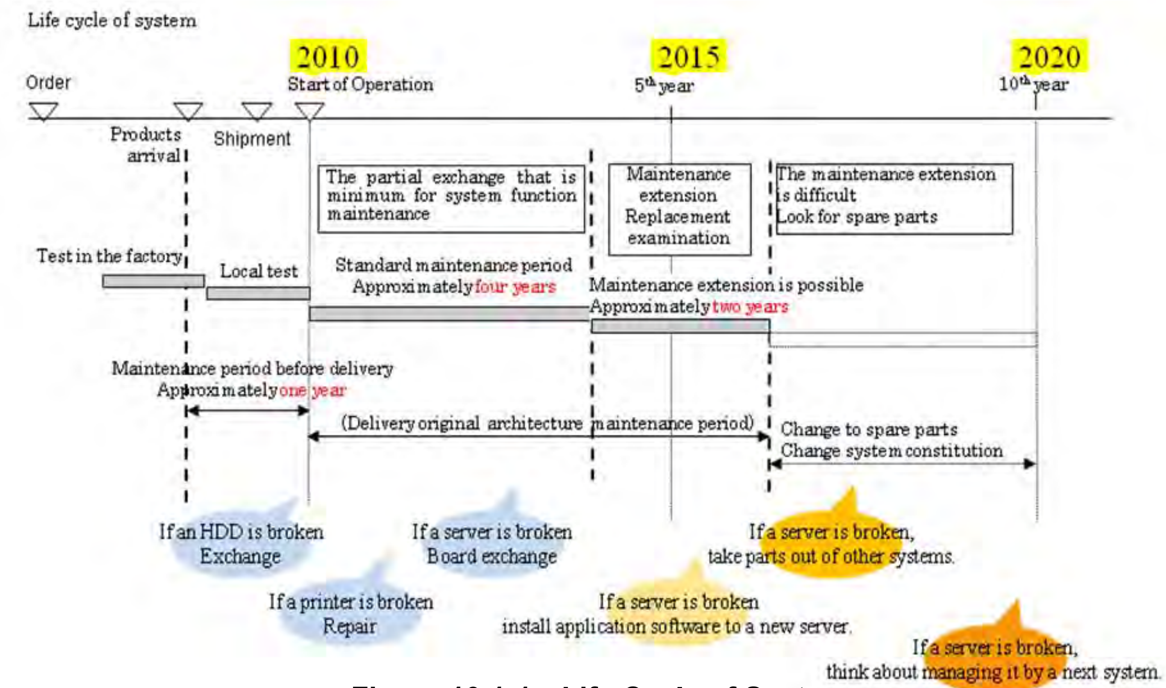


Figure 10.1-1 Life Cycle of System

Table 10.1-1 Maintenance Plan for NDLC system

Item	2014 – 2016	2016 - 2018	2018 - 2020
Method	Replace old device with healthy device from backup system.	Replace discontinued device with a new model	Replace the whole system
Function	No change in operative function.	No change in operative function.	Able to consider compatibility with future power grid. Ex. Develop compatibility with renewable energy Source:s control, grid expansion, and additional plan degree function.
Cost	Small - Hardware replacement - Software installation	middle - New hardware procurement - Hardware replacement - Software installation to new OS - Software settings	large - New SCADA /EMS system procurement.
Reliability	Degradation - Reliability of the whole system decreases due to replacing parts from backup system.	equivalent - No change in system composition. Hardware (HW) selectable from latest model.	equivalent - HW adopts the latest model, and the system constitution shall be equal to the present or appropriate.
Performance	Equivalent - HW is equivalent to conventional system deployed.	equivalent - Performance of the whole system is equivalent to conventional system deployed	rise - Performance would rise by the introduction of the latest hardware model

Table 10.1-2 Maintenance Status of Main Servers of NDLC (exceeded deadline indicated in red)

Server	Code	Serial Number	Model	OS	Individual date of Deadline for maintenance	Deadline for product maintenance
SCADA/EMS Server 1	BDNDS01	GB8628DD9P	HP ProLiant DL580 G3	Linux	Jul 31,2009	Sep 30,2015
SCADA/EMS Server 2	BDNDS02	GB8628DD96	HP ProLiant DL580 G3	Linux	Oct 15,2009	Sep 30,2015
HIS Server	BDNHS01	GB8628DD9L	HP ProLiant DL580 G3	Linux	Oct 15,2009	Sep 30,2015
ARCHIVE Server	BDNAS01	GB8627CXHT	HP ProLiant DL380 G4	Win2003	Oct 8, 2009	Sep 30,2015
Storage	BDNCK01	<offline>	HP StorageWorks 1/8 autoloader	-		
Storage	BDNTL01	<offline>		-		
RSC Server	BDNRS01		HP ProLiant ML350 G4p	Win2003		Sep 30,2015
WEB Server 1	BDNWI01	GB8627CXJT	HP ProLiant DL380 G4	Win2003	Oct 8, 2009	Sep 30,2015
WEB Server 1	BDNWI02	GB8627CXJ4	HP ProLiant DL380 G4	Win2003	Oct 8, 2009	Sep 30,2015
Front Ends Server 1	BDNFE01	GB8627CXJ8	HP ProLiant DL380 G4	Win2003	Oct 8, 2009	Sep 30,2015
Front Ends Server 2	BDNFE02	GB8627CXHH	HP ProLiant DL380 G4	Win2003	Oct 8, 2009	Sep 30,2015
Front Ends Server 3	BDNFE03	SGH250HXYL	HP ProLiant DL380e Gen8		Jan 16,2016	
Front Ends Server 4	BDNFE04	SGH250HXYJ	HP ProLiant DL380e Gen8		Jan 16,2016	
PDS/GENESYS Server	BDNDC01		HP ProLiant DL380 G4	Win2003	Aug 12,2009	Sep 30,2015
DTS Server	BDNDS03	GB8628DD9J	HP ProLiant DL580 G3	Linux	Oct 15,2009	Sep 30,2015
OAG Server 1	BDNIC01	GB8628D6YS	HP ProLiant DL380 G4	Win2003	Aug 12,2009	Sep 30,2015
OAG Server 2	BDNIC02	GB8627CXJH	HP ProLiant DL380 G4	Win2003	Aug 8,2009	
Supervisor Workstation		(Unconfirmed)	HP ProLiant ML350 G4p	WinXPpro	(Unconfirmed)	Jun 30,2015
Operator Workstation		(Unconfirmed)	HP ProLiant ML350 G4p	WinXPpro	(Unconfirmed)	Jun 30,2015
Other Workstations 4	BDNOC04	CZC6270350	XW4300? Compaq dc7600 Small Form Factor PC	WinXPpro	-	Dec 31,2011
Other Workstations 20	BDNOC20	CZC6281G5X	XW4300 Workstation	WinXPpro	-	Dec 31,2011
Other Workstations 21	BDNOC21	CZC6281G62	XW4300 Workstation	WinXPpro	-	Dec 31,2011
DLP		6890045570	(Unconfirmed)		(Unconfirmed)	

Table 10.1-3 Maintenance Status of Bidyut Bhaban System Servers (exceeded deadline indicated in red)

Server	Code	Serial Number	Model	OS	Individual date of Deadline for maintenance	Deadline for product maintenance
SCADA/EMS Server	BDBDS01	(Unconfirmed)	HP ProLiant DL580 G3	Linux	(Unconfirmed)	Sep 30,2015
HIS Server	BDBHS01	(Unconfirmed)	HP ProLiant DL580 G3	Linux	(Unconfirmed)	Sep 30,2015
ARCHIVE Driver	BDBAD01	(Unconfirmed)	HP ProLiant DL380 G4	Win2003	(Unconfirmed)	Sep 30,2015
OAG Driver	BDB1C01	(Unconfirmed)	HP ProLiant DL380 G4	Win2003	(Unconfirmed)	Sep 30,2015
WEB Interface	BDBW101	(Unconfirmed)	HP ProLiant DL380 G4	Win2003	(Unconfirmed)	Sep 30,2015
TFE/CFE Server		(Unconfirmed)	HP ProLiant DL380 G4	Win2003	(Unconfirmed)	Sep 30,2015
RSC Server	BDBRS01	(Unconfirmed)	HP ProLiant ML350 G4p	Win2003	(Unconfirmed)	Sep 30,2015
Other Workstations 1-3	BDBOC 01～03	(Unconfirmed)	HP ProLiant ML350 G4p	Win2003	(Unconfirmed)	Sep 30,2015
Other Workstations 4-9	BDBOC 04～09	(Unconfirmed)	XW4300	WinXPpro	-	Dec 31,2011

10.1.2 Necessary additional functions for the next generation SCADA/EMS

For Bangladesh (or NDLC), it is necessary to create the central load dispatching office equipped with the advanced power system operation function mentioned below, in order to operate the power system from 2020 and onwards. It should be considered, that such system development, as well as personnel training, requires time and continuous investment to fully understand and operate the system deployed.

Demand Forecast: The demand forecast function predicts the gross demand for the next day by using multiple regression analysis based on previous demand data, past weather conditions, type of the day (i.e. day of the week, singular point, etc.), and future weather forecast information. For weather forecast, the Bangladesh weather forecast data shall be gained using the Internet.

Generation Scheduling: The Generation Scheduling (Resource Scheduling (RS)) function finds the least-cost dispatch of available generation resources to meet the electrical load and required reserve. In order to use the planning information of plant for this function, cooperation between NLDC and power plant will be required.

Supply and demand Control: EMS controls power output of generator based on the combination of LFC and Economic Dispatch Control (EDC). The combination of LFC and EDC is called AGC.

Since in this function, control value is calculated based on generator characteristic, the cooperative relations of NLDC and power plants will be required.

Voltage and Reactive power control (VQC): This function send reactive power signal to generators to regulate voltage targeted to this function. Reactive power signal originates from operators' key input value. Voltage regulation control value is sent from the operator. Operator shall confirm if the actual voltage reaches the target or not.

System Analysis (frequency calculation, load flow analysis): Since short-circuit capacity increases with introduction of 400 kV transmission lines, system analysis becomes important. It is calculated what kind of influence arbitrary supply-and-demand conditions are given based on the online information of a system, and it has on a system.

Since to operate the system requires technical knowledge about operation data analysis, operator is required to understand about function as well as hardware operation. Personnel training require 2 to 3 years training.

Record and Statistics: Recorded statistical data will serve as a foundation in demand forecast and system analysis. Therefore it is important to record system monitoring information correctly and to store statistical information for future reference. Daily Reports are stored in the style which takes in monitoring information by a system function and an operator corrects.

10.1.3 Preparation before the next system introduction

Before the beginning of operation of the next system, the enforcement period of personnel training, system analysis, and system development will be required. Therefore, it is strongly recommended for NLDC, vendors, and any relating actors to start the next systems development at an early stage.

10.2 Introduction of Power System Stabilizing Scheme

After the entire power system blackout on 1st Novemnber, 2014, Government formed an investigation team to identify the root cause and preventive measures. According to the JICA Survey Team's preliminary study, Power System Stabilizing Scheme sometimes fails due to the heavily loaded transmission lines around Chittagong. Further study shall be made based on the investigation team's report and JICA's next capacity building after reviewing the future grid's configuration.

10.3 Automatic Generation Control (AGC)

AGC shall be developed in not only technology matter but also power purchase agreement issue between NLDC and respective power plant.

First of all, AGC implementation physically needs the SCADA AGC functions and the controlled power generation plant connected to SCADA system on real-time channel.

The technical improvement process shall be planned as follows.

1) Identify whether the current SCADA system can perform the required AGC functions through the AGC simulation test and what kind of data is necessary for AGC regarding with power generation characteristics.
2) Investigate some favorable power plants about the interface of real-time power generation control including power setting signal, generation limitations and generation response time.
3) AGC field-test between NLDC and model power plants by connecting each other through the on-line signal
4) Expand the AGC control to other effective power plants such as IPP and new P/S.

From Japanese power utility experience, total of AGC power reSource:s are estimated to be 1% of maximum power demand, i.e. if the power demand is max of 7,000 MW, the required AGC generation power will be 70 MW and Gas Turbine and Combined Gas Turbine are suitable for flexibility of generation adjustment.

Secondly, it is necessary for AGC implementation to revise the power purchase agreement between power plant and BPDB because there is no agreement regarding AGC service.

It is preferable to introduce the ancillary service fee in order to encourage the private power plant to cooperate with NLDC for frequency control, reactive power adjustment and/or voltage regulation.

This power purchase agreement issue shall be discussed with BPDB.

10.4 Telecommunication System

A very large majority of substations in PGCB have now been connected by OPGW. Optical transmission system with OPGW is used for primary communication lines, and PLC is used for backup communication lines. Optical transmission equipment using OPGW was first introduced to PGCB in 2005. So, the optical transmission equipment is still good enough to use. PGCB said that there are no critical failures in their telecommunication facilities at the present.

However, PGCB have been using GPRS for data transmission between NLDC and some power stations. GPRS has potential risks from the viewpoint of security and service sustainability, so this telecommunication system should be replaced with a private network in the future. In particular, the telecommunication link with AGC power station is recommended to be switched to a private network urgently.

10.5 Necessary Organization Restructuring and Review of Codes and Contracts

To solve issues in current generation planning, such as uncertainty in fuel supply, limited amount of spinning reserve, slow response of generation unit due to obsolete generator control over voice, the new power system planning and operational procedures must be developed by maximizing on-hand reSource:s with the information already available in NLDC. After the approval of the revision of Electricity act, the Grid Code must be revised to increase NLDC's authority in generation planning, and practical workflow of short-term generation planning should be developed.
After confirming the effectiveness of AGC of selected generators, revised planning and operational rules and procedures must be developed and agreed mutually by NLDC, BPDB, and IPP operators. Details of proposed procedures shall be studied during the next

In accordance to the review of Grid Code, introduction of ancillary services and its incentives for power producers shall be studied and shall be reflected to corresponding Power Purchase Agreements so that faster and effective control of power system can be achieved.

Chapter 11
Implementation Plan
and
Procurement Policy

Chapter 11 Implementation Plan and Procurement Policy

11.1 Implementation and Procurement Policy of the Project

11.1.1 Implementation Policy

The Project is composed of the packages shown in Table 11.1-1 and these packages will be implemented in two stages, as shown in Table 11.1-2.

Table 11.1-1 Packages of the Project

No.	Contents of the Package
TL-1	- 400 kV Meghnaghat - Madunaghat T/L - 230 kV LILO at Madunaghat SS from 230 kV Hathazari – Sikalbaha T/L
TL-2	- 400 kV Madunaghat - Matarbari T/L
TL-3	- 230 kV Madunaghat - Old Madunaghat T/L
SS-1	- 400/230 kV Meghnaghat SS with 400/230 kV transformers and 400 kV bays
SS-2	- 400/230 kV Madunaghat SS with 400/230 kV transformers and 400 kV bays with GIS facilities
SS-3	- 230/132 kV Madunaghat SS
AR-1	- Access roads for 400/230 kV Madunaghat SS

The packages, except for AR-1, will be executed in turn-key contracts.

Table 11.1-2 Phasing of the Project Components

Package No.	Phase 1	Phase 2
TL-1	●	
TL-2		●
TL-3		●
SS-1	●	●
SS-2	●	●
SS-3		●
AR-1	●	

The responsibilities of the executing agency, consultants and contractors of the Project are assumed to be as below.

(1) Executing agency of Bangladesh side

The executing agency for the Bangladesh Project is PGCB. PGCB will be responsible for the following during implementation.

(a) Organization of a new implementation unit for the Project
(b) Coordination among the related ministries, provincial authorities and other authorities concerned for smooth implementation of the Project
(c) Acquisition of rights to enter designated project areas and acquisition of and/or compensation for lands and houses within the right of way of the transmission lines
(d) Prior securing of the environmental certificate for the Project
(e) Appointment of the Project consultants and cooperation with/assistance for them
(f) Close communication with JICA 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 the 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 the employees for operation and maintenance of the transmission line facilities
(l) Proper operation and maintenance of the transmission line facilities after commissioning.
PGCB should secure budget and staff to execute the above duties

(2) Consultants

The consultants will be responsible for the following particulars.

(a) Basic design of the Project including site survey, system switching procedure, and transmission line route investigation
(b) Preparation of the design report (subject to the approval of PGCB)
(c) Preparation of the bidding documents (subject to the approval of PGCB)
(d) Assistance for PGCB in the evaluation of proposals submitted by bidders (technical and financial)
(e) Assistance for PGCB in contract negotiations with prospective bidders and in conclusion of the contracts
(f) Examination of manufacturing/working drawings and various communications from the contractors 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' on site work
(i) Examination of O&M manuals for the completed facilities submitted by the contractors
(j) Inspection of facilities immediately prior to expiration of the guarantee period for the facilities
(k) Transfer of technical knowledge to PGCB staff in charge of the Project
(l) Development of the completion report

(3) Contractors

The contractors should be fully responsible for the following work 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/erection work and installation of the equipment and materials
(e) Verification of proper functions of all the facilities completed
(f) Commissioning of the facilities to PGCB,
(g) Preparation of O&M manuals for the completed facilities and the completion report
(h) Transfer of knowledge to PGCB through their working period for construction, maintenance and operation of the Project facilities

11.1.2 Procurement Policy

(1) Mode of procurement

The contractors for the Project, composed of three transmission line packages and three substation packages, will be selected through ICB (International Competitive Bidding) mode for turn-key basis.

(2) Procurement Sources

The Source:s of the facilities/equipment for the Project will not be limited in principle because of the ICB-based procurement. However, the contractors 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 contractors 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 the facilities

It will be specified in the contract documents that the contractors should guarantee all functions of the facilities provided under the Project for a certain period after commissioning. Besides, it is also recommended that the contractors will train on the job site of PGCB's operators and maintenance staff during the construction period and for a certain period after commencement of substation operations. A special term will be included in the contract documents as one of the contractors' duties.

11.1.3 Scope of Services of the Consultants

The services of the consultants 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 lines and substations. The consultants 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 consultants will execute the detailed design, cost estimate and detailed implementation plan for the Project through discussion with PGCB and in accordance with the results of the field survey and investigation. A design report, prepared by the consultant, will cover the entire results of the design. After approval of the design report by the funding institutions or in parallel with the report preparation, the consultant will prepare bidding documents for the Project.

(b) Public bidding and contract

The consultants will carry out assistance for PGCB during public announcements of bid, bid opening, bid evaluation, contract negotiation and preparation of the contract documents.

(c) Procurement management

The consultants will manage all work for examinations of the contractors' drawings and designs, and inspections/tests of equipment/materials at the contractors' factories.

(d) Supervision of contractors' on site work

Through the whole period of the contractors' on site work, the consultants will supervise all the on site work. The consultants will have responsibility for education of PGCB's operators and maintenance staff regarding the facilities after completion of the Project.

(e) Commissioning test and inspection for defect liability period

After completion of the construction of all facilities, the consultants will supervise the contractors' commissioning tests of individual facilities for the transmission lines as well as the substations, and also for the system operation test combining both the transmission lines and the substations. Furthermore, the consultant will check the Project completion report and O&M manuals of the completed facilities to be submitted by the contractors, and assist PGCB with their procedures for issuing taking over certificates to the contractors. Immediately before the expiration of the defect liability period of the Project facilities, the consultants, in conjunction with PGCB, will inspect all the Project-related facilities for issuing final certificates to the contractors.

(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 reject the proposals of the contractors and order them to re-design to fully comply with the contract specifications if needed.

(b) Inspections 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 to assure their quality. PGCB staff will be witness to these factory inspections and tests.

(3) Quality control during construction

(a) Construction drawings

The consultants will order the contractors to submit construction drawings, construction schedules and plans for quality control of the work, and manage quality control and progress of the work done by the contractors.

(b) Tests of materials

The consultants will order the contractors 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 contractors to carry out compression tests on concrete pieces sampled by the consultants from mixing batches.

(c) Control of on site work

During the construction period of transmission lines (foundation work, tower erection and stringing) and substations (land formation, foundation work, installation of substation buildings and equipment), the consultants and PGCB inspectors will check for damage to equipment and materials, and order the repair or replacement of damaged equipment and materials if found. Prior to the issuing of payment certificates to the contractors, the consultants and PGCB inspectors will inspect not only the construction progress but also the quality of all the facilities claimed by the contractors in their application of the payment.

(d) Commissioning tests

The consultants and PGCB will finally confirm quality of the facilities by comprehensive commissioning inspections and tests to be carried out before taking over the facilities.

11.1.4 Expertise Requirements

The assumed consultancy services for construction of the transmission lines and the substations are provided by the foreign and local consultants listed below, which shall include but not be limited to the following.

(1) Foreign consultants

(a) Project Manager
(b) Deputy Project Manager (Transmission Line)
(c) Deputy Project Manager (Substation)
(d) Transmission Line Engineer (Electrical)
(e) Substation Engineer (Electrical)
(f) Transmission Line Engineer (Tower)
(g) Substation Engineer (Structure)
(h) Transmission Line Engineer (Civil)
(i) Control System Engineer
(j) Environmental Expert
(k) Protection System Engineer
(l) Commercial and Procurement Expert
(m) Communication System Engineer
(n) Legal Expert
(o) Civil Engineer (Substation)
(p) Safety Expert

(2) Local consultants

(a) Leader
(b) Civil Engineer (Transmission Line)
(c) Civil Engineer (Substation)
(d) Transmission Line Engineer
(e) Substation Engineer
(f) Environmental Specialist
(g) Control System Engineer
(h) Legal and Contractual Expert
(i) Protection System Engineer
(j) Procurement Materials Control Expert
(k) Document Control and Administration

11.2 Implementation Schedule of the Project

11.2.1 Implementation Schedule for Construction of the Transmission Lines

Regarding the 400 kV Meghnaghat – Madunaghat T/L, for which the total length is approximately 214 km, and the 230 kV LILO at Madunaghat SS from Hathazari – Sikalbaha T/L, of approximately 5 km in total, it seems that the construction of these transmission lines will be completed in 34 months considering 2 dry seasons and some margin, assuming that there is no major difficulty in terms of land acquisition and compensation that influences the construction period and considering the aforementioned actual achievement.

On the other hand, it seems that the construction of the 400 kV Madunaghat – Matarbari T/L, for which the total length is approximately 92 km, and the 230 kV Madunaghat – Old Madunaghat T/L, of approximately 8 km in total, will be completed in 30 months under the above mentioned conditions.

The expected implementation schedule of the transmission lines of the Project from the selection of consultant until the commencement of operation through the contract with the contractors is shown in the Figure below.

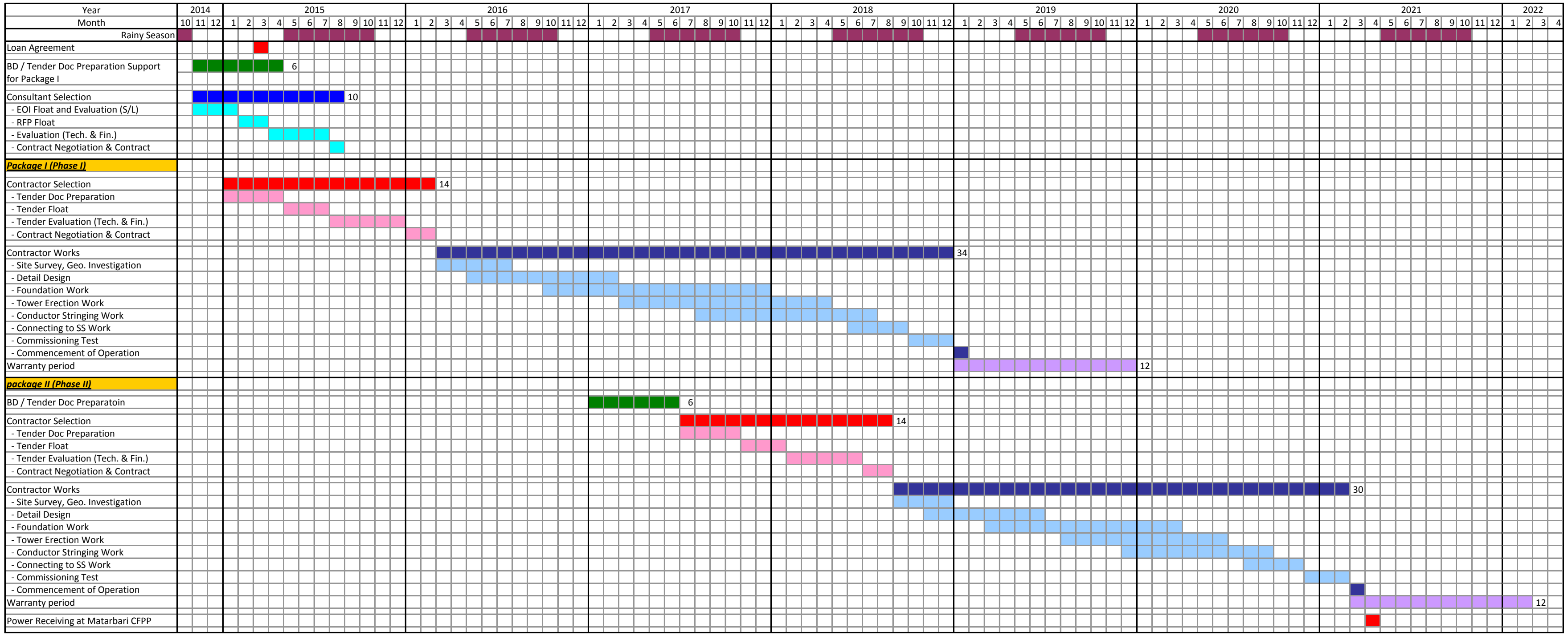


Figure 11.2-1 Implementation Schedule for Construction of the Transmission Line

11.2.2 Implementation Schedule for Construction of the Substations

The expected implementation schedules for each substation of the Project from the selection of consultant until the commencement of operation through the contract with the contractors are shown from the next page.

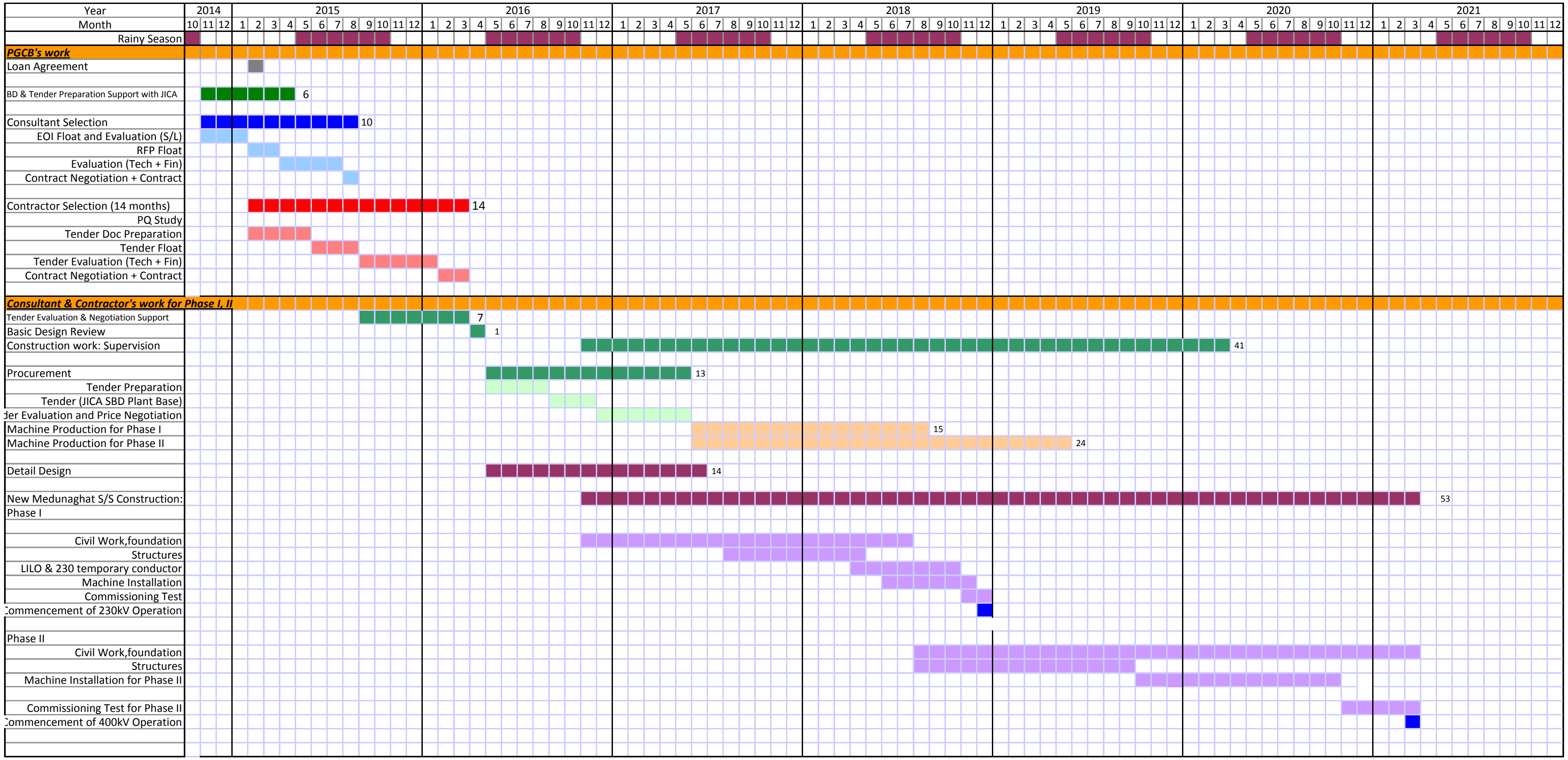


Figure 11.2-2 Implementation Schedule for Construction of the 400/230 kV Meghnaghat SS

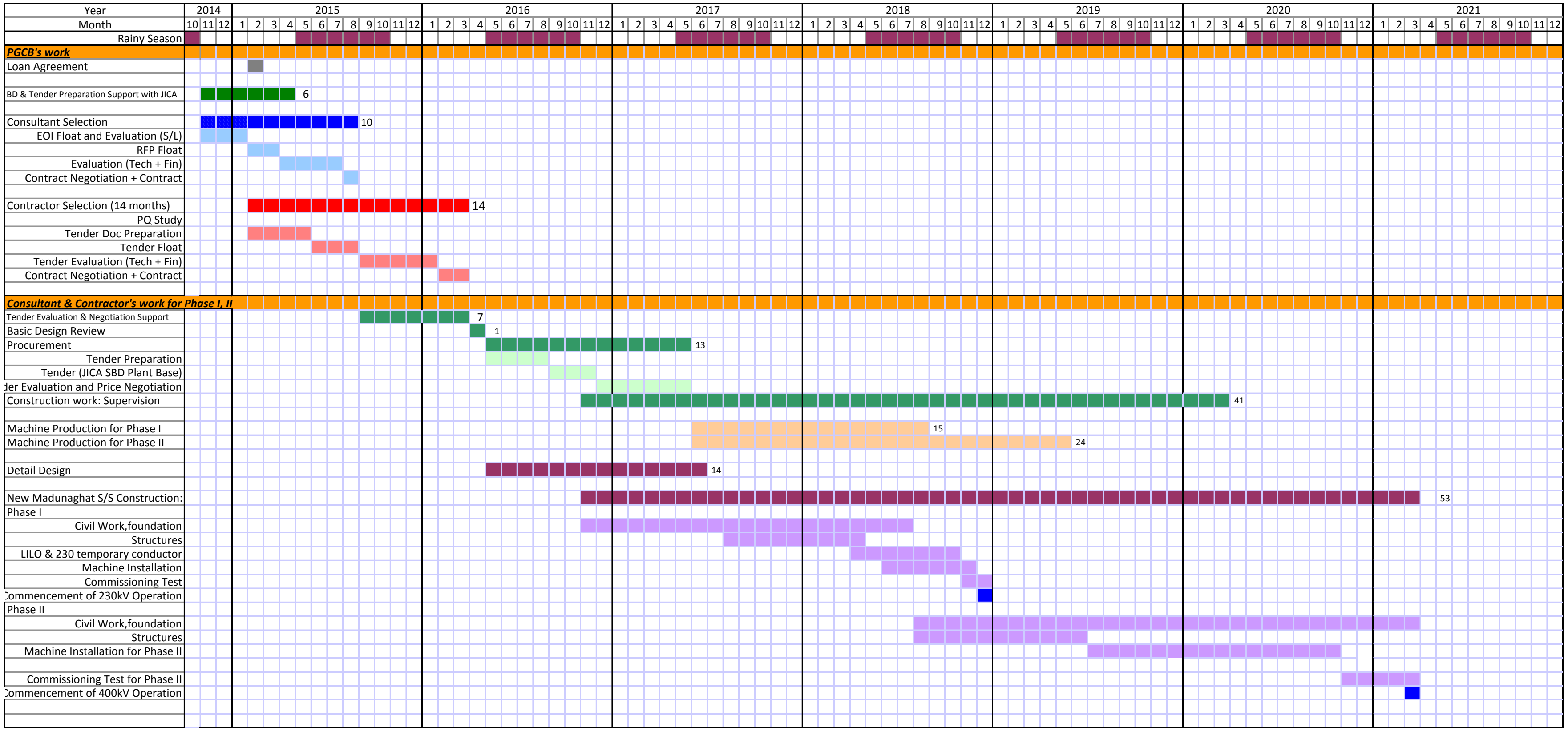


Figure 11.2-3 Implementation Schedule for Construction of the 400/230kV Madunaghat SS

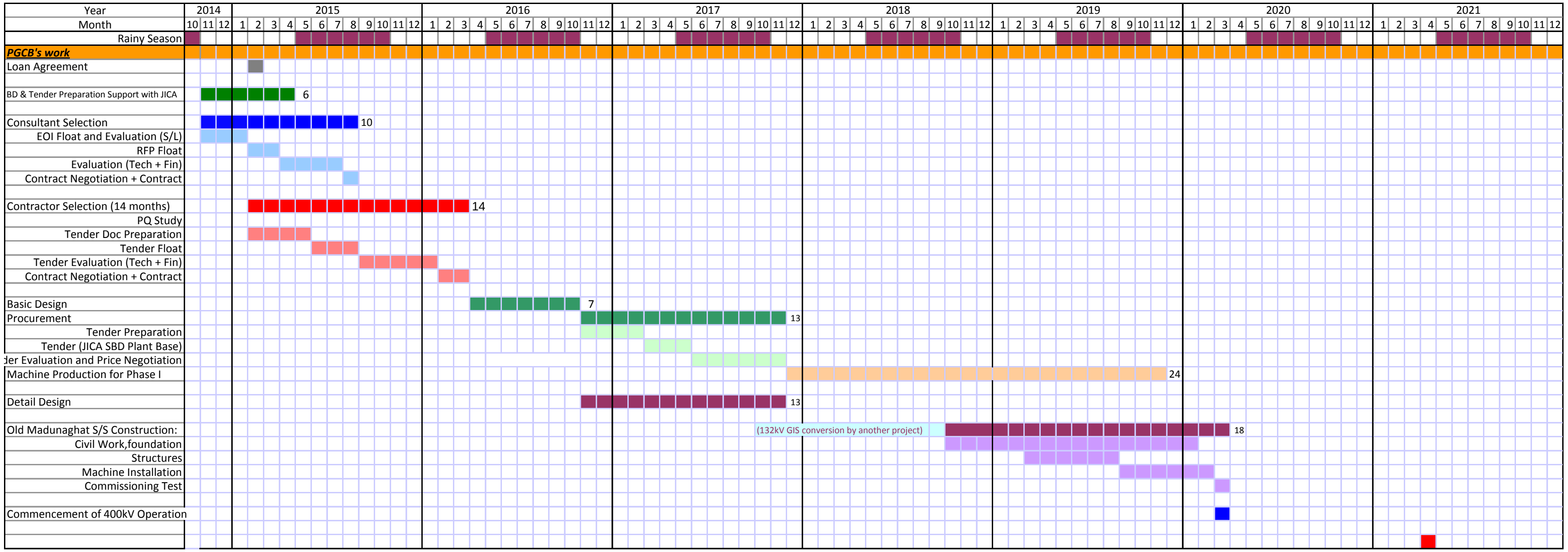


Figure 11.2-4 Implementation Schedule for Construction of the 230/132kV Madunaghat SS

Chapter 12
Environmental and Social Considerations

Chapter 12 Environmental and Social Considerations

12.1 Considerations for Environmental and Social Environment

12.1.1 Outline of Project Components Which Cause Environmental and Social Impact

The Project is comprised of i) extension of 400 kV transmission lines between Meghnaghat SS, Madunaghat SS, Anowara PP, and Matarbari CFPP for approximately 300 km, ii) establishment of new 400 kV / 230 kV Meghnaghat SS, iii) reinforcement of 230 kV / 132 kV Madunaghat SS, iv) extension of 230 kV transmission lines between Madunaghat SS and Old Madunaghat SS, and LILO at Madunaghat SS from Hathazari – Sikalbaha T/L, v) improvement of the National Load Dispatching Center, and vi) improvement of related facilities including access road (see Chapters 8 to 10 for technical details). Route maps of the above transmission lines and substation locations are shown in Chapter 8.

Among the above components, those which are anticipated to cause environmental and social impact are i), iii), iv) and vi). Transmission line projects are placed in the RED CATEGORY project list in the Environmental Conservation Rules (ECR) which were stipulated in 1997 in Bangladesh. PGCB submitted applications for an Initial Environmental Examination (IEE) for site clearance, a full Environmental Impact Assessment (EIA) for environmental clearance, and an Environmental Monitoring Plan (EMP) prior to the project implementation in the country.

12.1.2 Present Natural Environment and Social Conditions

The location of new Meghnaghat SS is in Sonargaon Upazila, Narayanganj District of Dhaka Division. That of new Madunaghat SS is in Raozan Upazila, Chittagong District.

Meghnaghat SS site is reclaimed land with no natural vegetation. Waterfowls such as shore birds are habiting at a tidal mudflat adjacent to the reclaimed land. A small village, Kaijar Gao, with a population of 100, is adjacent to the planned transmission line (see photos below).

(Source: Taken by the JICA Survey Team)

Figure 12.1-1 Site for Meghnaghat SS

(Source: Taken by the JICA Survey Team)

Figure 12.1-2 Surroundings of Meghnaghat SS

At the candidate site for Madunaghat SS, there is a paddy field, adjacent to which there is a small forest.

(Source: Taken by the JICA Survey Team)

Figure 12.1-3 Potential Site for Madunaghat SS

(Source: Taken by the JICA Survey Team)

Figure 12.1-4 Surroundings of existing Madunaghat SS

As of 2011, when an official census was conducted for the first time in ten years, there were 89,565 households (400,358 people: 4.4 persons per household) in Sonargaon Upazila. The population density was 2,322 per square kilometer. In Raozan Upazila, there were 63,375 households comprised of 322,840 people (5.0 persons per household), and the population density was 1,309 per square kilometer. The below table shows an overview of the two substation sites by Upazila.

The population in Sonargaon is less literate (54.6 % in total) than that of Raozan (62.3 %). Raozan had better figures than Sonargaon in all figures of school attendance rates from 6 to 10, from 11 to 14 and from 15 to 19 years of age. Girls' schooling was more prevalent than boys in the age groups from 6 to 10, and from 11 to 14.

More than half of the population in both Upazilas was involved in the service industry (51.0 % in Sonargaon and 53.1 % in Raozan), followed by the agriculture industry (32.4 % and 33.3 % respectively).

Table 12.1-1 Overview of the Demographic Trend at Locations of Substations

Upazila	Area	Population	Population Density	No of Household	Household size	Sex ratio	Population below 15	Literacy Rate		
								Total	Male	Female
	(acres)	(person)	(km2)	(nos)	(person)	(male/female)	(%)	(%)		
Sonargaon	42,422	400,358	2,322	89,565	4.4	104	33.1	54.6	56.7	52.5
Raozan	60,936	322,840	1,309	63,375	5.0	94	33.0	62.3	62.8	61.9

Upazila	School attendance rate									Employment		
	Age 6-10			Age 11-14			Age 15-19					
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Agriculture	Industry	Service
	(%)			(%)			(%)			(%)		
Sonargaon	51.5	50.7	54.6	51.2	48.4	61.6	36.2	36.6	35.8	32.4	16.5	51.0
Raozan	84.0	84.0	84.1	86.5	84.6	88.5	46.2	47.0	45.5	33.3	13.6	53.1

Upazila	Drinking Water			Electricity Connection	Type of House Structure				Toilet Facilities			
	Tap	Tube well	Others		Pucka	Semi-pucka	Kutcha	Jhupri	Sanitary (water-sealed)	Sanitary (non water-sealed)	Non-sanitary	None
	(%)			(%)	(%)				(%)			
Sonargaon	4.9	93.0	2.2	96.9	13.4	22.6	63.7	0.4	16.4	60.6	21.6	1.4
Raozan	5.5	91.0	3.5	90.3	22.5	16.8	56.1	4.6	38.7	45.2	14.5	1.5

(Source: Bangladesh Bureau of Statistics, Population Census 2011, 2012.)

Note 1) Literacy Rate: Distribution of population aged 7 years and above who can write a letter.
2) Employment: Distribution of population aged 7 years and above who do not attend school but are employed.
3) *Pucka*: Made of inorganic materials such as brick and concrete, etc.

Semi-pucka: Made of mix of some organic and inorganic materials such as steel houses, wooden houses, etc.
Kutcha: Made of totally organic materials such as bamboo houses, mud houses, jute stick and catkin grass houses, etc.
Jhupri: Made of temporary materials. Often called 'shanties'.

Except for drinking water and type of house structure, inhabitants more or less have the necessary facilities for basic living conditions. 93.0% of the Sonargaon population had drinking water from tube wells, 96.9% were connected to electricity, 63.7% lived in kutcha houses, and 77.0% had sanitary toilet facilities. In Raozan, 91% of the population depends on tube wells. Over 90% had electricity, more than half live in a kutcha type of house, and 83.9% had sanitary toilet facilities.

In addition to the above two Upazilas, there are nineteen other Upazilas that the transmission line will pass through from Narayanganj District to Cox's Bazar District.

In Laksam (Comilla), there is a small forest near the planned transmission lines. Paddy, maize and vegetable fields are spread through the surrounding area. Chittagong Hill Tracts in Mirsharai Upazila (Chittagong District) is designated as "reserved forest" by the Bangladesh Forest Department (BFD). According to the Forest Act 1927 of Bangladesh, the "reserved forest" is defined as "common tropical evergreen / semi evergreen forest" reserved mainly for economic activities, not as those to be protected against any activity. Almost all of the forest there are not natural forests. Teak and rubber trees are planted along road sides passing through the forest (see the photos below). Monkey, Wild Bear, Sambar, King cobra, and Monitor Lizard inhabit there.

(Source: Taken by the JICA Survey Team)

Figure 12.1-5 Laksam East

(Source: Taken by the JICA Survey Team)

Figure 12.1-6 Chittagong Hill Tracts

Burumchhara (Anowara Upazila, Chittagong) lies next to the Sangu River where paddy fields are spread, adjacent to which there is a small forest. Some reptiles, amphibians, and waterfowls such as shore birds are habiting. There are a few houses near the planned line route.

To the East of Anowara PP (Banshkali Upazila), some reptiles, amphibians, and waterfowls such as shore birds are habiting. And there are a few houses near the planned transmission line route.

Population density of the above 21 Upazilas ranges between 680 persons / km² (Fatikchhari) and 2,493 (Patiya). Average household sizes are between 4.4 persons per household (Sonargaon) and 5.5 (Moheskhali). Approximately 40% of the population is below fifteen years old, and literacy rates are between 30.8% (Moheskhali) and 63.5 (Hathazari).

(Source: Taken by JICA Survey Team)

Figure 12.1-7 Burumchhara (Surrounding of the River)

(Source: Taken by JICA Survey Team)

Figure 12.1-8 East of Anowara PP

Table 12.1-2 Overview of the Demographic Trend at Transmission Line Route 1/3

Upazila	Area	Population	Population Density	No of Household	Household size	Sex ratio	Population below 15	Literacy Rate		
								Total	Male	Female
	(acres)	(person)	(km2)	(nos)	(person)	(male/female)	(%)	(%)		
Gazaria	32,371	157,988	1,206	34,994	4.5	99	33.5	57.2	59.6	54.8
Matlab	31,958	210,050	1,624	45,569	4.6	87	36.3	56.7	56.9	56.6
Kachua	58,271	382,139	1,621	76,642	5.0	90	39.2	53.8	53.1	54.4
Daudkandi	77,838	349,910	1,111	69,014	5.0	94	36.7	50.7	52.2	49.3
Chandina	49,673	350,273	1,742	69,736	5.0	90	39.4	51.0	51.5	50.6
Barura	59,724	405,118	1,676	82,588	4.9	89	38.0	52.1	51.1	52.9
Laksam	38,745	294,719	1,880	57,119	5.1	91	39.0	52.9	52.6	53.1
Nangalkot	55,835	373,987	1,655	72,891	5.1	85	41.1	51.2	49.7	52.4
Feni Sadar	55,894	512,646	2,266	97,869	5.1	99	34.8	62.8	64.6	61.1
Chhagalnaiya	34,495	187,156	1,341	36,744	5.0	92	34.6	63.4	65.3	61.6
Mirsarai	119,324	398,716	826	79,545	5.0	89	34.2	55.1	57.1	53.3
Fatikchhari	191,146	525,555	680	100,009	5.2	98	37.5	51.4	52.8	50.0
Hathazari	60,867	431,121	1,753	81,292	5.2	99	34.0	63.5	65.0	62.0
Boalkhali	31,249	223,125	1,764	44,108	5.0	96	32.9	58.9	60.2	57.6
Patiya	52,350	528,120	2,493	101,599	5.1	102	34.5	54.9	57.3	52.5
Anowara	40,551	259,022	1,578	49,966	5.1	96	39.0	51.9	54.6	49.5
Banshkhali	93,135	431,162	1,144	84,216	5.1	97	43.9	37.4	38.5	36.3
Pekua	34,500	171,453	1,229	31,944	5.4	101	45.7	35.3	35.6	35.0
Maheshkhali	89,498	321,218	887	58,177	5.5	107	38.1	30.8	30.5	31.1

(Source: Bangladesh Bureau of Statistics, Population Census 2011, 2012.)

Note 1) Literacy Rate: Distribution of population aged 7 years and above who can write a letter.
2) Gazaria belongs to Munshiganj District of Dhaka Division. Matlab and Kachua are located in Chandpur District. Daudkandi, Chandina, Barura, Laksam and Nangalkot Upazilas are in Comilla. Feni Sadar and Chhagalnaiya belong to Feni District. Mirsharai, Fatikchhari, Hathazari, Raozan, Boalkhali, Patiya, Anowara and Banshkhali are located in Chittagong District. And Cox's Bazar District has Pekua and Moheskhali.

School attendance is common for children up to fourteen years old. In sixteen out of nineteen Upazilas, over half of the employment population is involved in the agriculture sector, and the remaining six Upazilas are prominent in the service industry (see the table below).

Table 12.1-3 Overview of the Demographic Trend at Transmission Line Route 2/3

Upazila	School attendance rate									Employment		
	Age 6-10			Age 11-14			Age 15-19					
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Agriculture	Industry	Service
	(%)			(%)			(%)			(%)		
Gozaria	83.3	82.9	83.8	85.6	83.2	88.1	47.6	49.8	45.4	63.9	19.5	16.6
Matlab	80.5	79.9	81.1	85.5	81.6	89.2	49.5	51.3	48.0	72.0	7.9	20.1
Kachua	79.9	79.0	80.9	84.1	79.5	88.7	47.2	47.0	47.4	72.9	3.6	23.5
Daudkandi	77.4	76.8	78.0	81.3	77.8	84.8	41.6	42.0	41.1	66.2	7.0	26.8
Chandina	75.5	74.6	76.5	80.3	75.3	85.2	41.2	39.9	42.4	73.9	6.7	19.4
Barura	78.9	77.5	80.3	83.0	77.2	88.8	42.9	41.4	44.3	79.7	3.9	16.3
Laksham	79.6	78.5	80.7	81.5	76.1	86.9	40.4	39.7	41.1	51.6	4.1	44.3
Nangalkot	79.0	78.1	79.9	82.3	76.5	87.8	42.2	40.8	43.2	67.0	7.8	25.1
Feni Sadar	82.7	82.9	82.5	84.5	82.5	86.6	46.4	49.5	43.4	30.2	11.9	57.9
Chhagalnaiya	83.3	83.5	83.1	85.7	84.4	87.1	47.7	51.9	43.7	52.5	12.1	35.4
Mirsarai	82.4	81.9	82.9	82.6	81.1	84.2	40.7	44.8	37.2	59.3	5.0	35.7
Fatikchhari	79.0	78.1	79.9	82.3	76.5	87.8	36.7	38.0	35.5	54.9	15.1	30.0
Hathazari	79.0	78.1	79.9	82.3	76.5	87.8	47.5	48.2	46.8	25.7	14.9	59.4
Boalkhali	79.0	78.1	79.9	82.3	76.5	87.8	44.9	42.5	47.2	36.6	12.1	51.3
Patiya	79.0	78.1	79.9	82.3	76.5	87.8	44.1	43.9	44.2	33.2	16.5	50.3
Anowara	80.0	79.6	80.5	82.3	80.0	84.7	42.1	42.8	41.4	64.7	7.4	28.0
Banshkhali	71.2	69.8	72.8	74.5	70.7	78.6	23.2	18.1	27.5	78.0	5.6	16.4
Pekua	69.5	67.9	71.3	70.0	63.5	76.8	32.9	30.8	35.1	83.4	3.3	13.3
Maheshkhali	62.7	60.4	65.2	61.7	51.2	72.8	27.1	22.8	32.0	81.6	3.0	15.4

(Source: Bangladesh Bureau of Statistics, Population Census 2011, 2012.)

Note: Employment: Distribution of population aged 7 years and above who do not attend school but are employed.

The next table shows to what extent the local population has access to basic infrastructure and services in their living environment. Except for Hathazari and Feni Sadar, more than 90% of the population in all Upazilas depends on tube wells for drinking water. Access to electricity varies from one to another, the lowest of which is Pekua (19.2%) and the highest, Sonargaon (96.9%). In all Upazilas except Hathazari, the kucha-type house is dominant among all types.

Further breakdown of demographic information will be given in the latter part of the social survey.

Table 12.1-4 Overview of the Demographic Trend at Transmission Line Route 3/3

Upazila	Drinking Water (%)			Electricity Connection (%)	Type of House Structure (%)				Toilet Facilities (%)			
	Tap	Tube well	Others		Pucka	Semi-pucka	Kutcha	Jhupri	Sanitary (water-sealed)	Sanitary (non water-sealed)	Non-sanitary	None
Gozaria	3.8	90.5	5.7	77.6	8.0	12.4	78.8	0.8	20.1	58.2	19.2	2.4
Matlab	6.0	87.8	6.2	49.5	4.9	6.9	87.5	0.8	25.0	38.7	32.2	4.2
Kachua	1.1	93.5	5.4	55.1	4.6	4.8	90.1	0.5	3.7	53.7	39.7	2.9
Daudkandi	5.0	89.5	5.5	80.8	7.7	7.3	84.5	0.5	16.0	56.9	23.8	3.2
Chandina	1.5	93.3	5.1	66.3	6.3	10.8	81.6	1.3	20.7	57.6	18.3	3.5
Barura	0.9	95.0	4.0	61.5	6.8	11.2	81.0	1.0	18.5	67.4	11.6	2.5
Laksham	4.4	89.3	6.4	77.5	7.9	11.7	79.7	0.8	17.0	58.5	21.3	3.2
Nangalkot	1.1	91.7	7.2	49.9	7.1	8.6	83.0	1.3	13.7	61.5	20.8	4.0
Feni Sadar	12.2	84.4	3.4	82.7	21.8	24.6	52.3	1.3	10.3	63.0	25.2	1.5
Chhagalnaiya	4.1	90.8	5.7	81.1	18.4	15.8	64.5	1.2	14.8	54.2	30.1	1.0
Mirsarai	1.6	93.9	4.5	56.0	9.6	9.2	79.2	2.1	15.7	60.5	21.7	2.1
Fatikchhari	3.2	85.0	11.8	61.8	13.6	12.6	67.9	5.8	13.4	44.4	33.4	8.7
Hathazari	20.3	74.0	5.8	89.9	28.2	23.0	46.2	2.7	31.5	49.3	17.5	1.7
Boalkhali	1.3	95.2	3.6	88.0	16.5	10.7	66.1	6.7	21.0	61.7	16.1	1.2
Patiya	2.3	93.3	4.4	85.3	14.8	14.9	65.8	4.5	19.8	52.7	24.9	2.7
Anowara	3.5	89.2	7.3	63.8	12.8	14.6	60.6	12.1	14.6	44.0	36.3	5.2
Banshkhali	0.5	95.0	4.5	29.2	6.4	7.2	69.5	16.9	12.5	35.0	46.9	5.5
Pekua	0.5	97.7	1.8	19.2	5.1	5.6	77.2	12.0	33.4	38.0	22.4	6.1
Maheshkhali	0.4	89.5	10.1	25.6	2.8	5.8	77.9	13.5	3.4	24.6	52.1	9.9

(Source: Bangladesh Bureau of Statistics, Population Census 2011, 2012.)

Note: *Pucka*: Made of inorganic materials such as brick and concrete, etc.
Semi-pucka: Made of mix of some organic and inorganic materials such as steel houses, wooden houses, etc.
Kutcha: Made of totally organic materials such as bamboo houses, mud houses, jute stick and catkin grass houses, etc.
Jhupri: Made of temporary materials. Often called 'shanties'.

12.1.3 Relevant International and Domestic Legislation applied in Bangladesh

Bangladesh has joined, ratified and signed major international agreements, treaties, and protocols regarding environmental protection and conservation of natural resources. The major ones are listed below:

- Rio Declaration, 1992
- Convention on Biological Diversity, Rio de Janeiro, 1992
- Convention on Wetland of International Importance Especially as Waterfowl Habitat, 1972
- United Nations Convention on the Law of the sea, Montego Bay, 1982
- Convention relative to the Preservation of Fauna and Flora in their Natural State, 1933
- International Convention for the Protection of Birds, 1950
- International Plant Protection Convention, 1951

The following are national strategies, policies, ordinances and regulations related to environmental issues in Bangladesh.

- Environment Pollution Control Ordinance, 1977
- Environmental Standards in Bangladesh, 1991
- National Conservation Strategy, 1992
- Environmental Policy, 1992
- National Environmental Management Action Plan "NEMAP", 1995
- Environmental Conservation Act, 1995
- Environmental Conservation Rules, 1997
- Wild Life (Preservation) Order, 1973

(1) Environmental Standards

Details of the environmental standards applicable in Bangladesh are described in the Environmental Conservation Rules of 1997. Regulated Areas spread to all industries, and regulated items are air quality, water quality (surface water, drinking water), noise (boundary, Source:), emissions from motor vehicles or ships, odor, sewage discharge, waste from industrial units and industrial effluents or emissions. Project proponents must be compliant with the Bangladesh National Environmental Quality Standards with which industrial effluent is set.

Items and standards which are related to the construction of transmission lines are listed below.

1) Air ambient (Noise)

For noise, a standard limit is set for each zone class category. The following table shows the noise standard in Bangladesh and international standard as defined by the International Finance Corporation (IFC).

Table 12.1-5 Standards for Sound

No	Zone Class	Limits in dBa (ECR)		Limits in dBa (IFC)	
		Day	Night	Day	Night
a	Silent Zone	45	35	55	45
b	Residential Zone	50	40		
c	Mixed Zone (this area is used for a combination of residential, commercial and industrial purposes)	60	50	70	70
d	Commercial Zone	70	60		
e	Industrial Zone	70	70		

(Source: The Environmental Conservation Rules, 1997 and IFC Environmental Health and Safety Guidelines 2007)

2) Water Quality

The table below shows the water quality standard for inland surface water in Bangladesh.

Table 12.1-6 Standard for Water Quality (Inland Surface Water)

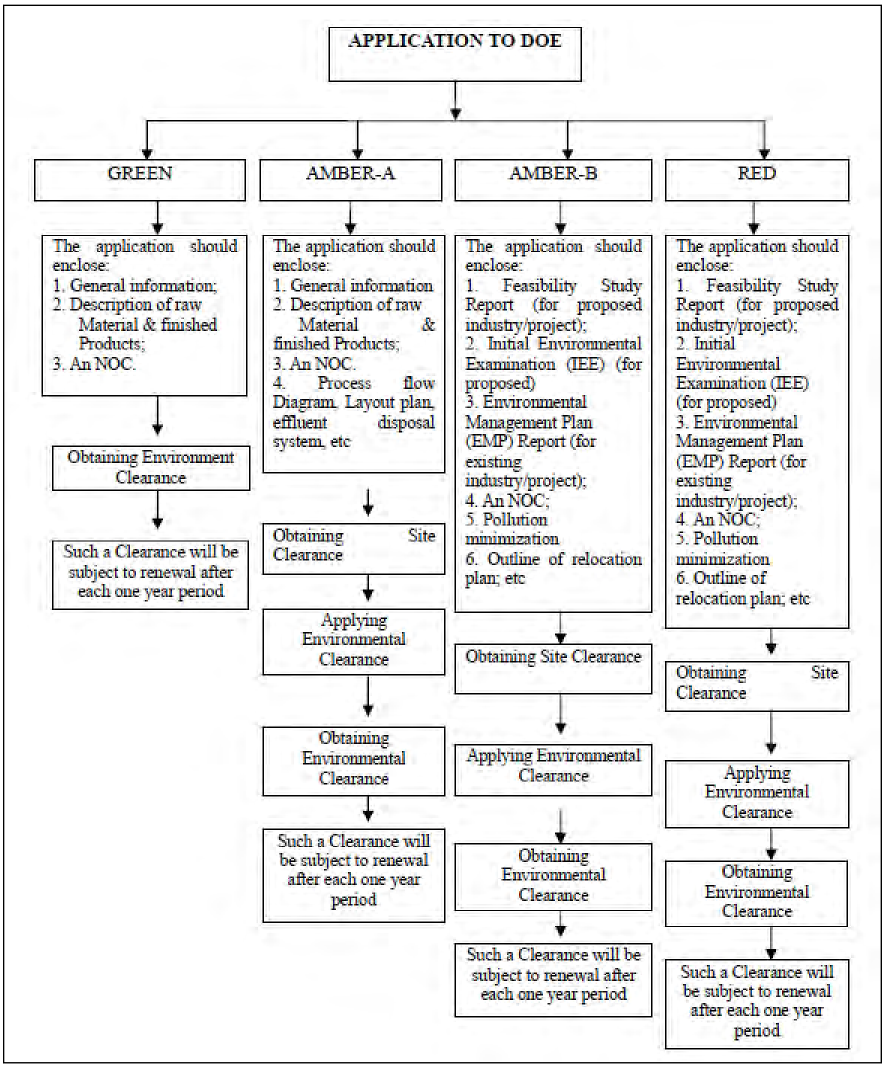
No	Best Practice based classification	pH	BOD mg/1	Dissolved Oxygen (DO), mg/l	Total Coliform Bacteria quantity/ml
a	Potable Water Source: supply after bacteria freeing only	6.5-8.5	2 or less	6 or above	50 or less
b	Water used for recreation purpose	6.5-8.5	3 or less	5 or above	200 or less
c	Potable Water Source: Supply after conventional processing	6.5-8.5	3 or less	6 or above	5,000 or less
d	Water used for fish-culture	6.5-8.5	6 or less	5 or above	5,000 or less
e	Industrial use water including	6.5-8.5	10 or less	5 or above	5,000 or less
f	Water used for irrigation	6.5-8.5	10 or less	5 or above	5,000 or less

(Source: The Environmental Conservation Rules, 1997)

(2) EIA Procedures

The Environmental Policy enacted in 1992 is the basis for all the EIA related laws and regulations in Bangladesh. It provides an outline of the policy principles, and states the environmental policy, framework and system in fifteen different subject fields. It also stipulates the legal position of the National Environment Committee and Department of Environment (DOE) as being responsible for ensuring application of environmental laws and the issuance of necessary clearances in industrial and development activities.

The procedures and requirements for EIA under the power sector are stipulated under the Environmental Conservation Rules of 1997. The Act classifies projects for DOE's prior approval in four categories (Green, Amber-A and -B, and Red). Transmission line projects are included in the RED CATEGORY ("64 Water, Power and Gas distribution line laying/relaying/extension"). Subject to a satisfactory review of the environmental assessment, the DOE issues an authorization for projects to proceed. The authorization consists of two parts: a "site clearance", which gives approval to the proposed site, and a "technical clearance", which approves the project content. For each authorization, an IEE and a full EIA are required respectively. The steps for environmental clearances for projects under each category are shown in the following figure.



(Source: Department of Environment, Ministry of Environment and Forest, EIA Guidelines for Industries, Dhaka, 1997. p.7)

Figure 12.1-9 Steps Involved in Environmental Clearance for Each Category

The project owner shall apply to the DOE in the prescribed format for the application of a Site Clearance Certificate (SCC) by conducting an IEE. The project owner is required to collect baseline data in respect of the project and the environmental conditions of the project and its site, specify significant items pertaining to IEE, examine mitigation measures, EMP, alternative site or other project improvements and describe terms of reference (TOR) for the EIA.

The application shall contain the following documents[3]:

a. Report on the feasibility of the industrial unit or project
b. IEE Report, TOR for EIA and Process Flow Diagram
c. Report on EMP and Process Flow Diagram, Layout Plan
d. No Objection Certificate of the local authority
e. Emergency plan relating adverse environmental impact and plan for mitigation of the effect of pollution
f. Outline of the relocation, rehabilitation plan (where applicable)
g. Other necessary information (where applicable)

For Orange-B and Red Category projects, the SCC shall be issued within sixty days of the receipt of the application along with the comments from DOE on the TOR of the EIA. The project owner shall submit the EIA report prepared on the basis of a program outlined in the IEE Report along with a time schedule for DOE's approval.

A key requirement of the EIA for projects classified in the Amber-B and Red categories is an EMP. The project proponents are expected to describe how it performs environmental mitigation measures stated in the EIA. The EMP must contain descriptions regarding organization and management responsibilities in detail, give details of how mitigation measures identified in the EIA are implemented and how monitoring is carried out. Even after obtaining approval from DOE, the project owner is required to comply with the environmental regulations.

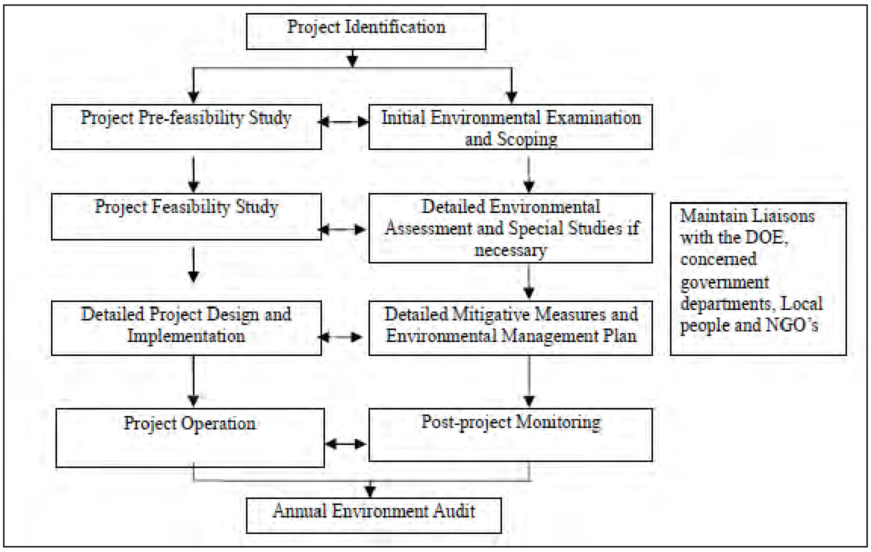
Another sixty working days are necessary for DOE to approve an EIA for Red Category projects. After the EIA is approved, the project owner shall apply for an Environmental Clearance Certificate (ECC), without which the project owner shall not start operation of the project. An ECC shall be granted to the project owner within sixty working days, or shall be rejected stating appropriate reasons[4].

The validity period of the ECC shall be one year, except for the Green Category. For the renewal of the ECC, the project owner shall satisfy the environmental standards as well as the on-site inspection as required by the DOE.

When preparing the EIA report, the general public should be involved as part of the decision-making process and project development, according to the EIA Guideline for Industries. To achieve effective public participation, it is recommended to communicate with as many people as possible, and start such communications as early as possible in as many different ways as possible[5].

The flow of each environmental assessment, consultation and monitoring is shown in the figure below.

[3] Section 6, the Environmental Conservation Rules 1997.
[4] Ibid., Section 9.
[5] *The EIA Guideline for Industries* introduces some techniques for effective communication such as radio and television, news releases, newsletters, advertisements, sample polls, lobbying, workshops, public meetings, public hearings, information van, and citizen advisory committee.



(Source: Department of Environment, Ministry of Environment and Forest, EIA Guidelines for Industries, Dhaka, 1997. pp.8)

Figure 12.1-10 Project Planning, Implementation and EIA Process

(3) Organizations involved

The Ministry of Environment and Forests (MOEF) was newly formed in 1989 by transferring the DOE and the BFD in response to the gain in significance of environmental issues in Bangladesh. It administers the environment of the country and handles all the issues related to environmental policies and regulations. It also coordinates forestry activities. MOEF is now a permanent member of the Executive Committee for the National Economic Council, which is the major decision-making body for economic policy issues with the responsibility to approve government funded projects.

MOEF supervises the activities of the following departments and a corporation.

- Department of Environment (DOE)[6]
- Bangladesh Forest Department (BFD)
- Bangladesh Forest Research Institute
- Bangladesh National Herbarium
- Bangladesh Forest Industries Development Corporation

As one of two important wings under MOEF, DOE is represented by a Director General who has the following authorities stipulated by law.

- Cease any activities deemed to have harmful affect on human lives or to the environment[7]
- Declare contaminated area as natural life preservation area[8]
- Issue ECC upon development of new project

[6] The Environmental Pollution Control Board (EPCB) was established in response to the enactment of the Environmental Pollution Control Act, 1977. It aimed to suggest policy decisions and implementation measures for environmental management. EPCB was replaced by the Department of Environmental Pollution Control (DEPC) in 1982, and the Department of Environment (DOE) took over DEPC's roles and functions under special order by the Minister and went under the jurisdiction of MOEF in 1989. Regional offices are located in 6 Divisions: Dhaka, Chittagong, Khulna, Barisal, Sylhet, and Rajshahi.

[7] Business operators have the right to appeal, and the procedure of the appeal is stipulated, although there is no opportunity of appealing unless urgency is admitted.

[8] It is DOE who manages the activities and schedules in those areas.

The Director General also may, without issuing SCC at the first instance, directly issue an ECC if he, on the application of an industrial unit or project, considers it appropriate to issue such certificate to the industrial unit or project[9].

BFD under MOEF has responsibility to protect and manage all protected national forests. The staff members of the BFD are spread widely in districts and unions which possess protected forests. Wildlife within the forests is also protected.

Other organizations relating to the environmental roles are:

- Ministry of Land: Land Reform and Land Acquisition Directorate
- Bangladesh Water Development Board (BWDB)
- Ministry of Fisheries and Livestock: Directorate of Fisheries

(4) Protected areas and ecologically critical areas

There are seventeen national parks, seventeen wildlife sanctuaries, five botanical gardens and eco-parks in Bangladesh notified under the Wild Life (Preservation) Order 1973, having a total area of 2,722.4 km².

There are nine ecologically critical areas (ECA), and the total area is 8,063.2 km² excluding the Gulshan-Banani-Baridhara Lake in Dhaka. Although industrial development is restricted within ECAs, IEE will be implemented as an exception if the project possesses a high development possibility and a high priority as a nation. And DOE will render a judgment concerning project implementation.

The list of protected areas which are designated by the Wildlife Preservation Act (1974) and ECAs declared under the Order 1973 is shown in the following two tables.

Table 12.1-7 List of National Parks, Wildlife Sanctuaries and National Gardens

Item	No	Name	Place	Size (km^2)
A	1	Bhawal National Park	Gazipur	50.2
	2	Modhupur National Park	Tangail/ Mymensingh	84.4
	3	Ramsagar National Park	Dinajpur	0.3
	4	Himchari National Park	Cox's Bazar	17.3
	5	Lawachara National Park	Moulavibazar	12.5
	6	Kaptai National Park	Chittagong Hill Tracts	54.6
	7	Nijhum Dweep National Park	Noakhali	163.5
	8	Medha Kachhapia National Park	Cox's Bazar	4.0
	9	Satchari National Park	Habigonj	2.4
	10	Khadim Nagar National Park	Sylhet	6.8
	11	Baraiyadhala National Park	Chittagong	29.3
	12	Kuakata National Park	Patuakhali	16.1
	13	Nababgonj National Park	Dinajpur	5.2
	14	Shingra National Park	Dinajpur	3.1
	15	Kadigarh National Park	Mymensingh	3.4
	16	Altodighi National Park	Naogaon	2.6
	17	Birgonj National Park	Dinajpur	1.7
B	1	Rema-Kalenga Wildlife Sanctuary	Hobigonj	18.0
	2	Char Kukri-Mukri Wildlife Sanctuary	Bhola	0.4
	3	Sundarban (East) Wildlife Sanctuary	Bagerhat	312.3

[9] Ibid., Section 7 (4).

Item	No	Name	Place	Size (km^2)
	4	Sundarban (West) Wildlife Sanctuary	Satkhira	715.0
	5	Sundarban (South) Wildlife Sanctuary	Khulna	369.7
	6	Pablakhali Wildlife Sanctuary	Chittagong Hill Tracts	420.9
	7	Chunati Wildlife Sanctuary	Chittagong	77.6
	8	Fashiakhali Wildlife Sanctuary	Cox's Bazar	32.2
	9	Dudh Pukuria-Dhopachari Wildlife Sanctuary	Chittagong	47.2
	10	Hazarikhil Wildlife Sanctuary	Chittagong	29.1
	11	Sangu Wildlife Sanctuary	Bandarban	57.6.
	12	Teknaf Wildlife Sanctuary	Cox's Bazar	116.2
	13	Tengragiri Wildlife Sanctuary	Barguna	40.5
	14	Dudh mukhi Wildlife Sanctuary	Bagerhat	1.7
	15	Chadpai Wildlife Sanctuary	Bagerhat	5.6
	16	Dhangmari Wildlife Sanctuary	Bagerhat	3.4
	17	Sonarchar Wildlife Sanctuary	Patuakhali	20.3
	18	Nazirganji Wildlife Sanctuary	Pabna	146.0
	19	Shilanda-Nagdemra Wildlife Sanctuary	Pabna	24.2
	20	Nagarbari-Mohanganji Wildlife Sanctuary	Pabna	408.1
C	1	National Botanical Garden	Dhaka	0.8
	2	Baldha Garden	Dhaka	-
	3	Madhabkunda Eco-Park	Moulavibazar	2.7
	4	Sitakunda Botanical Garden and Eco-park	Chittagong	8.1
	5	Dulahazara Safari Parks	Cox's Bazar	6.0

(Source: MOEF Data, December, 2014)

Note: A: National Park, B: Wildlife Sanctuary, C: Botanical Garden

Table 12.1-8 List of Environmental Critical Areas

Item	No	Name	Place	Size (km^2)
F	1	The Sundarbans	Bagerhat, Khulna, Satkhira	7,620.3
	2	Cox's Bazar (Teknaf, Sea beach)	Cox's Bazar	104.7
	3	St. Martin Island	Cox's Bazar	5.9
	4	Sonadia Island	Cox's Bazar	49.2
	5	Hakaluki Haor	Moulavi Bazar	183.8
	6	Tanguar Haor	Sumamganj	97.3
	7	Marjat Baor	Jhinaidha	2
	8	Gulshan-Banani-Baridhara Lake	Dhaka	-
	9	Rivers (Buriganga, Bait, Turag, and Sitalakhya)	Dhaka	-

(Source: MOEF Data, December, 2011)

Note: F: Environmental Critical Area

12.1.4 Examination of Alternatives including Zero-Option

Chittagong is the biggest industrial and port city of Bangladesh. Its industrial growth rate is very high, and power demand in Chittagong has been rapidly increasing. On the other hand, power generation in the Chittagong area has been kept low due to severe fuel shortages. At present, Chittagong is connected with Dhaka via Comilla by two 230 kV circuits (Hathazari – Comilla – Meghnaghat) and two 132 kV circuits (Hathazari – Feni – Comilla – Haripur). These lines are not at all sufficient for the power supply to meet the near future demand of the Chittagong area.

Under these circumstances, PGCB has planned to establish the 400 kV Meghnaghat-Madunaghat transmission line, which will be charged at 230 kV to supply reliable power to Chittagong. It will then be charged at 400 kV to evacuate power after construction of the Coal Fired Power Plant in Matarbari in Cox's Bazar District in 2022. In addition to these transmission lines, Matarbari-Madunaghat 400 kV T/L and two 400/230 kV substations at Meghnaghat and Madunaghat will also be required in the second phase to evacuate this power to the cities of Dhaka and Chittagong.

(1)Non-implementation of the project (Zero-option)

From an environmental and social considerations point of view, non-construction of transmission lines, which would not cause any adverse impacts on the natural and social environment, is preferable.

However, if this project were not to be implemented, the electric power supplied to the Chittagong area from Dhaka (Meghnaghat SS) would be suspended and also, electric power generated (planned in 2022) from the Matarbari CFPP would be hampered indefinitely.

According to the results of the survey on natural environment and social environment, critical natural habitats of Flora and Fauna are not involved in the project site and the economic benefits of implementation of the Project far outweigh the adverse impacts on the social environment, almost all of which can be controlled and minimized to an allowable level.

The potential environmental impact in the case of non-implementation of the Project is described in the following table.

Table 12.1-9 Potential environmental impact in case of non-implementation

Items	Positive Effects	Negative Effects
Transmission line demand	- None	- To supply electric power generated at Matarbari CFPP to Dhaka city, a new transmission line passing through residential areas, or areas with abundant natural resources, will be built.
Pollution of environment	- No waste - No noise problems	- None
Natural environment	- No tree-felling - No bird strike accidents	- None
Social environment	- No acquisition of land	- No expected employment opportunities - No expected introduction of new business related to project

(Source: JICA Survey Team)

(2)Candidate Routes

Three routes for the proposed 400 kV transmission line from Meghnaghat to Matarbari via Madunaghat were identified from the desktop study and the results of partial site survey, as follows:

a) Candidate Route-I

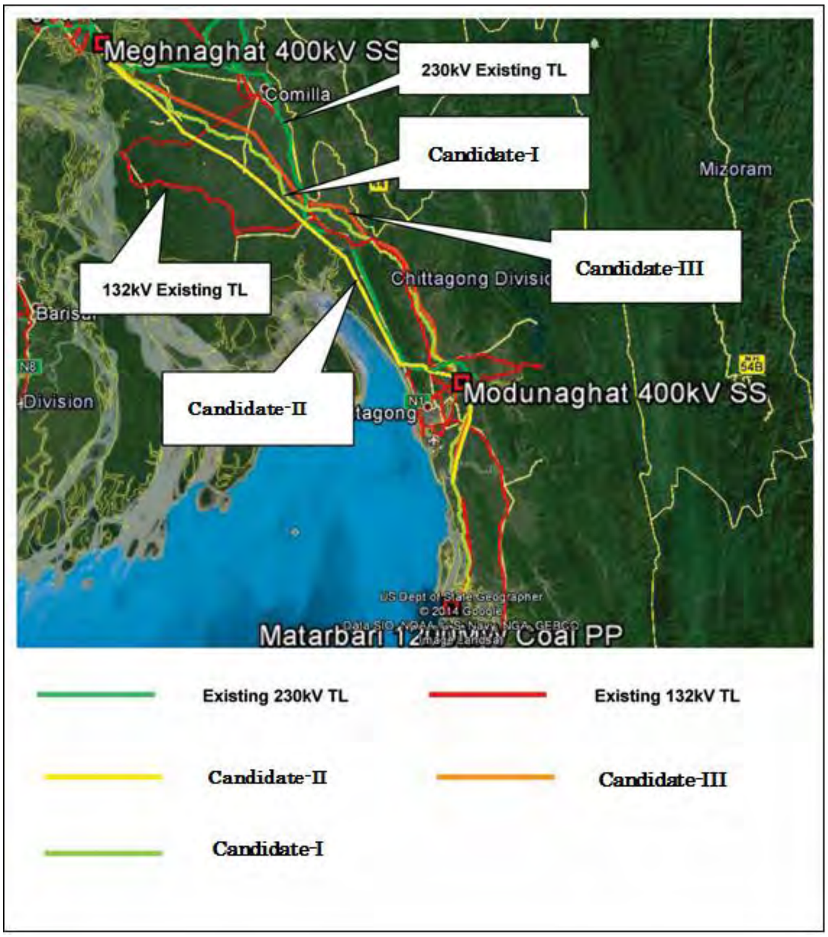
Candidate Route-I of 400 kV transmission line from Meghnaghat 400 kV SS at Sonargaon Upazila of Narayanganj District, passing through Sonargaon, Gazaria, Daudkandi, Barura, Kachua, Laksam, Feni, Chhagalnaiya, Mirsharai, Fatikchhari, Hathazari, Raozan, Boalkhali, Patiya and Anowara, Banshkhali and Pekua Upazilas and ending at the proposed 2 x 600 MW Matarbari CFPP. This will cross four major rivers, namely, Meghna, Gomoti, Karnafully and Sangu. This line will also cross a hilly area in Ramgar from Karerhat to Heyako of approximately 10 km in length.

b) Candidate Route-II

Candidate Route-II was proposed to draw along the Dhaka-Chittagong highway (Sonargaon, Gazaria, Daudkandi, Kachua, Laksam, Feni, Mirsharai and Sitakundu Upazilas) up to Comilla, and then cross the hill and pass through Hathazari Upazila, Madunaghat SS, Boalkhali, Patiya, Anowara, Banshkhali and Pekua Upazila and end at the proposed 2 x 600 MW Matarbari CFPP.

c) Candidate Route-III

Candidate Route-III was proposed to draw along the Candidate Route-I (Sonargaon, Gazaria, Daudkandi, Barura, Kachua, Laksam, Feni, Mirsharai Chhagolnaiya, Fatikchhari, Hathazari, Raozan (Madunaghat), Boalkhali, Patiya, Anowara, Banshkhali, Pekua and Maheshkhali Upazilas) in order to reduce significant adverse impact to the urban landscape caused by stringing of transmission lines and taking into account of possibility of salt damage.



(Source: JICA Survey Team)

Figure 12.1-11 Google Earth Map showing the proposed Routes of 400 kV T/L

(3)Evaluation of Candidate Routes of Transmission Line

The environmental and social impacts were assessed based on the results of the survey on nature and social conditions. A scoring method by rating the degree of environmental and social impacts (0, -1 or -2) was applied. The table below shows the grand assessment results.

0: No impact
-1: Small-scale impacts but not severe
-2: Severe impacts but not irreversible

Table 12.1-10 Natural and Social Environmental Impacts of the Transmission Line

Sl. No.	Description of Item	Candidate Routes					
		Candidate Route-I	score	Candidate Route-1I	score	Candidate Route-III	score
1.	Length	314 km	-1	310 km	0	320 km	-2
2,	Rail Crossing	4	-1	4	-1	2	0
3.	Major River Crossing	6	0	7	-1	6	0
4	EHV TL crossing	8	-1	7	0	9	-2
5	Hilly area crossing	1	0	1	0	1	0
6	National Highway Crossing	2	0	3	-1	2	0
7	Topography	Medium Low, high and medium high land	0	Medium Low, high and medium high land	0	Medium Low, high and medium high land	0
8	Proximity of coast	Away from the coast	0	Near the coast	-1	Away from the coast	0
9	Natural Environment	Less forest	0	Less forest	0	Near forest	-1
10	Resettlement	No Resettlement required	0	Small-scale resettlement required	-1	Resettlement required	-2
11	Impact on living condition and livelihoods in ROW	Less negative impact	0	More negative impact	-1	Most serious impact	-2
Evaluation			**-3**		**-6**		**-9**

(Source: JICA Survey Team)

(4)Conclusion

Candidate Route-I is considered to be the most advantageous, and Candidate Route-I to the PGCB is recommended as the best practicable environmental option for transmission lines.

12.1.5 Scoping Results and TOR for Natural and Social Environmental Survey

The following two tables show the scoping drafts for transmission lines and substations. They were prepared based on the generally expected impacts of constructing transmission lines from Meghnaghat to Matarbari while their locations were not completely fixed (as of the end of May 2014). The locations of substations (Meghnaghat SS and Madunaghat SS) were, on the other hand, almost fixed at that point.

Table 12.1-11 Result of Scoping for Transmission Lines

Item	No.	Impact	Rating		Result
			Design / construction Phase	Operation Phase	
Pollution mitigation measure	1	Air pollution	B-	D	**Construction phase:** Generation of dust by land preparation and other construction work is expected, but the impact will be temporary. Generation of air pollutants (Sulfur Oxide (SOx), Nitrogen Oxides (NOx), and others) from operation of heavy machines and trucks is predicted, but the impact will be limited only to within the surrounding area. **Operation phase:** No specific air pollution is anticipated.

Item	No.	Impact	Rating: Design / construction Phase	Rating: Operation Phase	Result
	2	Water pollution	B-	B-	Soil runoff may occur from the exposed soil of the embankment and cut slope and water pollution of the downstream area of the surrounding river is predicted.
	3	Waste	B-	D	**Construction phase:** General waste and hazardous waste generated by the construction work is predicted. **Operation phase:** No general waste or hazardous waste is anticipated.
	4	Noise and Vibration	B-	D	**Construction phase:** Impact of noise and vibration is predicted, caused by operation of heavy machines and trucks, but this will be limited to the surrounding area. **Operation phase:** No specific noise or vibration is anticipated.
Natural environment	5	Natural reserve	B-	D	**Construction phase:** There is a possibility that the transmission line passes by the Ecologically Critical Area, and the impact of air pollution, noise and vibration due to construction work is anticipated. **Operation phase:** No specific impact on the natural reserve is predicted.
	6	Ecosystem	B-	B-	**Construction phase:** There is a possibility that the transmission line passes by the Reserved Forest, and the impact of air pollution, noise and vibration due to construction work is anticipated on the terrestrial ecosystem. **Operation phase:** Bird-strike and other impacts are anticipated.
	7	Geography and geology	C	C	The impact is unknown (it will be identified in further site survey).
Social environment	8	Land Acquisition and Resettlement	C	D	**Design phase:** Settlements and houses were avoided when the route map was first drafted at the end of May 2014 based on the available secondary information and site survey in May. The social survey, planned from June to July 2014, will identify the ground reality in detail. The extent of the impact is therefore unknown at this stage. **Operation phase:** Not Appicable (N/A)
	9	Disturbance to Poor People	C	C	The extent of the impact is unknown at this stage.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	C	C	The proposed construction site of the transmission line is located close to the Chittagong Hill Tracts (CHT), where the indigenous population is related to neighboring Myanmar, and there is a possibility that ethnic minority groups and indigenous people live within the surrounding hill area. The social survey planned from June to July 2014 will identify the ground reality in detail. The extent of the impact is therefore unknown at this stage.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	C	C	The extent of the impact is unknown at this stage.
	12	Land Use and Utilization of Local Resources	C	C	The extent of the impact is unknown at this stage.

Item	No.	Impact	Rating: Design / construction Phase	Rating: Operation Phase	Result
	13	Disturbance to Water Usage, Water Rights etc	C	C	In general, soil runoff may occur from the exposed soil of the embankment and cut slope, resulting in water pollution of the downstream area of the surrounding river and alteration of water use. The extent of the impact is, however, unknown at this stage.
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	**Construction phase:** Increased traffic is predicted. **Operation phase:** No specific adverse effect is predicted on the existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	C	D	**Design phase:** The extent of the impact is unknown at this stage. **Operation phase:** No specific impact is predicted concerning the social infrastructure and local decision-making institutions.
	16	Misdistribution of Benefits and Damages	C	D	**Design phase:** The extent of the impact is unknown at this stage. **Operation phase:** No specific impact is predicted.
	17	Local Conflicts of Interest	C	D	**Design phase:** The extent of the impact is unknown at this stage. **Operation phase:** No specific impact is predicted.
	18	Cultural Heritage	C	C	The extent of the impact is unknown at this stage.
	19	Landscape	C	C	The extent of the impact is unknown at this stage.
	20	Gender	C	C	The extent of the impact is unknown at this stage.
	21	Children's Rights	C	C	The extent of the impact is unknown at this stage.
	22	Infectious Diseases such as HIV/AIDS	B-	D	**Construction phase:** A temporary influx of migrant labor during construction period may increase the risk of transmitted diseases. **Operation phase:** There is no specific negative impact anticipated.
	23	Working Conditions (including working safety)	B-	B-	**Construction phase:** In general, a high risk of accidents is predicted in construction work. **Operation phase:** There is a risk of accidents such as electric shocks and falls during maintenance work.
	24	Others	C	C	The extent of the impact is unknown at this stage.
Others	25	Accidents	B-	B-	Accidents may occur including soil runoff caused by floods, and break-down of towers by cyclones.
Others	26	Cross-boundary impact and climate change	D	D	Cross boundary and CO_2 emission concerning the transmission line are not anticipated.

(Source: JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Table 12.1-12 Result of Scoping for Substations

Item	No.	Impact	Rating: Design / construction Phase	Rating: Operation Phase	Result
Pollution mitigation measure	1	Air pollution	B-	D	**Construction phase:** Generation of dust through land preparation and other construction work is expected, but the impact will be temporary. Generation of air pollutants (SOx, NOx, and others) from operation of heavy machines and trucks is predicted, but the impact will be limited only to within the surrounding area. **Operation phase:** No specific air pollution is anticipated.
	2	Water pollution	B-	B-	Soil runoff may occur from the exposed soil of the embankment and water pollution of the surrounding waterway for paddy fields is predicted.
	3	Waste	B-	B-	**Construction phase:** General waste and hazardous waste generated by the construction work is predicted. **Operation phase: G**eneral waste and hazardous waste is anticipated.
	4	Noise and Vibration	B-	D	**Construction phase:** Impact of noise and vibration is predicted, caused by operation of heavy machines and trucks, but this will be limited to the surrounding area. **Operation phase:** No specific noise or vibration is anticipated.
Natural	5	Natural reserve	D	D	N/A
	6	Ecosystem	D	D	No specific adverse effect is predicted on the ecosystem of the site and its surrounding area.
	7	Geography and geology	C	C	The impact is unknown (it will be identified in further site survey).
Social environment	8	Land Acquisition and Resettlement	B-	D	**Design phase:** As much as 220 acres of land, which is presently owned by BPDB, has already been secured and is available for the future development of Meghnaghat SS. BPDB and PGCB will take all official procedures for transferring the ownership. Whereas, it is anticipated that 20 acres of paddy field land is to be acquired for Madunaghat SS. The extent of the impact is, however, unknown at this stage. No resettlement is anticipated. **Operation phase:** N/A
	9	Disturbance to Poor People	B- / C	B-/ C	**Construction phase:** Sharecroppers (*bargadars*) at Madunaghat SS site may lose their means of livelihoods temporarily during the construction phase. The extent of the impact is, however, unknown at this stage. **Operation phase:** Poverty resulting from losses of livelihood means may occur if appropriate measures are not taken.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	D	D	No ethnic minority groups or indigenous people live at the sites for Meghnaghat SS and Madunaghat SS.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	B-/C	B-	**Construction phase:** Sharecroppers (*bargadars*) at Madunaghat SS site may lose their means of livelihoods temporarily. The extent of the impact is, however, unknown at this stage. **Operation phase:** Sharecroppers at Madunaghat SS site may lose their means of livelihoods permanently.

Item	No.	Impact	Rating		Result
			Design / construction Phase	Operation Phase	
	12	Land Use and Utilization of Local Resources	B-	B-	**Construction phase:** It is anticipated that 20 acres of paddy field land is to be acquired for Madunaghat SS. **Operation phase:** Land use will change permanently.
	13	Disturbance to Water Usage, Water Rights etc	C	C	The extent of the impact is unknown at this stage.
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	**Construction phase:** Increased traffic is predicted. **Operation phase:** No specific adverse effect is predicted on the existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	B-	D	**Design phase:** It is the Deputy Commissioner's Office of the District that takes the initiative in conducting local consultations and the detailed measurement surveys for land acquisition, which will cause certain impact on the social infrastructure and local decision-making institutions. **Operation phase:** No specific impact is predicted.
	16	Misdistribution of Benefits and Damages	C	C	The extent of the impact is unknown at this stage.
	17	Local Conflicts of Interest	C	C	The extent of the impact is unknown at this stage.
	18	Cultural Heritage	D	D	There is no cultural, historical or traditional heritage in the substation sites. No specific impact is thus predicted.
	19	Landscape	D	D	No specific impact is predicted.
	20	Gender	D	D	There is no specific negative impact anticipated.
	21	Children's Rights	D	D	There is no specific negative impact anticipated.
	22	Infectious Diseases such as HIV/AIDS	B-	D	**Construction phase:** A temporary influx of migrant labor during construction period may increase the risk of transmitted diseases. **Operation phase:** There is no specific negative impact anticipated.
	23	Working Conditions (including working safety)	B-	B-	**Construction phase:** A high risk of accidents is predicted in construction work. **Operation phase:** There is a risk of accidents such as electric shocks and falls during maintenance work.
	24	Others	C	C	The extent of the impact is unknown at this stage.
Others	25	Accidents	B-	B-	Accidents may occur including soil runoff caused by floods, and break-down of towers by cyclones.
	26	Cross-boundary impact and climate change	D	D	Cross boundary and CO_2 emissions are not anticipated.

(Source: JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

12.1.6 Results of Natural and Social Environmental Survey

(1) Survey on Natural Environment

The Project is categorized as Red, which requires an IEE and a comprehensive EIA. And the proposed project to be implemented by PGCB requires strict compliance with laws, rules and regulations pertinent to the environment.

Based on the alignment of transmission line routes and substation sites, investigations on soil conditions, comprehensive surveys of natural environment on the transmission line route, and social survey were carried out from June 2014 to December 2014. The IEE report was compiled and submitted to DOE on 8th of July 2014 (see attached Appendix-VI-a), for which the DOE provided its approval as of 11th of September 2014 (see attached Appendix-VI-b).

The following table, map and series of photos show the survey sites. Each photo inserted in the above is compatible with the candidate survey site (Site “1” up to Site “7") in the following table and map.

The survey on natural environment was carried out twice for rainy and dry seasons based on the TOR for the survey (see attached Appendix-V) at the beginning of July 2014 and early November at each location.

Table 12.1-13 Outline of Survey Sites and Environmental Features

Survey Site		Place			Remarks
No.	Name	Upazila	District	Division	
1	Meghnaghat S/S and its surroundings.	Sonargaon and Gazaria	Narayanganj and Munshiganj	Dhaka	Photo 12-1-1 and 12-1-2
2	Laksam East	Laksam	Comilla	Chittagong	Photo 12-1-3
3	Chittagong Hill Tracts	Mirsharai	Chittagong	Chittagong	Photo 12-1-4
4	Madunaghat SS	Raozan	Chittagong	Chittagong	Photo 12-1-5
5	Surroundings of existing Madunaghat SS	Raozan	Chittagong	Chittagong	Photo 12-1-6
6	Burumchhara (River’s Surroundings)	Anowara	Chittagong	Chittagong	Photo 12-1-7
7	East of Anowara PP	Banshkali	Chittagong	Chittagong	Photo 12-1-8

(Source: JICA Survey Team)

a) Results of Flora and Fauna survey

The results of the survey on the above seven sampling sites are given in the attached Appendix VII.

a. Flora

Almost all areas for the construction of the transmission lines are largely comprised of man-made fields of rice fields, scrub with scattered trees of cash crop, non-timber trees near local residents’ houses and forest area managed by Bangladesh Forest Industries Development Corporation (BFIDC).

In all, 152 species in the rainy season and 145 species in the dry season were recorded in the transmission line sites and those species were widely distributed and common in the region (Biologist-group’s views of Chittagong University) except three endangered species as follows designated by the International Union for Conservation of Nature and Natural Resources (IUCN) status declaration of 2014.

- *Borassus flabellifer L. (Barb tree)*
- *DipterocarpusTurbinatus Gaertn. (Common Gurjun tree)*
- *Swietenia mahagoni (L) Jacq. (Spanish mahogany)*

b. Fauna

<Insects>

A total of 61 species in the rainy season and 47 species in the dry season were recorded in the Transmission Line area. All of them have Not Threatened (NO) status per the IUCN status declaration of 2014.

<Amphibians>

A total of 11 species in the rainy season and 7 species in the dry season were recorded in the Transmission Line area, all of which are Not Threatened (NO) status per the IUCN status declaration of 2014.

<Reptiles>

A total of 31 species in the rainy season and 12 species in the dry season were recorded in the Transmission Line area, all of which are Not Threatened (NO) status per the IUCN status declaration of 2014.

<Birds>

A total of 61 species of birds in the rainy season and 53 species of birds in the dry season were recorded in the Transmission Line area. No threatened species, as designated by the IUCN status declaration of 2014, were recorded.

<Mammals>

A total of 19 species in the rainy season and 13 species in the dry season were recorded in the Transmission Line area. All of these species have Not Threatened (NO) status as per the IUCN status declaration of 2014.

b) Threatened Species in project areas

From the results of the survey on flora and fauna, a total of three species of plants, shown in the table below, were identified as designated threatened species (CR or EN) on the IUCN Red List of 2014.

No threatened species were recorded on fauna in the three sampling sites.

Table 12.1-14 Threatened species observed in Project Sites

Taxa	No.	Scientific Name	Season		Conservation Status	Remarks (comments by Biologist)*[10]	Location where found
			Rainy	Dry	IUCN (2014)		
Plant	1	*Borassus flabellifer L.*	○	○	EN	-The species is common in some parts of Bangladesh	Map-1
	2	*Dipterocarpus Turbinatus Gaertn*	○	○	CR	The species is very common in the forest of South-east Bangladesh	Map-2
	3	*Swietenia mahagoni (L) Jacq.*	○	○	EN	This is introduced species. It is widely cultivated in roadsides, homestead forests throughout Bangladesh	Map-3
Total	**3**		**(3)**	**(3)**			

(Source: JICA Survey Team)

Note: CR-Critically Endangered, EN-Endangered

[10] Biologist－group’s views of Chittagong University

(Source: JICA Survey Team)

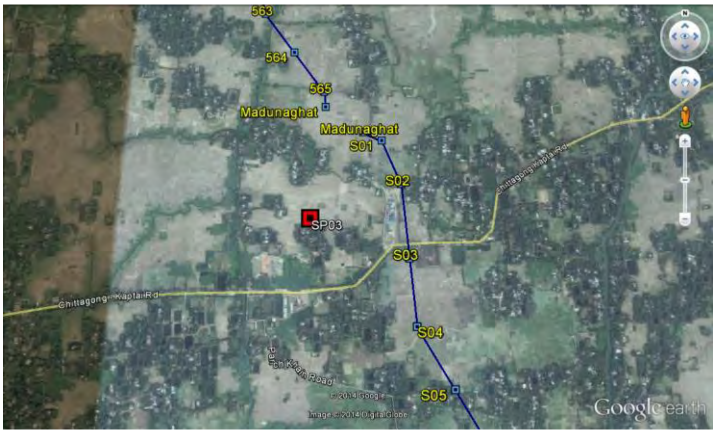
Note: in sparse forest far from tower No. s107

Figure 12.1-12 Site where threatened species was found (Map-1)

(Source: JICA Survey Team)

Note: in forest around residence, 30m from tower No. 559

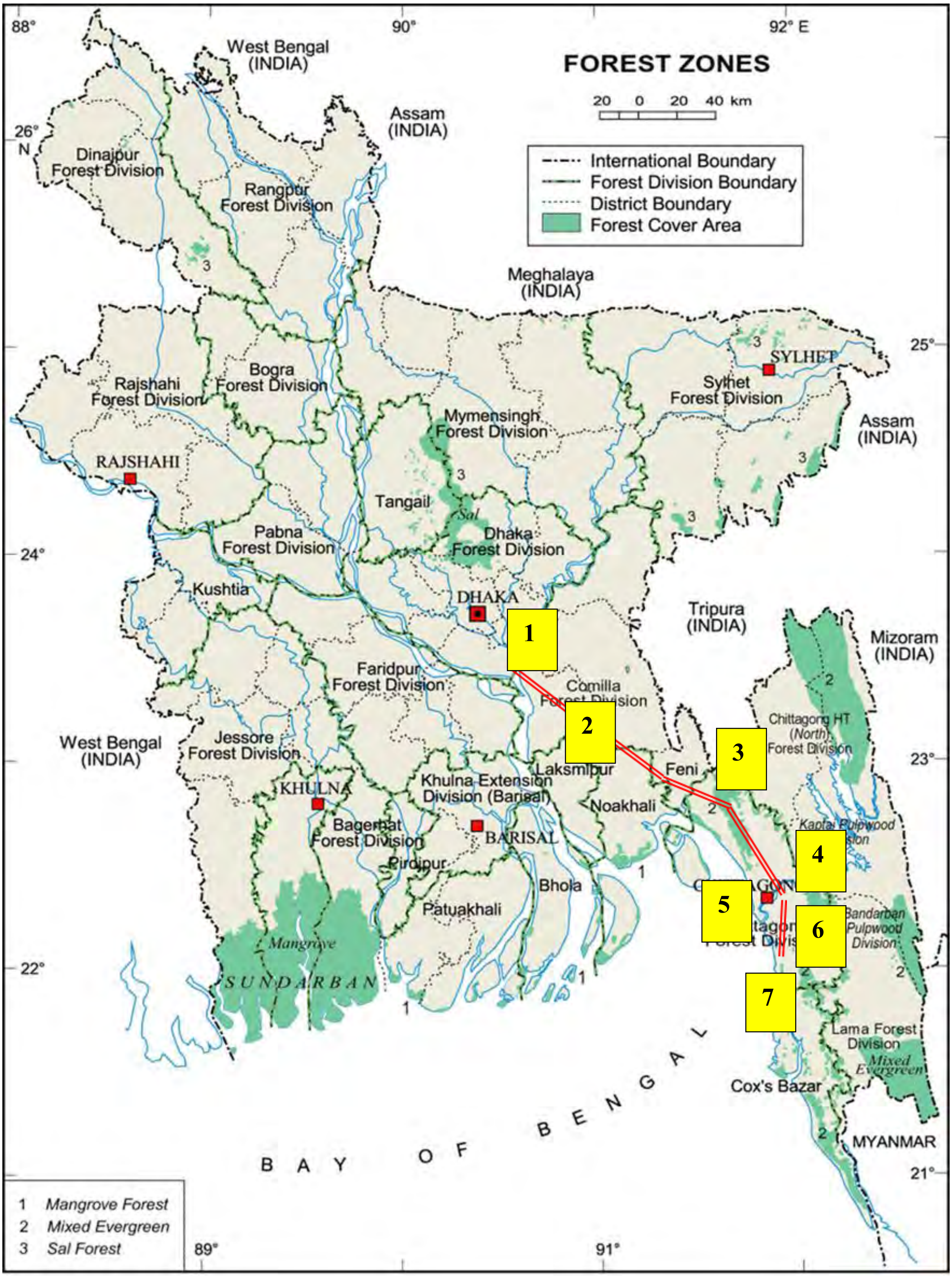
Figure 12.1-13 Site where threatened species was found (Map-2)



(Source: JICA Survey Team)

Note: in forest around residence, 80m from tower No. S002

Figure 12.1-14 Site where threatened species was found (Map-3)



(Source: Bangladesh Forest Department, 1999)

Note: the survey locations and transmission line route are drawn by the JICA Survey Team

Figure 12.1-15 Candidate Locations for Natural Environment Survey

(2) Survey on Social Environment

1) 400 kV Transmission Lines

The land owners of the proposed tower locations of 400 kV transmission line were identified during the route survey in June and July 2014 as listed in the Appendix VIII.

Socioeconomic survey comprised of population census, asset inventory, and household survey using a set of questionnaire was conducted in seven Upazilas (Mirsharai, Anowara, Banshkhali, Raozan, Laksam, Gazaria and Sonargaon) along the proposed 400 kV transmission line. Total 184 household heads have been interviewed as summarized in the table below. The findings are described in the Appendix VIII.

Table 12.1-15 Summary of Interviewed Households on Transmission Line Route

Division	District	Upazila	No of interviewee	No. of Family Member	Sex		Occupation										
					Male	Female	Farmer	Business	Service	student	House wife	Agriculture Labor/ Day Labor	Unemployed	Teacher	Retired/Elder	Driver	others
Chittagong	Chittagong	Anowara	35	177	101	76	10	13	2	1	6	0	3	0	0	0	0
		Banshkhali	31	164	77	87	9	8	3	0	4	5	0	1	0	1	0
		Raozan	27	115	64	51	5	2	1	0	12	1	0	0	0	2	4
	Comilla	Laksam	29	130	67	63	5	6	1	0	11	1	0	0	2	2	1
Dhaka	Munshiganj	Gazaria	32	133	78	55	6	17	3	0	1	1	0	0	1	0	3
	Narayanganj	Sonargaon	30	125	67	58	3	13	7	0	1	0	0	0	4	0	2
Total			184	844	454	390	38	59	17	1	35	8	3	1	7	5	10

(Source: JICA Survey Team)

2) 230 kV Transmission Lines

The land owners of the proposed tower locations of 230 kV transmission line were identified during the route survey in December 2014 and January 2015 as listed in the Appendix VIII.

3) 400 kV Substations

There are two 400 kV substations to be constructed under this project: Meghnaghat 400kV Substation located in Sonargaon Upazila, and Madunaghat 400 kV SS in Raozan Upazila of Chittagong District. The location of the proposed Meghnaghat 400 kV SS is within Meghnaghat power station complex. The land of this complex was acquired and developed by BPDB. Subsequently the lands are being used by different IPPs for power generation and also by PGCB for grid substations. Therefore there is no need of land acquisition for the proposed Meghnaghat 400 kV SS and no resettlement is expected to be required.

The proposed Madunaghat 400 kV SS is located at East Gujra Union of Raozan Upazila of Chittagong district in the North West side of a 25 MW power station operated by the Rural Power Company Limited (RPCL) located on the north side of Chittagong – Kaptai road. Less than 10 acres of land will be required to construct the proposed Madunaghat 400kV SS. 36 land owners of the substation area were identified as below. The findings are described in the Appendix VIII. The land owners of 15 plots were not identified during the survey period in November 2014. There were two sharecroppers who cultivated the land during the survey period.

Table 12.1-16 Summary of Interviewed Households on new Madunaghat SS

Division	District	Upazila	No of interviewee	No. of Family Member	Sex		Occupation										
					Male	Female	Farmer	Business	Service	student	House wife	Teacher	Retired/Elder	Driver	Electrician	Foreign service	others
Chittagong	Chittagong	Raozan	36	151	81	70	6	10	3	1	5	2	6	1	1	1	0

(Source: JICA Survey Team)

12.1.7 Environmental Evaluation

This Paragraph describes the results of predictions and impact evaluations of the major environmental impact items for the proposed transmission line, substation and access road. There is no item evaluated as “A” (significant positive/negative impact is expected).
These predictions and impact evaluations have been made studying mitigation measures for avoiding or mitigating impacts with respect to various forms of environmental items.

(1) Transmission line
1) Pre-construction Phase
a. Land Acquisition
Findings: Number of towers constructed for 400 kV T/L from Meghnaghat to Matarbari is approximately 800 in total. It requires 2m² of land per one suspension tower base (approximately 550 in number) and 3m² of land per one tension tower base (approximately 250 in number): in total, 1,860 m^2 of paddy land and certain trees will be permanently affected by the tower construction. Construction of one tower base for 230 kV requires 1m² of land per one suspension tower (approximately 20 in number) and 1m² of land per one tension tower (approximately 10 in number). The number of towers for the 230 kV T/L will be 30 in total, and 80 m^2 of land will be permanently acquired. In conclusion, not more than 2,000 m^2 in total is approximately required to acquire the land for tower foundations.
Mitigation Measures: Such permanent land acquisition for the above tower bases shall be conducted on the basis of compensation at replacement cost. Trees within clearance distance from cables will be removed. Standing crops and trees will be compensated at market price. However, given an informed consent, the land owners have the right to fully exercise their power of choice: to voluntarily or involuntarily provide their land for tower bases. If PGCB does not purchase the land under the proposed transmission towers, PGCB shall restore the land to its original conditions after construction of the transmission towers.

b. Right of Way (ROW)
Findings: The construction period of each tower is expected to last 30 days, during which the construction site (700 m^2 per tower) and temporary access road (200 m^2) will be blocked and farm activities will be disturbed. It is long enough to lose the income opportunity for land owners for one crop season, and job opportunity and crop share for sharecroppers and cultivators too.
Wiring work will last 3 weeks per 3 km, which will require safety instruction for local farmers. It is, however, not anticipated that their farming activities will be hindered. Settlements and homesteads were avoided when the route map was drafted so no land acquisition or involuntary resettlement is anticipated.
Mitigation Measures: ROW compensation shall be conducted to replace their crop income for one season, plus one time assistance for three months of their wages.

1) Construction Phase
a) Pollution control
a. Air Pollution
Findings: Dust is expected from land preparation and other construction work, but the impact will be temporary. Generation of air pollution (SO_2, NO_2) from the operation of heavy machinery and trucks is predicted, but the impact will be limited to within the surrounding area.
Mitigation Measures: Watering the road and construction site, especially in the dry season, and using cover sheets on trucks for the transportation of soil will be undertaken in order to reduce dust. There will be periodic maintenance and management of all construction machinery and vehicles to reduce exhaust discharged from such machinery and vehicles.

b. Water Pollution

Findings: There may be soil runoff from the exposed soil of the embankments and cut slopes, and water pollution of the downstream area of the surrounding river is predicted.

Mitigation Measures: The transmission line route shall avoid using steep sloping land, and any slopes used shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

c. Waste

Findings: Waste generated from the construction work will include metal chips, waste plastic, wood shavings, waste glass and waste oil. Furthermore, household waste discarded from the camping ground of the workers will include cans, bottles and garbage. If such waste is inadequately handled, river water and underground water may be contaminated, and sanitation problems may arise.

Mitigation Measures: To separate waste collection, recycling and reuse of waste will be promoted and non-recyclable waste will be disposed of at appropriate sites according to related regulations. Hazardous waste will be treated under the related regulations. To reduce the amount of solid waste discharged from the workers during the construction work, efforts will be taken to employ local workers wherever possible, so that the amount of household waste at the site will be minimized. These measures will be taken to ensure that water pollution or sanitary problems resulting from waste will not arise.

d. Noise and Vibration

Findings: Noise and vibration are expected to be caused by the operation of heavy machinery and trucks, but this will be limited to the surrounding area.

Mitigation Measures: In the actual construction work, schedule management will be performed to maintain constant amounts of construction work and low noise/low vibration equipment will be used as much as possible. Construction work will be performed during the daytime, especially piking work. Measures for reducing the generation of noise, such as speed reduction of vehicles in residential areas, will be taken, thereby minimizing vehicle noise and vibration impacts.

b) Natural Environment

a. Natural Resources

Findings: The transmission line route through over reserved forest area called Mirsharai with 13,160 hectare (ha) in size, in which partially 12-26 tree or rubber tree are planted, is located near Chittagong Tract Hill.

About 13 km length of transmission line will pass through this forest and 35 towers will be constructed, affecting a total of 1.4 ha forest for the tower sites. 20 towers, occupying 0.8 ha, out of 35 towers will be constructed after cutting trees at the site, in which 96 trees of teak and 64 rubber trees and scattered shrub will be cut.

Mitigation Measures: Compensation for the affected trees will be paid for once on their initial removal.

b. Ecosystem

Findings: The transmission line route bypasses the protected area, and will use land used for rice fields and other agricultural activity, and no primeval forests or tropical rain forests. Very few trees, which are commonly seen in project sites, will be cut down accompanied with the construction activities.

There are no habitats of precious species of Fauna designated as threatened species by IUCN, but some of Flora designated as threatened species by IUCN is found away from the transmission line route and so will not be affected directly by construction activities.

c. Topography and Geology

Findings: There may be soil runoff from the exposed soil of the embankments and cut slopes.

Mitigation Measures: The transmission line route shall avoid using steep sloping land, and any slope used shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

c) Social Environment

a. Disturbance to Poor People

Findings: Livelihood means of cultivators and sharecroppers will be temporarily lost during the construction period due to the blockage of farm land for construction purposes. They work on a daily basis and they are not well-paid.

Mitigation Measures: Compensation for their income for one season shall be offered to them in order for them to sustain themselves and find other job opportunities.

b. Disturbance to Ethnic Minority Groups and Indigenous People

Findings: According to the results of the Population Census of 2011 and interview survey conducted during the field survey, no ethnic minority groups or indigenous people have been identified along the transmission line route.

c. Deterioration of Local Economy such as Losses of Employment and Livelihood Means

Findings: Land owners, cultivators and sharecroppers will temporarily lose their means of livelihood during the construction period due to the construction blockage of farm land. The period for such blockage will last for 30 days, and in the worst scenario their loss can last for the whole season.

Mitigation Measures: Compensation for such income loss for one season shall be offered for them to sustain themselves and seek other job opportunities.

d. Land Use and Utilization of Local Resources

Findings: Farm activities will be disturbed temporarily due to the construction work. It is estimated that approximately 800 m^2 per tower base will be blocked exclusively for the construction, and farm activities will be disturbed for 30 days, which may affect their standing crops for a whole season.

Mitigation Measures: Compensation for such income loss for one season shall be offered for them to sustain themselves and seek other job opportunities.

e. Disturbance to Water Usage, Water Rights, etc.

Findings: Transmission line route has been selected avoiding any steep sloping land. Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

f. Infectious Diseases

Findings: Temporary influx of migrant labor during construction period may increase risk of infection.

Mitigation Measures: Local people will be prioritized as laborers for simple work during the construction period, which will help lower the risk of infectious diseases brought by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc).

g. Work Conditions (Including Work Safety)

Findings: Labor accidents may occur anytime without prevention measures including safety education and training, allocation of protective equipment and distribution of protection clothes to laborers and workers.

Mitigation Measures: The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those concerning provision of protective equipment, etc.

h. Right of Way

Findings: Farm activities will be disturbed temporarily due to the construction work. Land owners, cultivators and sharecroppers will temporarily lose their means of livelihood during construction period due to the construction blockage of farm land. The period for such blockage will last for 30 days, which may affect their standing crops for a whole season.

Mitigation Measures: Compensation for such income loss for one season shall be offered for them to sustain themselves and seek other job opportunities.

i. Accidents

Findings: Traffic and labor accidents can occur at any time, harming local residents living in surrounding areas and workers involved in construction work.

Mitigation Measures: As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

2) Operation Phase

a) Pollution control

a. Air Pollution

Findings: Air Pollution is not expected to be caused by operation of Transmission line.

b. Water Pollution

Findings: Water Pollution is not expected as embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

c. Noise and Vibration

Findings: Noise and Vibration is not expected to be caused by operation of Transmission line.

b) Natural Environment

a. Ecosystem

Findings: Bird strikings caused by the transmission line are expected. Bird species inhabiting areas along the proposed transmission line route are mainly sandpipers and plovers, and their flight altitude is relative low; therefore, the possibilities of bird strikes are small.

However, installing signs to prevent birds striking the transmission line is considered necessary.

b. Topography and Geology

Findings: Embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff.

c) Social Environment

a. Work Conditions (Including Work Safety)

Findings: Labor accidents such as electric shocks while in construction period may occur at any time if there are no protection measures.

Mitigation Measures: The work safety plan shall stipulate mitigation measures on such aspects as safety education and training, allocation of protective equipment and distribution of protective clothes to laborers and workers.

b. Accidents

Findings: The transmission line route was selected avoiding any steep sloped areas. -Preventing soil loss by stabilizing any slopes of the construction area with concrete as necessary based on geological survey. Tower breakdown by cyclones will not occur as wind pressure is taken into account in the design. Land traffic accidents may also occur during construction phase.

Mitigation Measures: As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

(2) Substation (Madunaghat)

3) Pre-construction Phase

a. Land Acquisition

Findings: Approximately 7 ha of farm land will be required for the construction of the new Madunaghat SS in Raozan Upazila of Chittagong District.

Mitigation Measures: It is the Deputy Commissioner of Chittagong District who is conducting land acquisition and payment of compensation in accordance with the Ordinance 1982. PGCB shall pay the DC Office when the budget is allocated from the Government of Bangladesh. A top-up payment shall be made on the basis of compensation at replacement cost. Trees within clearance distance from cables shall be removed. And standing crops and trees shall be compensated at market price.

b. Social Institutions such as Social Infrastructure and Local Decision-making Institutions

Findings: Land acquisition at new Madunaghat SS will cause permanent loss of land, standing crops and livelihood means of cultivators and sharecroppers.

Mitigation Measures: The Deputy Commissioner's Office of Chittagong District will take responsibility for initiatives to conduct local consultations concerning compensation in accordance with the Ordinance 1982, on top of which compensation at replacement cost shall be added as agreed between PGCB and JICA.

c. Misdistribution of Benefits and Compensation

Findings: Equality of compensation and fair treatment among the project affected people must be assured.

Mitigation Measures: Landowners and other affected people must be legitimately identified for proper payment of compensation.

d. Local Conflicts of Interest

Findings: In the case that equality of compensation and fair treatment among the project affected people is not assured, disputes and conflicts among them can occur at any time.

Mitigation Measures: Regulations of Bangladesh stipulate that public consultation must be held in the land acquisition process, and that complaints or suggestions must stay heard for immediate action.

4) Construction Phase

a) Pollution control

a. Air Pollution

Findings: Dust is expected from land preparation and other construction work, but the impact will be temporary and in a limited area. Generation of air pollution (SO_2, NO_2) from the operation of heavy machinery and trucks is predicted, but the impact will be limited to within the surrounding area.

Mitigation Measures: Watering the road and construction site, especially in the dry season, and using cover sheets on trucks for the transportation of soil will be undertaken in order to reduce dust.

There will be periodic maintenance and management of all construction machinery and vehicles to reduce exhaust discharged from such machinery and vehicles.

b. Water Pollution

Findings: There may be soil runoff from the exposed soil of the embankments, and water pollution of the downstream area of the surrounding river is predicted.

Mitigation Measures: Any slopes of embankments shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

Sites of Substations shall be surrounded by gutters made of concrete to avoid direct leakage of turbid water outside the site.

c. Noise and Vibration

Findings: Noise and vibration are expected to be caused by the operation of heavy machinery and trucks, but this will be limited to the surrounding area.

Mitigation Measures: In the actual construction work, schedule management will be performed to maintain constant amounts of construction work and low noise/low vibration equipment will be used as much as possible.

Construction work will be performed during the daytime.

Measures for reducing the generation of noise, such as speed reduction of vehicles in residential areas, will be taken, thereby minimizing vehicle noise and vibration impacts.

b) Natural Environment

a. Ecosystem

Findings: The sites for substations will be constructed in rice fields by landfill activity.

Habiting plants and small animals in sites are commonly seen and impacts from the project on these habitats are expected to be insignificant from the point of view of the ecosystem.

b. Topography and Geology

Findings: There may be soil runoff from the exposed soil of the embankments.

Mitigation Measures: Any slope of embankment shall be reinforced with concrete, plantation or other means to minimize soil runoff.

c) Social Environment

a. Disturbance to Poor People

Findings: Livelihood means of sharecroppers will be permanently lost. Sharecroppers work on a daily basis and they are not well-paid.

Mitigation Measures: Compensation for their income shall be offered to them in order for them to sustain themselves and bridging support shall be given until they find other job opportunities.

b. Disturbance to Ethnic Minority Groups and Indigenous People

Findings: According to the results of the Population Census of 2011 and interview survey conducted during JICA survey, no ethnic minority groups or indigenous people have been identified in the substation site of Raozan Upazila.

c. Deterioration of Local Economy such as Losses of Employment and Livelihood Means

Findings: Land owners will permanently lose their land and their sharecroppers will permanently lose their means of livelihood.

Mitigation Measures: Compensation for such income loss shall be offered at replacement cost for their losses, to sustain them and enable them to seek other job opportunities. Mitigation measures will involve employing as many local residents as possible, and using services and products offered by the local community.

d. Land Use and Utilization of Local Resources

Findings: Farm activities will be disturbed permanently due to the permanent acquisition of land as large as 7 ha at the new Madunaghat SS site. Land owners will permanently lose their land and their sharecroppers will permanently lose their means of livelihood.

Mitigation Measures: Compensation for such losses shall be offered, to sustain them and enable them to seek other job opportunities.

e. Infectious Diseases

Findings: Temporary influx of migrant labor during construction period may increase risk of infection.

Mitigation Measures: Local people will be prioritized as laborers for simple work during the construction period, which will help lower the risk of infectious diseases brought by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc).

f. Work Conditions (Including Work Safety)

Findings: Labor accidents may occur anytime without prevention measures including safety education and training, allocation of protective equipment and distribution of protective clothes to laborers and workers.

Mitigation Measures: The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those concerning provision of protective equipment, etc.

g. Accidents

Findings: Accidents can occur at any time, harming local residents living in surrounding areas and workers involved in construction work.

Mitigation Measures: As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

5) Operation Phase

a) Pollution control

a. Air Pollution

Findings: Air Pollution is not expected to be caused by operation of Substation.

b. Water Pollution

Mitigation Measures: Embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

c. Noise and Vibration

Findings: Low frequency sound and vibration will occur. However, the impact is limited as the facilities will be kept inside the site, so no noise or vibration is expected outside the substation.

b) Natural Environment

a. Ecosystem

Findings: Impacts on the ecosystem are not expected by operation of Substation.

b. Topography and Geology

Mitigation Measures: Embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff.

c) Social Environment

a. Disturbance to Poor People

Findings: Sharecroppers who permanently lost their means of livelihood during construction work may not be able to find other job opportunities in the surrounding area even after the construction work.

Mitigation Measures: Bridging support shall be given to them until they find new jobs.

b. Deterioration of Local Economy such as Losses of Employment and Livelihood Means

Findings: Sharecroppers who permanently lost their means of livelihood during construction work may not be able to find other job opportunities in the surrounding area even after the construction work.

Mitigation Measures: Bridging support shall be given to them until they find new jobs.

c. Land Use and Utilization of Local Resources

Findings: Changes in the traditional land usage patterns and utilization of local resources may last even after the construction work is over.

Mitigation Measures: Bridging support shall be given to them until they find new jobs and new land.

d. Electromagnetic Fields

Findings: Negative impact of electromagnetic fields on human health is not anticipated if local residents keep out of the substation complex.

e. Work Conditions (Including Work Safety)

Findings: Labor accidents may occur anytime without prevention measures including safety education and training, allocation of protective equipment and distribution of protective clothes to laborers and workers.

Mitigation Measures: The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those concerning provision of protective equipment, etc.

f. Accidents

Findings: Accidents can occur at any time, harming local residents living in surrounding areas and workers involved in construction work.

Mitigation Measures: As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

(3) Access Road Expansion

The access road will be constructed by expanding an existing farm road of 3.5 meters to 5.0 meters in width and 1,000 meters in length.

This small scale expansion shall be developed via the landfill activity of adjacent rice fields, so no serious impact on the natural and social environment nearby is estimated due to the project.

6) Pre-construction Phase

a. Land Acquisition

Findings: The existing road will be expanded by 2 m for 1,000 m up to the new substation, for which approximately 2,000 m^2 of land will be required.

Mitigation Measures: It is the Deputy Commissioner of Chittagong District who will conduct land acquisition and payment of compensation in accordance with the Ordinance 1982. PGCB will pay the DC Office when the budget is allocated from the Government of Bangladesh. A top-up payment shall be made on the basis of compensation at replacement cost to bridge the gap with the JICA Guidelines. Trees within clearance distance from cables will be removed. And standing crops and trees will be compensated at market price.

b. Social Institutions such as Social Infrastructure and Local Decision-making Institutions

Findings: Land acquisition for expanding the existing road will cause permanent loss of land, standing crops and livelihood means of cultivators and sharecroppers to some extent.

Mitigation Measures: The Deputy Commissioner's Office of Chittagong District will take responsibility for initiatives to conduct local consultations concerning compensation in accordance with the Ordinance 1982, on top of which compensation at replacement cost shall be added as agreed between PGCB and JICA.

c. Misdistribution of Benefits and Compensation

Findings: Equality of compensation and fair treatment among the project affected people must be assured.

Mitigation Measures: Landowners and other affected people must be legitimately identified for proper payment of compensation.

d. Local Conflicts of Interest

Findings: In the case that equality of compensation and fair treatment among the project affected people is not assured, disputes and conflicts among them can occur at any time.

Mitigation Measures: Regulations of Bangladesh stipulate that public consultation must be held in the land acquisition process, and that complaints or suggestions must stay heard for immediate action.

7) Construction Phase

a) Pollution control

a. Air Pollution

Findings: Dust is expected from land preparation and other construction work, but the impact will be temporary. Generation of air pollution (SO_2, NO_2) from the operation of heavy machinery and trucks is predicted, but the impact will be limited to within the surrounding area.

Mitigation Measures: Watering the road and construction site, especially in the dry season, and using cover sheets on trucks for the transportation of soil will be undertaken in order to reduce dust.

b. Water Pollution

Findings: There may be soil runoff from the exposed soil of the embankments, and water pollution of the downstream area of the surrounding river is predicted.

Mitigation Measures: Embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

c. Noise and Vibration

Findings: Noise and vibration are expected to be caused by the operation of heavy machinery and trucks, but this will be limited to the surrounding area.

In the actual construction work, schedule management will be performed to maintain constant amounts of construction work and low noise/low vibration equipment will be used as much as possible.

Construction work will be performed during the daytime.

b) Natural Environment

a. Ecosystem

Findings: Adjacent rice field after the landfill activity will be used for. the planned expansion site of the road.

Mitigation Measures: Habiting plants and small animals in sites are commonly seen and impacts from the project on these habitats are expected to be insignificant from the point of view of the ecosystem.

b. Topography and Geology

Findings: There may be soil runoff from the exposed soil of the embankments.

Mitigation Measures: Any slope of embankment shall be reinforced with plantation or other means to minimize soil runoff.

c) Social Environment

a. Disturbance to Poor People

Findings: Livelihood means of sharecroppers will be permanently lost. Sharecroppers work on a daily basis and they are not well-paid.

Mitigation Measures: Compensation for their income shall be offered to them in order for them to sustain themselves and bridging support shall be given until they find other job opportunities.

b. Disturbance to Ethnic Minority Groups and Indigenous People

Findings: According to the results of the Population Census of 2011 and interview survey conducted during JICA survey, no ethnic minority groups or indigenous people have been identified in the substation site of Raozan Upazila.

c. Deterioration of Local Economy such as Losses of Employment and Livelihood Means

Findings: Land owners will permanently lose their land and their sharecroppers will permanently lose their means of livelihood.

Mitigation Measures: Compensation for such income loss shall be offered at replacement cost for their losses, to sustain them and enable them to seek other job opportunities. Mitigation measures will involve employing as many local residents as possible, and using services and products offered by the local community.

d. Land Use and Utilization of Local Resources

Findings: Land acquisition for road expansion may hinder specific activities at homesteads and farm land along the road. Land owners will permanently lose their land and their sharecroppers will permanently lose their means of livelihood.

Mitigation Measures: Compensation for such losses shall be offered, to sustain them and enable them to seek other job opportunities.

e. Infectious Diseases

Findings: Temporary influx of migrant labor during construction period may increase risk of infection.

Mitigation Measures: Local people will be prioritized as laborers for simple work during construction period, which will help lower the risk of infectious diseases brought by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc).

f. Work Conditions (Including Work Safety)

Findings: Labor accidents may occur anytime without prevention measures including safety education and training, allocation of protective equipment and distribution of protective clothes to laborers and workers.

Mitigation Measures: The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those concerning provision of protective equipment, etc.

g. Accidents

Findings: Accidents can occur at any time, harming local residents living in surrounding areas and workers involved in construction work.

Mitigation Measures: As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

3) Operation Phase

a) Pollution control

Not applicable.

b) Natural Environment

Not applicable.

c) Social Environment

Not applicable.

Summary of Environmental Impact Assessment

The results of the environmental impact assessment are summarized in the following tables:

Table 12.1-17 Results of Environmental and Social Evaluation (Transmission Line)

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air pollution	B-	D	B-	D	**Construction phase:** - Prevention measures for dust dispersion will be taken by spraying water. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. **Operation phase:** - No specific air pollution is expected.

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
	2	Water pollution	B-	B-	B-	D	**Construction and Operation phase:** - The transmission line route was selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
	3	Waste	B-	D	B-	D	**Construction phase:** - General waste and hazardous waste are generated by the construction work. **Operation phase:** - No general waste or hazardous waste is expected.
	4	Noise and Vibration	B-	D	B-	D	**Construction phase:** - Construction machinery and vehicles will be maintained regularly. - Low-noise/low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area. **Operation phase:** - No specific noise or vibration is expected.
Natural Environment	5	Natural reserve	B-	D	D	D	**Construction phase:** - Transmission line route was selected avoiding any protected areas. **Operation phase:** - No specific impact on Natural reserve areas is predicted.
	6	Ecosystem	B-	B-	D	C-	**Construction phase:** - Transmission line route was selected avoiding any protected areas. - There are no flora species listed in the IUCN Red list under the transmission line route. - Precious species of insects, amphibians, reptiles, mammals and birds designated by IUCN are not observed under/along the transmission line route. **Operation phase:** - Birds striking the lines and other impacts are expected to be insignificant.
	7	Topography and Geology	C	C	B-	D	**Construction and Operation phases:** - Transmission line route was selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
Social Environment	8	Land Acquisition and Resettlement	C	D	B-	D	**Pre-construction phase:** - Construction of one tower base for 400 kV requires 2 m^2 of land for suspension tower (approximately 550 in number) and 3 m^2 of land for tension tower (approximately 250 in number). Not more than 2,000 m^2 in total is approximately required. - Construction of one tower base for 230 kV requires 1m^2 of land for suspension tower (approximately 20 in number) and 1m2 of land for tension tower (approximately 15 in number). Not more than 100 m^2 in total is approximately required. - Land acquisition will be conducted on the basis of compensation at replacement cost. - Trees within clearance distance from cables will be removed. - Standing crops and trees will be compensated at market price. - During construction period, certain parts will be blocked exclusively for the construction, and farm activities will be disturbed.
	9	Disturbance to Poor People	C	C	B-	D	**Construction phases:** - Sharecroppers are among vulnerable groups. Their livelihood means will be temporarily lost during the construction period.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	C	C	D	D	- No ethnic minority groups or indigenous people were identified along the transmission line route.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	C	C	B-/B+	D	**Construction phases:** - During construction period, certain parts will be blocked exclusively for the construction, and farm activities will be disturbed. - Mitigation measures will involve employing as many local residents as possible, and using services and products offered by the local community. **Operation phase:** - The transmission line construction area can be reused for farming after the completion of the transmission tower construction, except for the land for tower bases; therefore, adverse effects on income will be very limited.

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre-/ construction Phase	Operation Phase	Pre-/ construction Phase	Operation Phase	
	12	Land Use and Utilization of Local Resources	C	C	**B-**	**D**	**Construction phase:** - During construction period, certain parts will be blocked exclusively for the construction, and farm activities will be disturbed. **Operation Phase:** - The transmission line construction area can be reused for farming after the completion of the transmission tower construction, except for the land for tower bases; therefore, adverse effects on income will be very limited.
	13	Disturbance to Water Usage, Water Rights, etc.	C	C	**D**	**D**	**Construction and Operation phases:** - Transmission line route has been selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	D	D	**Construction phase:** - Since the volume of increased traffic will be small, no significant impact is anticipated. **Operation phase:** - No specific adverse effects are predicted for the existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	C	D	D	D	**Pre-construction phase:** - PGCB will, together with the contractor of the transmission lines, inform the land owners of their possible land use for the tower base, and duly take into account the land owners' responses and conclude agreements in writing with the land owners with regard to the land use for the tower base. Upon such communication with the land owners, PGCB will duly inform the land owners that they have the right to express objection to the possible land use. If PGCB does not purchase the land under the proposed transmission towers, PGCB shall restore the land to its original conditions after construction of the transmission towers. **Operation phase:** - No specific impact is predicted concerning social infrastructure and local decision-making institutions.
	16	Misdistribution of Benefits and Compensation	C	D	D	D	No specific impact is predicted concerning the misdistribution of benefits and compensation.

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
	17	Local Conflicts of Interest	C	D	D	D	No specific impact is predicted concerning local conflicts of interest.
	18	Cultural Heritage	C	C	D	D	- No specific impact is predicted concerning cultural heritage.
	19	Landscape	C	C	D	D	- Transmission line route has been selected avoiding any protected or scenic areas to the maximum extent.
	20	Gender	C	C	D	D	No specific negative impact expected.
	21	Children's Rights	C	C	D	D	No specific negative impact expected.
	22	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**Construction phase:** - Local people will be recruited for simple work to the maximum extent possible, which will help lower the risk of infectious diseases being transmitted by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc). **Operation phase:** - No specific negative impacts are expected.
	23	Work Conditions (Including Work Safety)	B-	B-	B-	B-	**Construction phase:** - The construction company shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on soft aspects (safety education and training, etc) and hard aspects (provide workers with appropriate protective equipment, etc). **Operation phase:** - The work safety plan shall be established including mitigation measures on soft aspects (safety education and training, etc) and hard aspects (provide workers with appropriate protective equipment, etc).
	24	Right of Way (ROW)	B-	D	B-	D	**Construction phase:** - Temporary disturbance to the local land use due to the blockage during construction period. **Operation phase:** - No specific impact is anticipated.
Others	25	Accidents	B-	B-	B-	D	**Construction phase:** - As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
	26	Cross-boundary Impact and Climate Change	D	D	D	D	- Cross boundary and CO2 emissions are not anticipated in relation to the transmission line.

(Source: JICA Survey Team)

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

Table 12.1-18 Results of Environmental and Social Evaluation (Substation)

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air pollution	B-	D	B-	D	**Construction phase:** - Prevention measures for dust dispersion will be taken by spraying water. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. **Operation phase:** - No specific air pollution is expected.
	2	Water pollution	B-	B-	D	D	**Construction and Operation phase:** - The site of Substation was selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
	3	Waste	B-	B-	B-	B-	**Construction phase:** - General waste and hazardous waste are generated by the construction work. **Operation phase:** - General waste is generated.
	4	Noise and Vibration	B-	D	B-	D	**Construction phase:** - Construction machinery and vehicles will be maintained regularly. - Low-noise/low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area. **Operation phase:** - Noise and vibration will be borne due to the

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
							operation of substation. However, it will be absorbed within the site, so no specific impact is anticipated outside.
Natural Environment	5	Natural reserve	D	D	D	D	**Pre-construction and Operation phases:** - The site of Substation was selected in a rice field, so that Natural resources do not exist.
	6	Ecosystem	D	D	D	D	**Construction phase:** - The site of Substation was selected avoiding any protected areas. - There are no flora species listed in the IUCN Red list in/around site of Substation. -Precious species of insects, amphibians, reptiles, mammals and birds designated by IUCN are not observed in/around site of Substation. **Operation phase:** - Birds striking the lines and other impacts are not expected.
	7	Topography and Geology	C-	C-	D	D	**Construction and Operation phases:** - The site of Substation was selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
Social Environment	8	Land Acquisition and Resettlement	B-	D	B-	D	**Pre-construction phase:** - Approximately 7 ha of farm land will be required for the construction of Madunaghat SS. - Land acquisition will be conducted on the basis of compensation at replacement cost. - Standing crops and trees will be compensated at market price.
	9	Disturbance to Poor People	B-/C-	B-/C-	B-	B-	**Construction and Operation phases:** - Sharecroppers are among vulnerable groups and they may lose their livelihood means permanently.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	D	D	D	D	**Construction and Operation phases:** - No ethnic minority groups or indigenous people were identified.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood	B-/C-	B-	B-/B+	B-	**Construction phases:** - Sharecroppers may lose their livelihood means permanently. - Mitigation measures will involve employing as many local residents as possible, and using services and products offered by the local community.

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
		Means					**Operation phase:** - Sharecroppers may lose their livelihood means permanently.
	12	Land Use and Utilization of Local Resources	B-	B-	B-	D	**Construction phase:** - 7 ha of farm land will be permanently lost.
	13	Disturbance to Water Usage, Water Rights, etc.	C	C	D	D	**Construction and Operation phases:** Discharged water from the substation site, both during construction period and operation period, will be treated at the catch basin and rain water will be collected at the gutter to drain. Water usage in the paddy field around the substation will therefore not be affected.
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	D	D	**Construction phase:** - Since the volume of increased traffic will be small, no significant impact is anticipated. **Operation phase:** - No specific adverse effects are predicted for the existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	B-	D	B-	D	**Pre-construction phase:** - The Deputy Commissioner's Office will take responsibility for initiatives to conduct local consultations concerning compensation by law. On top of that, compensation at replacement cost shall be added as agreed between PGCB and JICA. **Operation phase:** - No specific impact is predicted concerning social infrastructure and local decision-making institutions.
	16	Misdistribution of Benefits and Compensation	C	C	B-	D	**Pre-Construction phase:** Landowners and other affected people must be legitimately identified for proper payment of compensation **Operation phase:** No specific impact is predicted concerning the misdistribution of benefits and compensation.
	17	Local Conflicts of Interest	C	C	B-	D	**Pre-Construction phase:** Landowners and other affected people must be legitimately identified for proper payment of compensation **Operation phase:** No specific impact is predicted concerning local conflicts of interest.
	18	Cultural Heritage	D	D	D	D	- No specific impact is predicted concerning cultural heritage.

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre-/ construction Phase	Operation Phase	Pre-/ construction Phase	Operation Phase	
	19	Landscape	D	D	D	D	- Substation site has been selected avoiding any protected and scenic areas to the maximum extent.
	20	Gender	D	D	D	D	No specific negative impact expected.
	21	Children's Rights	D	D	D	D	No specific negative impact expected.
	22	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**Construction phase:** - Local people will be recruited for simple work as much as possible and there is a low risk of infectious diseases being transmitted by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc). **Operation phase:** - No specific negative impacts are expected.
	23	Work Conditions (Including Work Safety)	B-	B-	B-	B-	**Construction phase:** - The construction company shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc) and hard aspects (provide workers with appropriate protective equipment, etc). **Operation phase:** - The work safety plan shall be established including mitigation measures on soft aspects (safety training, etc) and hard aspects (provide workers with appropriate protective equipment, etc).
	24	Electromagnetic Field	D	B-	D	D	**Construction phase:** - No specific impact is anticipated. **Operation phase:** - No exceeding impact bigger than the present condition.
Others	25	Accidents	B-	B-	B-	D	**Construction phase:** - As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.
	26	Cross-boundary Impact and Climate Change	D	D	D	D	- Cross boundary and CO2 emissions are not anticipated in relation to the Substations due to small scale facility.

(Source: JICA Survey Team)

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

Table 12.1-19 Results of Environmental and Social Evaluation (Road Expansion to Madunaghat Substation)

Item	No.	Impact	Evaluation based Scoping		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air pollution	B-	D	B-	D	**Construction phase:** - Prevention measures for dust dispersion will be taken by spraying water. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. **Operation phase:** - No specific air pollution is expected as the length of road is only about 1,000m.
	2	Water pollution	B-	B-	D	D	**Construction :** - Increased turbidity will occur within a short period. **Operation phase:** - Any slopes shall be covered with vegetation or other means to minimize soil runoff and turbid water generation.
	3	Waste	B-	B-	B-	D	**Construction phase:** - General waste and hazardous waste are generated by the construction work. **Operation phase:** - No general waste or hazardous waste is expected.
	4	Noise and Vibration	B-	D	B-	D	**Construction phase:** - Construction machinery and vehicles will be maintained regularly. - Low-noise/low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area. **Operation phase:** - No specific noise or vibration is expected.
Natural Environment	5	Natural reserve	D	D	D	D	**Pre-construction and Operation phases:** - The expanding road will be constructed by using slope of existing road covered with grass or man-planted trees and rice fields, so natural resources are not seen.
	6	Ecosystem	D	D	D	D	**Construction phase:** - Each side of the road was paddy field and there are no protected areas nearby. - There are no flora species listed in the IUCN Red list in/along the road. -Precious species of insects, amphibians, reptiles, mammals and birds designated by IUCN are not observed in/along the road.

Item	No.	Impact	Evaluation based Scoping		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
							Operation phase: - Flora and Fauna along the road are observed widely.
	7	Topography and Geology	C-	C-	D	D	**Construction and Operation phases:** - The site of the road was selected avoiding any steep sloping land. - Any slopes shall be covered with vegetation to minimize soil runoff and turbid water generation.
Social Environment	8	Land Acquisition and Resettlement	B-	D	B-	D	**Pre-construction phase:** - Expansion of road will require 1,000m x 2m = 2,000m^2 of land. - Land acquisition will be conducted on the basis of compensation at replacement cost. - Trees within clearance distance from cables will be removed. - Standing crops and trees will be compensated at market price.
	9	Disturbance to Poor People	B-/C-	B-/C-	B-	D	**Construction:** - Sharecroppers may lose their livelihood means temporarily or partially.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	D	D	D	D	**Construction and Operation phases:** - No ethnic minority groups or indigenous people were identified.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	B-/C-	B-	B-/B+	D	**Construction phases:** - Sharecroppers may lose their livelihood means temporarily during construction period. - Mitigation measures will involve employing as many local residents as possible, and using services and products offered by the local community.
	12	Land Use and Utilization of Local Resources	B-	B-	B-	D	**Construction phase:** - Land acquisition for road expansion may hinder specific activities at homesteads and farm land along the road.
	13	Disturbance to Water Usage, Water Rights, etc.	C-	C-	D	D	**Construction** Discharged water from the construction site will be treated at the catch basin and rain water will be collected at the gutter to drain. Water usage in the paddy field around the substation will therefore not be affected. **Operation phases:** - No specific impact is predicted.

Item	No.	Impact	Evaluation based Scoping		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	D	D	**Construction phase:** - Since the volume of increased traffic will be small, no significant impact is anticipated. **Operation phase:** - No specific adverse effects are predicted for the existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	B-	D	B-	D	**Pre-construction phase:** - The Deputy Commissioner's Office will take responsibility for initiatives to conduct local consultations concerning compensation. On top of that, compensation at replacement cost shall be added according to the resettlement policy framework as agreed between PGCB and JICA. **Operation phase:** - No specific impact is predicted concerning social infrastructure and local decision-making institutions.
	16	Misdistribution of Benefits and Compensation	C-	C-	B-	D	**Pre-Construction phase:** -Landowners and other affected people must be legitimately identified for proper payment of compensation **Operation phase:** -No specific impact is predicted concerning the misdistribution of benefits and compensation.
	17	Local Conflicts of Interest	C-	C-	B-	D	**Pre-Construction phase:** -Landowners and other affected people must be legitimately identified for proper payment of compensation **Operation phase:** -No specific impact is predicted concerning the misdistribution of benefits and compensation.
	18	Cultural Heritage	D	D	D	D	- No specific impact is predicted concerning cultural heritage.
	19	Landscape	D	D	D	D	- Road expansion will not harm scenic areas.
	20	Gender	D	D	D	D	No specific negative impact expected.
	21	Children's Rights	D	D	D	D	No specific negative impact expected.
	22	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**Construction phase:** - Local people will be recruited for simple work as much as possible and there is a low risk of infectious diseases being transmitted by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc). **Operation phase:** - No specific negative impacts are expected.

Item	No.	Impact	Evaluation based Scoping		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
	23	Work Conditions (Including Work Safety)	B-	B-	B-	D	**Construction phase:** - The construction company shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc) and hard aspects (provide workers with appropriate protective equipment, etc).
	24	Others	C-	C-	D	D	N/A
Others	25	Accidents	B-	B-	B-	D	- As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.
	26	Cross-boundary Impact and Climate Change	D	D	D	D	- Cross boundary and CO2 emissions are not anticipated in relation to the access road due to its short length.

(Source: JICA Survey Team)

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)
D: No impact is expected.

12.1.8 Mitigation Measures and Required Budget

1) Implementation system

a) Construction phase

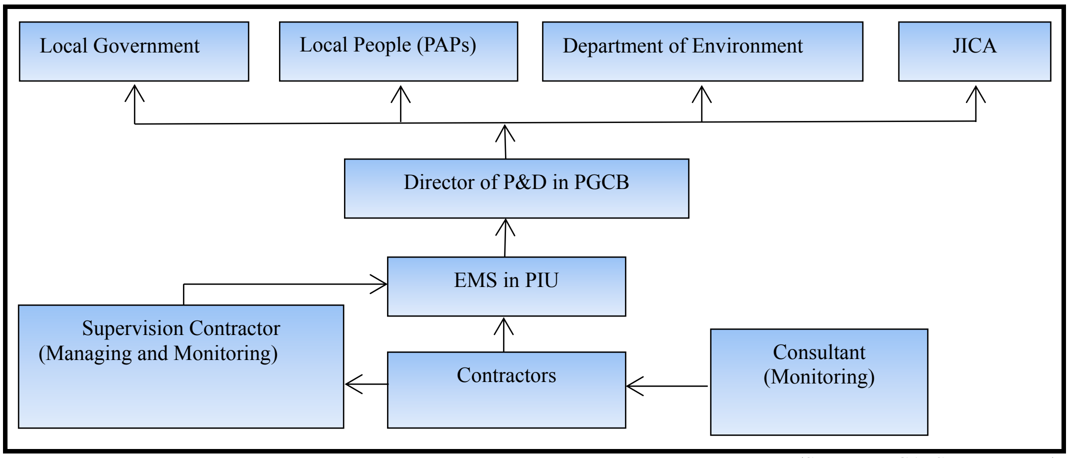
At the construction stage, the Project Implementation Unit (PIU) of PGCB, shall carefully take care for all construction activities with the supervision consultant, and encourage the contractor to fully understand the necessary mitigation measures and to implement them.

In this regard, an Environmental Management Section shall be organized in PIU prior to construction activities and some members of the PIU of Planning and Designing (P&D) in PGCB shall be designated as environmental management administrators.

During the construction activity, in which a large inflow of workers and vehicles is predicted, the Environmental Management Section shall encourage the surrounding community to understand the content and schedule of the construction activity and mitigation measures, and obtain local people’s opinions and change the mitigation measures as appropriate.

The Environmental Management Administrator shall regularly hold explanation sessions with the local people and submit reports to the Department of Environment of MOEF in Bangladesh, JICA and other relevant organizations about the implementation status of the environmental management, in addition to the environmental monitoring.

The following figure describes the environmental management and monitoring implementation structure with the reporting flow during the construction phase.



(Source: JICA Survey Team)

Figure 12.1-16 Environmental Management and Monitoring Implementation Structure during Construction Phase

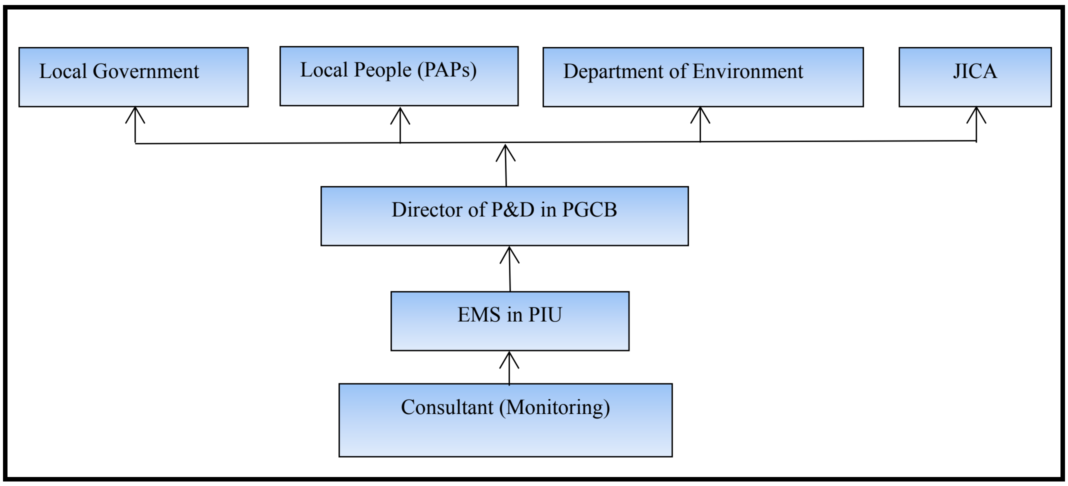
b) Operation phase

The Environmental Management Section shall report the contents and implementation status of the environmental management plan and the environmental monitoring plan to the director of the P&D in PGCB, with the director taking final responsibility.

The Environmental Management Section shall also regularly provide explanations to the local people and submit reports to the Department of Environment of MOEF, JICA and other relevant organizations about the implementation status of the environmental management, in addition to the environmental monitoring.

The Environmental Management Section shall also function as a grievance organization to understand and address any grievances from local people during the operation phase, and conduct appropriate mitigation measures.

The following figure describes the environmental management and monitoring implementation structure with the reporting flow during the operation phase.



(Source: JICA Survey Team)

Figure 12.1-17 Environmental Management and Monitoring Implementation Structure during Operation Phase

12.1.9 Environmental Monitoring Plan (EMP)

An EMP will be prepared based on the EMaP, in which anticipated impacts and counter-management efforts for particular items are described, in order to provide measurement tools and methods for the said items during pre-construction, construction and operation activities.

The environmental components that will be monitored are those that will be positively or negatively affected, or expected to be affected, by the project implementation.

Table 12.1-20 Environmental Management Plan (Transmission Line)

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Pre-construction Phase									
1	Land acquisition	- Loss of land at tower bases (permanent) - Kept out of the construction zone (temporary) - Livelihood means (temporary)	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Consideration for land owners, sharecroppers and compensation for standing agriculture products	- Towers are constructed in non-residential areas - Land acquisition shall be conducted on the basis of compensation at replacement cost - Standing crops and trees shall be compensated at market price - Temporary block out during construction period will occur for safety and security	- Tower bases	- During land acquisition process	- Implementation: Office of the Deputy Commissioner - Monitoring: PGCB	Expenses to be paid by PGCB
2	ROW	- Kept out of the construction zone - Trees will be removed if they are within clearance distance - Standing crops and trees will be affected	- Electricity Act 1910	- Consideration for land owners, sharecroppers and compensation for standing agriculture products	- Compensation shall be conducted in compliance with relevant laws and regulations	- ROW	- During the official procedure	- Implementation and monitoring: PGCB	Expenses to be paid by PGCB

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction Stage									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment 3) Air pollution arising from incineration of construction materials and waste	1) - 3) - Ambient Air Quality Standard	1) - 3) - Prevention of air pollution in the surrounding construction area	1) Dust prevention - Watering access roads and construction site, especially in the dry season - Using cover sheet on trucks for the transportation of soil 2) Gas emission prevention - Periodic maintenance and management of all construction machinery and vehicles 3) Waste management - Prohibit open burning and illegal dumping	1) - 3) - Construction area	1) - 3) -During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Water Quality	1) Run off water from construction area 2) Domestic wastewater of workers 3) Inappropriate	1) -3) - Wastewater standards	1) - 3) - Prevention of water pollution in the surrounding construction area	1) Run off water - Transmission line route was selected avoiding any steep sloped areas - Preventing soil	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB / Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		disposal of waste			loss by stabilizing any slopes of the construction area with concrete, as necessary based on geological survey 2) Domestic wastewater - Install wastewater treatment facility for workers, such as septic tanks 3) Waste management - Prohibit illegal waste disposal				
3	Waste	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous waste such as dry batteries, etc.	1) - 3) - Waste Management Rule	1) - 3) - Prevention of inappropriate waste disposal	1), 2) Construction and domestic waste - Conduct separate waste collection and promote recycling and reuse - Appropriate disposal of non-recyclable waste according to rules 3) Hazardous	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					waste - Hazardous waste should be treated under the related regulations				
4	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	1), 2) - Noise level standards	1), 2) - Reduction of noise level from construction activities	1) Construction machinery - Optimizing construction schedule - Perform construction work during daytime, especially piling work -Using low-noise/ low vibration equipment, as much as possible 2) Mobilization - Limit truck speed, especially around residential areas	1), 2) - Construction area	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
5	Ecosystem	1) Removal of vegetation 2) Loss of protected species	1) Cover of vegetation and trees 2) Existence of protected species	1), 2) - Mitigation of environmental impact on the loss of vegetation and protected species	1) Vegetation - Tower construction area should be re-vegetated with native plants 2) Protected	1), 2) - Transmission line route	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					species - Consult with specialists about moving individual animals if any protected species are discovered				
6	Topography and Geology	- Soil runoff	-Soil runoff	-Prevention of soil runoff	- Transmission line route was selected avoiding any steep sloped areas - Preventing soil loss by stabilizing any slopes of construction areas with concrete, as necessary based on geological survey	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
7	Disturbance to the Poor	- Loss of farmlands, being kept out of construction zones - Changing the traditional land usage patterns and utilization of local resources	- Employment of local residents	- Consideration of local residents' feelings	- Employ as many local residents as possible - Use the services and products offered by the local community	- Villages along the transmission line route	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
8	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood								
9	Land Use and Utilization of Local Resources								

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
10	Infectious Diseases	- Temporary influx of migrant labor during construction may increase risk of infection	-----	- Consideration of hygiene and sanitation of local residents	- Establish medical center and implementation of periodic medical check-ups - Education and training on workers' health care	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
11	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Prevention measures against labor accidents, accidents, and health problems	- Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Inspect and ensure that any lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate - Use facilities	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					and equipment that protect against electric shocks				
12	ROW	- Loss of standing crops - Loss of trees	-Electricity Act 1910	- Consideration to affected peoples' socioeconomic conditions	- Compensation should be conducted in compliance with relevant laws and regulations	- ROW	- During construction	- Implementation : Contractor - Supervision: PGCB	Expenses included in contract cost by Contractor
13	Accidents	- Land traffic accidents	- Land traffic	- Prevention of land traffic accidents	- Observation of traffic regulations, installation of traffic signs and education on safe driving - Training safe operation of vehicles	- Construction area - Roads near the construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
Operational Stage									
1	Water Quality	- Run-off water from tower bases and substation	------	- Prevention of water pollution in the surrounding construction area	- Re-vegetation of the tower bases and slopes in substation site	- Tower bases -Substation	- During the inspection work	PGCB	PGCB
2	Waste	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	Ecology	- Birds striking the lines	- Birds striking	- Prevention of birds striking	- Installation of lights and signs, etc., if needed	- Along the transmission line route	- During the inspection work	PGCB	PGCB

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
4	Topography and Geology	- Soil runoff	- Soil runoff	-Prevention of soil runoff	- Transmission line route was selected avoiding any steep sloped areas - Preventing soil loss by stabilizing any slopes of construction area with concrete, as necessary based on geological survey	- Along the transmission line route -Inside Substation site	- During the inspection work	PGCB	PGCB
5	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Prevention measures against labor accidents, accidents, and health problems	- Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Use facilities and equipment that protect against electric shocks	- Along the transmission line route and towers	- During the inspection work	PGCB	PGCB

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Pre-construction Phase									
1	Land acquisition	- Loss of land at tower bases (permanent) - Kept out of the construction zone (temporary) - Livelihood means (temporary)	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Consideration for land owners, sharecroppers and compensation for standing agriculture products	- Towers are constructed in non-residential areas - Land acquisition shall be conducted on the basis of compensation at replacement cost - Standing crops and trees shall be compensated at market price - Temporary block out during construction period will occur for safety and security	- Tower bases	- During land acquisition process	- Implementation: Office of the Deputy Commissioner - Monitoring: PGCB	Expenses to be paid by PGCB
2	ROW	- Kept out of the construction zone - Trees will be removed if they are within clearance distance - Standing crops and trees will be affected	- Electricity Act 1910	- Consideration for land owners, sharecroppers and compensation for standing agriculture products	- Compensation shall be conducted in compliance with relevant laws and regulations	- ROW	- During the official procedure	- Implementation and monitoring: PGCB	Expenses to be paid by PGCB

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction Stage									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment 3) Air pollution arising from incineration of construction materials and waste	1) - 3) - Ambient Air Quality Standard	1) - 3) - Prevention of air pollution in the surrounding construction area	1) Dust prevention - Watering access roads and construction site, especially in the dry season - Using cover sheet on trucks for the transportation of soil 2) Gas emission prevention - Periodic maintenance and management of all construction machinery and vehicles 3) Waste management - Prohibit open burning and illegal dumping	1) - 3) - Construction area	1) - 3) -During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Water Quality	1) Run off water from construction area 2) Domestic wastewater of workers 3) Inappropriate	1) -3) - Wastewater standards	1) - 3) - Prevention of water pollution in the surrounding construction area	1) Run off water - Transmission line route was selected avoiding any steep sloped areas - Preventing soil	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB / Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		disposal of waste			loss by stabilizing any slopes of the construction area with concrete, as necessary based on geological survey 2) Domestic wastewater - Install wastewater treatment facility for workers, such as septic tanks 3) Waste management - Prohibit illegal waste disposal				
3	Waste	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous waste such as dry batteries, etc.	1) - 3) - Waste Management Rule	1) - 3) - Prevention of inappropriate waste disposal	1), 2) Construction and domestic waste - Conduct separate waste collection and promote recycling and reuse - Appropriate disposal of non-recyclable waste according to rules 3) Hazardous	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					waste - Hazardous waste should be treated under the related regulations				
4	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	1), 2) - Noise level standards	1), 2) - Reduction of noise level from construction activities	1) Construction machinery - Optimizing construction schedule - Perform construction work during daytime, especially piling work -Using low-noise/ low vibration equipment, as much as possible 2) Mobilization - Limit truck speed, especially around residential areas	1), 2) - Construction area	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
5	Ecosystem	1) Removal of vegetation 2) Loss of protected species	1) Cover of vegetation and trees 2) Existence of protected species	1), 2) - Mitigation of environmental impact on the loss of vegetation and protected species	1) Vegetation - Tower construction area should be re-vegetated with native plants 2) Protected	1), 2) - Transmission line route	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					species - Consult with specialists about moving individual animals if any protected species are discovered				
6	Topography and Geology	- Soil runoff	-Soil runoff	-Prevention of soil runoff	- Transmission line route was selected avoiding any steep sloped areas - Preventing soil loss by stabilizing any slopes of construction areas with concrete, as necessary based on geological survey	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
7	Disturbance to the Poor	- Loss of farmlands, being kept out of construction zones - Changing the traditional land usage patterns and utilization of local reSource:s	- Employment of local residents	- Consideration of local residents' feelings	- Employ as many local residents as possible - Use the services and products offered by the local community	- Villages along the transmission line route	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
8	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood								
9	Land Use and Utilization of Local ReSource:s								

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
10	Infectious Diseases	- Temporary influx of migrant labor during construction may increase risk of infection	-----	- Consideration of hygiene and sanitation of local residents	- Establish medical center and implementation of periodic medical check-ups - Education and training on workers' health care	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
11	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Prevention measures against labor accidents, accidents, and health problems	- Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Inspect and ensure that any lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate - Use facilities	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					and equipment that protect against electric shocks				
12	ROW	- Loss of standing crops - Loss of trees	-Electricity Act 1910	- Consideration to affected peoples' socioeconomic conditions	- Compensation should be conducted in compliance with relevant laws and regulations	- ROW	- During construction	- Implementation: Contractor - Supervision: PGCB	Expenses included in contract cost by Contractor
13	Accidents	- Land traffic accidents	- Land traffic	- Prevention of land traffic accidents	- Observation of traffic regulations, installation of traffic signs and education on safe driving - Training safe operation of vehicles	- Construction area - Roads near the construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
Operational Stage									
1	Water Quality	- Run-off water from tower bases and substation	------	- Prevention of water pollution in the surrounding construction area	- Re-vegetation of the tower bases and slopes in substation site	- Tower bases -Substation	- During the inspection work	PGCB	PGCB
2	Waste	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	Ecology	- Birds striking the lines	- Birds striking	- Prevention of birds striking	- Installation of lights and signs, etc., if needed	- Along the transmission line route	- During the inspection work	PGCB	PGCB
4	Topography and Geology	- Soil runoff	- Soil runoff	-Prevention of soil runoff	- Transmission line route was selected avoiding any	- Along the transmission line route -Inside	- During the inspection work	PGCB	PGCB

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					steep sloped areas - Preventing soil loss by stabilizing any slopes of construction area with concrete, as necessary based on geological survey	Substation site			
5	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Prevention measures against labor accidents, accidents, and health problems	- Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Use facilities and equipment that protect against electric shocks	- Along the transmission line route and towers	- During the inspection work	PGCB	PGCB

(Source: JICA Survey Team)

Table 12.1-21 Environmental Management Plan (New Madunaghat Substation)

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Pre-construction Phase									
1	Land acquisition	- Land acquisition at new Madunaghat substation - Loss of land - Kept out of the construction zone - Standing crops - Livelihood means - Changing peoples` thinking through interacting with local government officers, local residents and others in the land acquisition procedure	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Consideration for land owners, sharecroppers and compensation for standing agriculture products	-- Land acquisition shall be conducted in compliance with relevant laws and regulations - DC Office will take responsibility for conducting local consultations concerning compensation by law. - Top-up payment and livelihood compensation shall be made	- Site of Madunaghat SS - Affected people	- During land acquisition process - Once after compensation	- Implementation: Office of the Deputy Commissioner - Monitoring: PGCB	Expenses to be paid by PGCB
2	Social Institutions								
3	Misdistribution of Benefits and Compensation	- Can occur among residents, workers, government officers, and local politicians	-----	- Consideration for land owners, sharecroppers and compensation for standing agriculture products	- Monitor the progress of Government procedure for land acquisition - Interviewing affected people	- Areas to be acquired - Affected people	- Once after the compensation is paid	- Implementation and Monitoring: PGCB	PGCB
4	Local Conflicts of Interest								

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction Stage									
1	Disturbance to the Poor	- Loss of farmlands, being kept out of construction zones - deterioration of the poor's living standard due to the temporary loss of job in ROW	- Employment of local residents	- Consideration of local residents' feelings and socioeconomic status	- Employ as many local residents as possible - Use the services and products offered by the local community	- Villages along the transmission line route	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood	- deterioration of local socioeconomic status due to the temporary loss of job in ROW							
3	Land Use and Utilization of Local Resources	- Changing the traditional land usage patterns and utilization of local resources							
4	Infectious Diseases	- deterioration of labor health - Spreads of infectious diseases	-	- Consideration of hygiene and sanitation of workers	- Establish medical center and implementation of periodic medical check-ups - Education and training on workers' health care	- Contractor's office	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
5	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads - Working at heights	- Prevention measures against labor accidents and	- Prepare a manual for labor accident prevention	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
			- Electric shocks	health problems	including safety education and training - Provide workers with appropriate protective equipment - Inspect and ensure that any lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate - Use facilities and equipment that protects against electric shocks				
6	Accidents	- Land traffic accidents	- Land traffic	- Prevention of traffic accidents	- Land traffic accidents - Observation of traffic regulations, installation of traffic signs and education on safe driving - Training safe	- Construction area - Roads near the construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					operation of vehicles				
Operational Stage									
1	Disturbance to the Poor	- Changing the traditional land usage patterns and utilization of local reources	- Employment of local residents	- Consideration of local residents' socioeconomic conditions	- Support transition period to find alternative jobs	- Villages near the substation site	- Transition period	- Implementation and Supervision: PGCB	PGCB
2	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood								
3	Land use and utilization of local resources								
4	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Prevention measures against labor accidents during operation and maintenance work, accidents, and health problems	- Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Use facilities and equipment that protect against electric shocks	- Substation	- During operation and maintenance work	- Implementation and supervision: PGCB	PGCB

(Source: JICA Survey Team)

Table 12.1-22 Environmental Management Plan (Access Road Expansion to New Madunaghat Substation)

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Pre-construction Phase									
1	Land acquisition	- Land acquisition along the existing road as far as 1,000m - Kept out of the construction zone - Standing crops - Livelihood means - Changing peoples` thinking through interacting with local government officers, local residents and others in the land acquisition procedure	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Consideration for land owners, sharecroppers and compensation for standing agriculture products - Confirmation of affected peoples' feelings	-- Land acquisition shall be conducted in compliance with relevant laws and regulations - DC Office will take responsibility for conducting local consultations concerning compensation by law. - Top-up payment and livelihood compensation shall be made	- Access road - Affected people	- During land acquisition process - Once after compensation	- Implementation: Office of the Deputy Commissioner - Monitoring: PGCB	Expenses to be paid by PGCB
2	Social Institutions								
3	Misdistribution of Benefits and Compensation	- Can occur among residents, workers, government officers, and local politicians	-----	- Consideration for land owners, sharecroppers and compensation for standing agriculture products	- Monitor the progress of Government procedure for land acquisition - Interviewing affected people	- Areas to be acquired - Affected people	- Once after the compensation is paid	- Implementation and Monitoring: PGCB	PGCB
4	Local Conflicts of Interest								

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction Stage									
1	Disturbance to the Poor	- deterioration of the poor's living standard due to the permanent loss of livelihood means	- Employment of local residents	- Consideration of local residents' socioeconomic conditions and feelings	- Employ as many local residents as possible - Use the services and products offered by the local community	- Villages along the road	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood	- deterioration of local socioeconomic status due to the permanent loss of livelihood means							
3	Land Use and Utilization of Local ReSource:s	- Changing the traditional land usage patterns and utilization of local reSource:s							
4	Infectious Diseases	- deterioration of labor health - Spreads of infectious diseases	-----	- Consideration of hygiene and sanitation of local residents	- Establish medical center and implementation of periodic medical check-ups - Education and training on workers' health care	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
5	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads	- Prevention measures against labor accidents, accidents, and health problems	- Prepare a manual for labor accident prevention including safety education and training - Provide	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Source:s of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					workers with appropriate protective equipment - Inspect and ensure that any lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate				
6	Accidents	- Land traffic accidents	- Land traffic	- Prevention of traffic accidents	- Traffic accidents - Observation of traffic regulations, installation of traffic signs and education on safe driving - Training safe operation of vehicles	- Construction area - Roads near the construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
Operational Stage									
	N/A								

(Source: JICA Survey Team)

Table 12.1-23 Environmental Monitoring Plan (Transmission Line)

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
Pre-Construction									
1	Land acquisition	- Loss of land at tower bases (permanent) - Kept out of the construction zone (temporary) - Livelihood means (temporary)	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Confirmation of compensation process	- Monitor the progress of Government procedure for land acquisition of 1) tower basis and 2) substation site	- Areas to be acquired	- Quarterly during the official process	- Implementation: Deputy Commissioner's Office - Monitoring: PGCB	PGCB
2	ROW Compensation	- Kept out of the construction zone - Trees will be removed if they are within clearance distance - Standing crops will be affected	- Electricity Act 1910 - JICA Guidelines for Environmental and Social Considerations (2010)	- Confirmation of compensation process	- Monitor the progress of Government procedure for general notification of ROW.	- ROW	- Quarterly during the official process	- Implementation and Monitoring: PGCB	PGCB
Construction Phase									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment	PM_{10} Ambient Air Quality Standard SO2, NO2	Evaluation of effect of the mitigation measures towards air pollution	Collecting samples and analyzing at a lab.	4 points Construction sites and surroundings, especially residential areas.	Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Water Quality	1) Run off water from construction	PH, BOD, SS, Oil, Coliforms,	Evaluation of effect of the	Collecting samples and analyzing at a	- Construction sites and	Once every three months	- Implementation: Contractor/	Expenses included in contract cost by

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		site 2) Domestic wastewater of workers 3) Inappropriate disposal of waste 4) Leakage of oil and chemical materials from construction activity	Wastewater standards Ambient water quality standards	mitigation measures towards water pollution	lab	surroundings, especially residential areas.		Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Contractor
3	Waste	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous waste such as dry batteries, etc.	1) - 3) - Waste Management Rules	1) - 3) - Evaluation of effect of the mitigation measures for waste	1) - 3) - Record of kinds and quantity of waste, and the disposal method	1) - 3) - Construction area	1) - 3) - Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
4	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	Noise level Noise level standards	Evaluation of effect of the mitigation measures towards noise level	Measurement using noise level meter	7 points- Construction sites and surroundings, especially residential areas. (sampling sites of survey for environment)	Once every three months	Expenses included in contract cost by Contractor	Expenses included in contract cost by Contractor
5	Ecosystem (Endangered Species)	- Existence of endangered species	Species, Number - Bangladesh Wild Life (Preservation) (Amendment) Act, 1974 - JICA Guideline	- Confirmation of endangered species existence	1), 2) - Observation	lines - Near rivers and Forest Hill	- Once a week in migration season	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method: Method of Collecting and Analyzing Data	Monitoring Method: Location	Monitoring Method: Duration and Frequency	Responsible Organization	Cost
			(2010)						
6	Disturbance to the Poor	- deterioration of the poor's living standard due to the temporary loss of job in ROW	--	- Confirmation of affected peoples' economic situation	- Interviewing affected people	- Affected people	- Simultaneously	- Implementation: Contractor - Monitoring: PGCB	Expenses included in contract cost by Contractor
7	Deterioration of local economy	- deterioration of local socioeconomic status due to the temporary loss of job in ROW	--	- Confirmation of affected peoples' economic situation	- Interviewing affected people	- Affected people	- Simultaneously	- Implementation: Contractor - Monitoring: PGCB	Expenses included in contract cost by Contractor
8	Land Use and Utilization of Local Resources	- Changing the traditional land usage patterns and utilization of local resources	-	- Consideration of local residents' feelings	- Interviewing affected people	- Villages along the transmission line route and substation	- Simultaneously	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
9	Infectious disease	- deterioration of labor health - Spreads of infectious diseases	- health condition	- Monitor the health condition	- Medical check-ups	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
10	Work Environment (Including Work Safety)	- Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Evaluation of effect of the work safety plan	- Record of accidents	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
11	ROW Compensation	- Kept out of the construction zone - Trees will be removed if they	- Electricity Act 1910 - JICA Guidelines for Environmental and Social	- Confirmation of compensation process	- Monitor the payment of ROW Compensation by the contractor for the entitled	- ROW	- Simultaneously	- Implementation: Contractor - Monitoring: PGCB	PGCB

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		are within clearance distance - Standing crops will be affected	Considerations (2010)		people.				
12	Accidents	- Land traffic accidents	- Land traffic	- Evaluation of effect of traffic schedule	- Record of accidents	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor.
Operation Stage									
1	Ecosystem (Endangered species)	- Existence of the towers and cable	**Species, Number** - Migratory birds	- Confirmation of bird strikes	- Observation	5 lines - Near rivers and Forest Hill	- Once a month in migration season	- PGCB/ Environmental Consultant	PGCB
2	Work Environment (Including Work Safety)	1) Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Evaluation of effect of the work safety plan	- Record of accidents	- PGCB office	- Once a year	Implementation and Monitoring: PGCB	PGCB

(Source: JICA Survey Team)

Table 12.1-24 Environmental Monitoring Plan (Madunaghat Substation)

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
Pre-Construction									
1	Land acquisition and Land Use	- Loss of land - Kept out of the construction zone - Standing crops - Livelihood means	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Confirmation of compensation process	- Monitor the progress of Government procedure for land acquisition	- Areas to be acquired	- Quarterly during the official process	- Implementation: Deputy Commissioner's Office - Monitoring: PGCB	PGCB
2	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	- Changing peoples` thinking through interacting with local government officers, local residents and others in the land acquisition procedure	-----	- Confirmation of affected peoples' feelings	- Interviewing affected people	- Affected people	- Once after compensation	- Implementation and Monitoring: PGCB	PGCB
3	Misdistribution of Benefits and Compensation	- Can occur among residents, workers, government officers, and local politicians	-----	- Confirmation of compensation process	- Monitor the progress of Government procedure for land acquisition - Interviewing affected people	- Areas to be acquired	- Once after the compensation is paid	- Implementation and Monitoring: PGCB	PGCB
4	Local Conflicts of Interest	- Can occur among residents, workers, government	-----	- Confirmation of affected peoples' feelings	- Interviewing affected people	- Affected people	- Once after compensation	- Implementation and Monitoring: PGCB	PGCB

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method: Method of Collecting and Analyzing Data	Monitoring Method: Location	Monitoring Method: Duration and Frequency	Responsible Organization	Cost
		officers, and local politicians							
Construction Phase									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment	PM_{10} Ambient Air Quality Standard SO2, NO2	Evaluation of effect of the mitigation measures towards air pollution	Collecting samples and analyzing at a lab.	4 points Construction sites and surroundings, especially residential areas.	Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Water Quality	1) Run off water from construction site 2) Domestic wastewater of workers 3) Inappropriate disposal of waste 4) Leakage of oil and chemical materials from construction activity	PH, BOD, SS, Oil, Coliforms, Wastewater standards Ambient water quality standards	Evaluation of effect of the mitigation measures towards water pollution	Collecting samples and analyzing at a lab	1 point- Foreside of the drain outlet. 3 points- Construction sites and surroundings, especially residential areas.	Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
3	Waste	1) Construction waste from construction work 2) Domestic waste from workers	1) - 3) - Waste Management Rules	1) - 3) - Evaluation of effect of the mitigation measures for waste	1) - 3) - Record of kinds and quantity of waste, and the disposal method	1) - 3) - Construction area	1) - 3) - Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		3) Hazardous waste such as dry batteries, etc.						Consultant	
4	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	Noise level Noise level standards	Evaluation of effect of the mitigation measures towards noise level	Measurement using noise level meter	7 points-Construction sites and surroundings, especially residential areas. (sampling sites of survey for environment)	Once every three months	Expenses included in contract cost by Contractor	Expenses included in contract cost by Contractor
5	Disturbance to the Poor	- deterioration of the poor's living standard due to the permanent loss of livelihood means	--	- Confirmation of affected peoples' economic situation	- Interviewing affected people	- Affected people	- Simultaneously	- Implementation: Contractor - Monitoring: PGCB	PGCB
6	Deterioration of local economy	- deterioration of local socioeconomic status due to the permanent loss of livelihood means	--	- Confirmation of affected peoples' economic situation	- Interviewing affected people	- Affected people	- Simultaneously	- Implementation: Contractor - Monitoring: PGCB	PGCB
7	Infectious disease	- deterioration of labor health - Spreads of infectious diseases	- health condition	- Monitor the health condition	- Medical check-ups	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
8	Work Environment (Including Work Safety)	- Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Evaluation of effect of the work safety plan	- Record of accidents	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
9	Accidents	- Land traffic accidents	- Land traffic	- Evaluation of effect of traffic schedule	- Record of accidents	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor.
Operation Stage									
1	Waste	1) Domestic waste from workers	- Waste Management Rules	- Evaluation of effect of the mitigation measures for waste	- Record of kinds and quantity of waste, and the disposal method	- On-site	- Continuous records	- Implementation and Monitoring: PGCB	PGCB
2	Disturbance to the Poor	- deterioration of the poor's living standard lasting after the construction	--	- Confirmation of affected peoples' economic situation	- Interviewing affected people	- Affected people	- Simultaneously	- Implementation and Monitoring: PGCB	PGCB
3	Work Environment (Including Work Safety)	1) Labor accidents	- Nos of accident	- Evaluation of effect of the work safety plan	- Record of accidents	- On-site	- Once a year	- Implementation and Monitoring: PGCB	PGCB

(Source: JICA Survey Team)

Table 12.1-25 Environmental Monitoring Plan (Road Expansion to Maduhaghat Substation)

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
Pre-Construction									
1	Land acquisition and Land Use	- Loss of land - Kept out of the construction zone - Standing crops - Livelihood means	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Confirmation of compensation process	- Monitor the progress of Government procedure for land acquisition	- Areas to be acquired	- Quarterly during the official process	- Implementation: Deputy Commissioner's Office - Monitoring: PGCB	PGCB
2	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	- Changing peoples` thinking through interacting with local government officers, local residents and others in the land acquisition procedure	-----	- Confirmation of affected peoples' feelings	- Interviewing affected people	- Affected people	- Once after compensation	- Implementation and Monitoring: PGCB	PGCB
3	Misdistribution of Benefits and Compensation	- Can occur among residents, workers, government officers, and local politicians	-----	- Confirmation of compensation process	- Monitor the progress of Government procedure for land acquisition	- Areas to be acquired	- Once after the compensation is paid	- Implementation and Monitoring: PGCB	PGCB
4	Local Conflicts of Interest	- Can occur among residents, workers,	-----	- Confirmation of affected peoples' feelings	- Interviewing affected people	- Affected people	- Once after compensation	- Implementation and Monitoring: PGCB	PGCB

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		government officers, and local politicians							
Construction Phase									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment	PM_{10} Ambient Air Quality Standard SO2, NO2	Evaluation of effect of the mitigation measures towards air pollution	Collecting samples and analyzing at a lab.	4 points Construction sites and surroundings, especially residential areas.	Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Waste	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous waste such as dry batteries, etc.	1) - 3) - Waste Management Rules	1) - 3) - Evaluation of effect of the mitigation measures for waste	1) - 3) - Record of kinds and quantity of waste, and the disposal method	1) - 3) - Construction area	1) - 3) - Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
3	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	Noise level standards	Evaluation of effect of the mitigation measures towards noise level	Measurement using noise level meter	7 points- Construction sites and surroundings, especially residential areas. (sampling sites of survey for environment)	Once every three months	Expenses included in contract cost by Contractor	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source: of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
4	Disturbance to the Poor	- deterioration of the poor's living standard due to the permanent loss of livelihood means	--	- Confirmation of affected peoples' economic situation	- Interviewing affected people	- Affected people	- Simultaneously	- Implementation: Contractor - Monitoring: PGCB	PGCB
5	Deterioration of local economy	- deterioration of local socioeconomic status due to the permanent loss of livelihood means	--	- Confirmation of affected peoples' economic situation	- Interviewing affected people	- Affected people	- Simultaneously	- Implementation: Contractor - Monitoring: PGCB	PGCB
6	Infectious disease	- deterioration of labor health - Spreads of infectious diseases	- health condition	- Monitor the health condition	- Medical check-ups	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
7	Work Environment (Including Work Safety)	- Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Evaluation of effect of the work safety plan	- Record of accidents	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
8	Accidents	- Land traffic accidents	- Land traffic	- Evaluation of effect of traffic schedule	- Record of accidents	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor.
Operation Stage									
	N/A								

(Source: JICA Survey Team)

12.1.10 Stakeholder Meeting

400 MW transmission line will be established from Meghnaghat to Moheshkhali Upazila's Matarbari 18 Upazilas passing two districts (Narayanganj and Munshiganj) of Dhaka Division, and four (Chadpur, Comilla, Feni and Chittagong Districts) of Chittagong division. Information was collected through key informant interviews with officials in these Upazilas, and focus group discussions were held among local residents. Facts and details of interviews and discussions are described as below:

(1) Transmission Line Route

1) Key informant Interview

81 people of different hierarchy (Upazila Nirbahi Officer (UNO), Land Officer, Fisheries Officer, Agriculture Officer, Statistical Officer, Education Officer, Upazila member / Upazila Chairman, Non-governmental organizations (NGO) worker, Public Heath Engineer,) along the transmission line route and substation sites of 18 Upazilas were interviewed from July to August 2014 (see the table below).

Table 12.1-26: Outline of Key Informant Interview

Division	District	Upazila	Dates	Interviewees	No
Dhaka	Narayangonj	Sonargaon	15 Jul 2014	UNO, Agriculture Officer, Statistical Officer, Education Officer, and Public Health Engineer	5
	Munshigonj	Gazaria	16 Jul 2014	UNO, Land Officer, Fisheries Officer, Agriculture Officer, Education Officer, NGO worker, Upazila Chairman / member, and Public Health Engineer	8
Chittagong	Chadpur	Kachua	21 Jul 2014	Land Officer, Fisheries Officer, Agriculture Officer, Education Officer, and NGO Worker	5
	Comilla	Doudkandi	17 Jul 2014	Fisheries Officer, Agriculture Officer, Statistical Officer, NGO worker, and Public Health Engineer	5
		Barura	20 Jul 2014	Land Officer, Fisheries Officer, Agriculture Officer, and NGO worker	4
		Laksam	20 Jul 2014	Fisheries officer, Education Officer, NGO worker, and Public Health Engineer	4
		Nangalkot	21 Jul 2014	UNO, Fisheries Officer, Agriculture Officer, Statistical Officer, Education Officer, and Upazila Chairman / member	6
	Feni	Feni Sadar	22 Jul 2014	Land Officer, Fisheries Officer, Agriculture Officer, Education Officer, Upazila Chairman / member and Public Health Engineer	6
		Dagonbhuyen	23 Jul 2014	Land Officer, Fisheries Officer, Agriculture Officer, Statistical Officer, Education Officer, and NGO worker	6
		Chhagalnaiya	23 Jul 2014	UNO, Agriculture Officer, Statistical Officer, Education Officer, and NGO worker	5
	Chittagong	Mirsharai	5 Aug 2014	Fisheries Officer, Agriculture Officer, Education Officer, Upazila Chairman / member, and Public Health Engineer	5
		Fatikchhari	13 Aug 2014	Agriculture officer	1
		Hathazari	11 Aug 2014	Fisheries Officer, Agriculture Officer, and Statistical Officer	3
		Raozan	10 Aug 2014	Fisheries Officer, Agriculture Officer, Statistical Officer, Education Officer and NGO worker	5
		Boalkhali	14 Aug	Agriculture Officer, Statistical Officer, and NGO	3

Division	District	Upazila	Dates	Interviewees	No
			2014	worker	
		Patiya	18 Aug 2014	UNO and Fisheries Officer	2
		Anowara	6 Aug 2014	Land Officer, Fisheries Officer, Agriculture Officer, Education Officer, and UP member of Borun Chora Union	5
		Banshkhali	7 Aug 2014	Fisheries Officer, Agriculture Officer, and Statistical officer	3
TOTAL					81

(Source: JICA Survey Team)

The 81 interviewees gave vital opinions and input on the establishment of the transmission line mainly focusing on two aspects: the benefits that they will receive in the future from the transmission line, and; the likely environmental hazards that may be resulted from the transmission line (see the table next page).

Table 12.1-27 Opinions of Each Stakeholder

Stakeholder	Advantages	Plausible Environmental Hazards	Suggestions and Recommendations
UNO	- Power shortage will decrease - New industries will be established - Our country will be developed - New transmission line will increase our export capacity and earn more foreign revenues - The rate of unemployment will decrease	- Production of crops and fruit-trees may decrease - Some houses and lands may be damaged - The production of crops from our agricultural sector may decrease - Trees may be affected - The establishment of the transmission line may result in cutting down of many trees - Many people and animals may lose their lives from electrical short-circuit	While establishing the 400 Mega Watt Transmission line, the officials have to keep in mind that the underprivileged people along with the lands, houses, farming lands, trees and different variety of species that are closely related with the transmission site are not affected from it.
Alternate Current (AC) Land	- Our local area will be developed - The power shortage will decrease - New industries will be established - The rate on unemployment will decrease - The watering process of the agricultural lands will become more efficient - The need of electricity in this digital age is necessary - Electrical appliances like computer, fan, laptop, Xerox machine etc. all can be used	- Crops may be damaged - Deforestation may lead to a lack of production of oxygen into the atmosphere - Lands and houses will be damaged - Agricultural lands will be decrease	For greater benefit, these minor damages have to be overlooked. If lands and trees are damaged, then proper compensation is required.
Fisheries Officers	- Our country will be developed - Agricultural sector will be benefited - If the 400 MW transmission line is established, it will then bring a permanent remedy to the power shortage in this country - It will be convenient for the fishing hatcheries - It is a very exciting news - Our education system will be benefited - The rate of opportunity in our respective surroundings will increase - Load shedding will decrease and power shortage will decrease - Fishing production will increase - Industrial sector will flourish with job opportunities and increase the number of job vacancies	- The production of crops will decrease - Fishing production will decrease - Crops and trees will be damaged - Environment will be polluted due to rapid industrialization - Deforestation will adversely effect the environment - Aquatic ecosystem will be heavily altered due to the discharge of effluents into the rivers and also from the mixing of air pollutants in to the water bodies - The natural habitat of mammalian birds will be affected	Officials have to closely monitor and control to reduce the adverse affects on the lands, trees and different species of mammals that are related to the transmission site
Agricultural Officers	- Our total local agricultural system will be benefited - The process of watering the crops will be more	- Aquatic mammals, plants / trees and crops may be affected - Discharge of air pollutants from the industries and	A close eye needs to be kept on the fact that the establishment of the transmission line does not affect the production of the crops. Electricity is

Stakeholder	Advantages	Plausible Environmental Hazards	Suggestions and Recommendations
	efficient - Our educational system will be benefited - There will be a rapid industrialization in our area - In the season of Boro, there will be an increased production of this Boro crops - Load shedding will decrease - Production of crops will increase - The lifestyle of local people will be improved - The quality of crops will be better - The demand of everyday electricity consumption will be fulfilled - The rate of unemployment will decrease - There are no likely environmental hazards regarding this project since the transmission line will be passed over a safe distance above us	with the discharge of industrial effluents can damage the environment and also the local trees and crops - The growth of trees and the production of crops may be inhibited - Local houses will be affected - There might be some problems while watching the television - Rapid industrialization may distort the ecological balance - Animals may be victims of genetic mutation - Deforestation may bring upon a negative impact in the environment - The amount of carbon dioxide gas in the atmosphere will increase - The mountains and other elevated landscapes may be affected - Pollutants might alter our genetic buildup - Deforestation will result in lack of production of oxygen gas in the atmosphere - The natural habitat of the animals may be damaged - Might facilitate global warming - Natural ecosystem of forestry may be affected which may result in no production of fruits	important since it clearly makes the total agricultural system more efficient with more yields of crops.
Statistical Officers	- Our country will be benefited if a new transmission line is installed which will decrease the overall power shortage in our country - Our educational systems will thrive positively - New industrials sectors will be established - Rate of unemployment will decrease - Number of opportunities for the people of this country will increase - Areas that do no have electricity will now be able to use the benefits of electricity as well - Our quality of life will increase - There are no cons regarding this issue	- Production of crops along with fruit-trees may be victims of the negative impacts that may cause decreased production of crops and fruits as a whole, which is undesirable for our country's overall economic system - Accidents may occur during storms and rainy days - Crops and trees may be damaged - Agricultural lands may be affected	As the 400 MW transmission line will go over the populated villages, it has to be kept in mind that its establishment does not create any negative societal, economic and environmental impact. The health issues of the population have to prioritized and focused so that they do not become a victim from the project.
Educational Officers	- People will not face any problem regarding the shortage in voltage	- The natural growth of plants and trees will be inhibited	Since the 400 Mega Watt transmission line will be passed over our village so we have to have our

Stakeholder	Advantages	Plausible Environmental Hazards	Suggestions and Recommendations
	- Sufficient supply of electricity will be determined - The rate of investments in small industries will increase - Our country will be developed - The shortage of power supply will decrease - There will be advancements in the sector of industries - The rate of unemployment will decrease - It will further improve the technological aspect of this country - People who are deprived of electricity will finally get to use it in their respective households	- The natural habitat of mammalian birds will be damaged - Deforestation will lead towards a disruption in our ecological balance - If the transmission line is not installed accurately then during the rainy seasons it may bring hazardous problems - Crops may be damaged and their production might decrease - Rapid industrialization may cause environmental problems and also contribute to air pollution	deserved priority when it comes to the consumption of electricity. Without electricity, our educational system will never thrive positively; as a result, we welcome the establishment of the transmission line. The committee has to keep a close eye on the fact that the agricultural lands are not affected from this project.
NGO Workers	- The shortage of power will decrease and thus people will be benefited - The watering process of the agricultural lands will become more efficient - New industries will be established - The opportunity of employment will increase - This will aid in societal development	- Plants and trees will be damaged and the amount of oxygen in the atmosphere will decrease - Crops may be damaged - The ecological balance of the environment may be damaged - The production of crops may decrease	A close eye needs to keep on the fact that the crops and houses are not damaged. The development plan of our Prime Minister will be implemented. Power generation will make the country self sufficient.
Upazila Chairman / Member	- Our country will be developed - The shortage of power will decrease - The number of new industries will increase - The rate of unemployment will decrease - The agricultural sector will improve	- Crops and agricultural lands may be damaged along with it may also damage the houses - The production of crops and growth of trees may decrease - Trees and fishes will be affected	Even though there will some damage to the lands and houses, still for the further benefit of the country, this damage are acceptable. If there is any damage to the houses and trees then proper compensation has to be provided.
Public Health Engineering Officer	- Our country will be developed - The opportunity for new employment will increase - Rate of industrialization will increase - The shortage of power will decrease - The educational facility will improve - People will finally get rid of load shedding	- Lands and crops may be damaged - The discharge of effluents in to the water bodies from the power plant may cause health hazards - Deforestation will disrupt the natural habitat of birds which may alter their regular movement and lead them to sit in the wires of the transmission line which may cause them to electrocuted and eventually die - The production of crops may decrease	The entire system needs to be closely monitored so that the lands, markets and houses are not damaged from the establishment of the transmission line.

(Source: JICA Survey Team)

2) Focus Group Discussion (FGD)

124 people (63 male and 61 female) living along and around the transmission line route were interviewed in two Divisions from July to September 2014 (see the table below).

Table 12.1-28 Outline of Focus Group Discussion

Division	District	Upazila	Dates	No of interviewees
Dhaka	Narayanganj	Sonargaon-1	22 Aug 2014	8 (male)
		Sonargaon-2	22 Aug 2014	8 (female)
	Munshiganj	Gazaria-1	5 Sep 2014	7 (male)
		Gazaria-2	5 Sep 2014	7 (female)
Chittagong	Comilla	Laksam-1	21 Aug 2014	8 (male)
		Laksam-2	21 Aug 2014	8 (female)
	Chittagong	Mirsharai-1	24 Jul 2014	12 (male)
		Mirsharai-2	25 Jul 2014	11 (female)
		Raozan-1	12 Aug 2014	8 (male)
		Raozan-2	12 Aug 2014	9 (female)
		Anowara-1	10 Aug 2014	10 (male)
		Anowara-2	10 Aug 2014	10 (female)
		Banshkhali-1	16 Aug 2014	10 (male)
		Banshkhali-2	16 Aug 2014	8 (female)
				124 (M63+F61)

(Source: JICA Survey Team)

Contents of each group's discussion are described as below:

Outcome of FGD-1 Group- Male (Sonargaon Upazila, Narayanganj District)

The total number of participants who took part in the discussion was eight. All of them were from Chotto Kazi Gaon Village, Mugrapara Union.

The average ages of the participants were 39.4. Five of them were service holders, two of them were farmers and 1 of them was a businessman. Their average family size is 5.88. Their average monthly income is 13,750 Tk. As for education qualification, one of them could sign his name, three of them completed their S.S.C. (Secondary School Certificate), H.S.C. (Higher Secondary Certificate) by one, two of them completed their 10th grade and the remaining one completed his 5th grade. Among the eight participants, five of them were married and the remaining three of them were unmarried. 1 of the participants is associated with an association that provide agriculture based micro credits to aid his own personal financial wellbeing, and the remaining of the seven participants are not associated with any type of association.

The participants informed that since their area is near Dhaka City, as a result, they more or less receive all the benefits they require. All of the citizens of their village take their medical treatment from Upazila Sadar Hospital, M.B.B.S. (Bachelor of Medicine, Bachelor of Surgery) Doctors, Private Clinics and local Pharmacies.

All of the participants present at the discussion take safe drinking water. There is no trace of arsenic in their area. All of the household members of the participants use 100% hygienic sanitary latrine. As a result, they are less prone to diseases. All of the participants welcomed the establishment of the transmission line in their area

Outcome of FGD-2 Group- Female (Sonargaon Upazila, Narayanganj District)

The total numbers of female participants were six. All of them were citizens of Choto Kaji Village under Mugrapara Union.

All of the participants who took part in the focus group discussion were all married. Among them, three of the participants could read and write, one of them completed her S.S.C, one completed her 5th grade and one completed her 9th grade. The average monthly incomes of the participants were 12,333 Tk. All of them are housewives. Their average age is 42.5. Their average number of members in their household is 5.33. None of the participants present at the discussion were associated with any association.

All of the participants informed that all of their household members take safe drinking water. There is no trace of arsenic in the area. All of them use hygienic sanitary latrine.

The participants take their medical treatment from Upazila Hospital, private clinics, pharmacies and M.B.B.S Doctors.

Outcome of FGD-3 Group- Male (Gazaria Upazila, Munshiganj District)

The male participants present at the discussion were citizens of Hossaindi Village under Hossaindi Union.

The total numbers of male participants were seven. Their average age is 36.9. Their average household members are 5.43. Among all the participants, three of them were businessmen, one farmer, one service holder, one driver and one of them is aged and is associated with some minor farming works. When their education qualification was monitored, the results were, one of them completed his Masters in Arts, one completed his M.S.C. (Master of Science), one could sign his name, one completed his 9th grade, one completed his 8th grade and one of them completed his 6th grade and the remaining person is illiterate. Among all of the participants, six were married and the remaining person was unmarried. Their average monthly income is 35,000 Tk. None of the participants were associated to any sort of private organizations and did not take any micro credit.

All of the participants present at the discussion informed that since their area is closely situated with the Dhaka-Chittagong highway, their transportation system is really good. Their area was under the Polli Biddut, but all of them informed that there is no supply of electricity at most of the times. The participants acquire their medical treatment from Upazila Hospital, Private Clinic and Pharmacy.

All of the participants present at the discussion drink safe drinking water. They also informed that there is no trace of arsenic in their area. All of the members of their household use 100% safe sanitary latrine. They also added that they are less affected from diseases since they use sanitary latrine. About the transmission line they said, that the establishment of the transmission line will develop their country as a whole.

Outcome of FGD-4 Group-Female (Gazaria Upazila, Munshiganj District)

The total number of participants was seven and all of them were citizens of Hossaindi Village under Hossaindi Union.

All of the present female respondents were married. And all of them were housewives. Their average age is 28.3. The total number of household members on an average is 4.86. The average monthly income of the participants was 22,143 Tk. Two of them were literate and the rest of the five participants could read and write but they did not pass the secondary school. Among the seven participants, two of them were members of a private association namely; Grameen Bank and the rest of the participants were not participants of any association.

All of the participants present at the focus group discussion informed that the transportation system in their area is good. And all of their requirements are well within their reach. The area is under Polli Biddut. But they complained that, most of the time there is no electricity.

100% people of the village drink safe water and there is no arsenic present in the water. Almost all the people use sanitary latrine. As a result, the rate of health related issues arise less.

Outcome of FGD-5 Group-Male (Laksam Upazila, Comilla District)

The total number of people taking part in the focus group discussion was eight in number. All of them are citizens of Norpoti Village under Norpoti Union.

Among the eight participants, six of them were married and the rest of the two were unmarried. Their average age is 38.8 and the average numbers of members in the household were five and their average monthly income is 6,250 Tk. For occupation, four participants were farmers, three of them were Masons, and 1 businessman. Five of them could both read and write and the rest of the three were illiterate. Among all the participants, two of them were associated with private associations and banks to aid their financial back up for agricultural purposes.

The participants informed that they take their medical treatments from Upazila Sadar Hospital, M.B.B.S Doctors and Pharmacies. They also informed that they drink safe drinking water and there is no trace of arsenic in their area. When asked about the transmission line, the participants informed that they have no idea regarding this issue. But, they also added that if there is any damage in the area, especially houses and trees, then the affected people must receive proper compensation.

Outcome of FGD-6 Group- Female (Laksam Upazila, Comilla District)

The participants were citizens of Norpoti Village under Norpoti Union.

The total numbers of participants present at the discussion were eight. All of them were married and housewives. Among them one completed her H.S.C, one completed her S.S.C, one completed her 9th grade, one completed her 8th grade, two completed her 5th grade and the rest of the two participants could sign their names and the remaining participant was an illiterate. Their average age was 33.8 and the average number of members in their household is 4.25. Their average monthly income is 7,875 Tk. Among the total seven participants, three of them were associated to an organization to receive micro credit to aid their financial status.

All of the participants present at the discussion informed that they all drink safe drinking water. There is no trace of arsenic in their area. All of the participants take their medical treatment from the local Upazilla Hospital, M.B.B.S Doctors and Pharmacies.

Outcome of FGD-7 Group- Male (Mirsharai Upazila, Chittagong District)

All of the above respondents were local citizens from the hilly area of Kayla Village where transmission line will be installed. There were in total of twelve respondents. Among them, five were businessmen, ten were drivers, two were quack doctors, three were farmers and one is a student. Among the twelve participants, two of them passed their BSS/B.Com. (Bachelor of Social Science, Bachelor of Commerce), H.S.C by one, S.S.C by four and the rest of them four did not pass their secondary school.

The average monthly income of the participants is 12,167 Tk. per month and their average age is 47.0, average family size is 7.83 and among them, ten are married, two are unmarried. Three of them are related with the government project “Ekti Bari Ekti Khamar” and one of them is involved with local organization of “Driver Shamiti”.

They complained that they cannot directly use the generated electricity and they are using solar panels, which is very costly. They want electricity provided by either BPDB or REB.

Outcome of FGD-8 Group- Female (Mirsharai Upazila, Chittagong District)

The female participants were the local residents of Pschim Sonai Village of Karerhat Union.

The number of participants in the FGD was eleven. Their average family income was 11,182 Tk and average age was 33.0. Only one participant was unmarried. Their average family size per household is 5.64. All of them were housewives and only one participant was a student. Two of them passed their S.S.C/H.S.C, three of them could sign their names and six of them were below S.S.C.

None of them are involved with any association. There are in total of 320 households in the village. Village and population size is 1,606. They use solar power energy which is costly; as a result, they want electricity in their locality. The road communication is very bad since it is a hilly area. From the meeting it is known that the participants are not aware of the transmission line. But informed that trees will be cut off due to the establishment of the new transmission line.

Outcome of FGD-9 Group- Male (Raozan Upazila, Chittagong District)

The total number of male participants present at the discussion was 8. All of them were citizens of Gorib Ullah Para Village of East Gujra Union.

The average monthly income of all the participants was 9,375 Tk. All of them were related to some sort of occupation: four of them were farmers, two of them were boatmen, one driver and the remaining participant was a businessman. Their average age is 39.5. Their average numbers of household members are 6.5. Among them twelve are unmarried and seven of them are married. None of the participants did not complete their S.S.C exam. However, all of them could read and write. Three of the participants were associated with a business association named Grameen Bank and they took necessary micro credits to aid their financial situation.

All of the participants present at the discussion informed that they drink safe drinking water. They also informed that there is no trace of arsenic in their area. They visit the Upazila Sadar Hospital to receive their medical treatment besides; they also take medical aid from the local M.B.B.S Doctors and pharmacy.

The participants informed that they are not aware of the establishment of the transmission line. But they also added they welcome the installment of the transmission line since it will develop their area and also decrease the rate of unemployment in their area. They also informed that the people who will likely be affected from the negative impacts from this transmission line should receive proper compensation.

Outcome of FGD-10 Group- Female (Raozan Upazila, Chittagong District)

All the participants present in the focus group discussion were citizens of Goribullah Para Village, East Gujra Union. The participants present in the discussion were nine in numbers.

All of them were married and their average age was 38.7. Their average monthly income is 8,778 Tk. All of them are housewives and do household chores in their everyday life. Their average family size is 6.44. Among all the participants, five of them couldn't read or write. One of them could sign her name and the rest of the three completed their 8th grade. Among nine participants, eight of them were associated to a private association namely, Grameen Bank and BRAC.

The participants present at the discussion informed that they receive their medical treatment from the local Upazila Sadar Hospital and also from the M.B.B.S and Quack Doctors. Everybody drinks safe drinking water. They also informed that there is no arsenic present in their drinking water. None of the female participants are aware of the establishment of the transmission line. However, they welcomed the consumption of electricity in their area.

Outcome of FGD-11 Group- Male (Anowara Upazila, Chittagong District)

All of the participants were citizens of north Borungacha Village, Kanumajhir Haat under Borungacha Union. They live near the Shangu River. This area is influenced by the followers of Hindu Religion.

The total number of participants present at the discussion was ten. All of them are married. Among them, seven could sign their names, one completed his H.S.C, 8th grade by one and 9th grade by one. Among the participants, six of them were businessmen, three of them were fishermen and one of them was retired due to ageing.

The average monthly income of the participants was 16,200 Tk. Their average age is 57.3. Their average family size is 6.3. Among the ten participants, six of them were associated to some association to receive micro credits to aid their business and medical purposes.

Most of the citizens of this area take fishes as their Source: of protein. All of them drink safe drinking water. There is no trace of arsenic in the area. All of the members of the household of the participants use 75%-80% hygienic sanitary latrines. All of the members take their medical treatments from Upazila Health Complex, M.B.B.S doctors and pharmacies. They are not aware of the fact that a transmission line is going to be established. However, they also added that the affected people should receive proper compensation.

Outcome of FGD-12 Group – Female (Anowara Upazila, Chittagong District)

All of the participants present at the focus group discussion were from North Borungacha Village under Borungacha Union.

The number of participants who took part in the focus group discussion was ten. All of them were married and housewives. Among them eight of the members were literate. The rest of the two members did not know how to read and write. Their average age is 47.5 and the average number of household members in their family is 7.5. Their average monthly income is 9,400 Tk. They are living in this area since their in-laws are local citizens of this area. Among the ten members, seven of them are associated to some NGO. They took some micro credit to facilitate their business and farming. All of the participants were Hindu in religion.

All of the participants present used to consume fresh drinking water. They informed that there is no trace of arsenic in their drinking water. All of the participants present at the focus group discussion use 75% hygienic sanitary latrine. They are not aware of the 400 MW transmission line. Most of the participants take their medical aid from the local Upazila Sadar Hospital. Besides that, they also take their necessary medical services from the local M.B.B.S doctors and pharmacy.

Outcome of FGD-13 Group- Male (Banshkali Upazila, Chittagong District)

There were in total of ten participants, and all of them were from Dongra (East) Village, Khan Khanabad Union. Two participants were teachers, four farmers, one farmer/businessman, one carpenter and one businessman.

Their average age is 50.0 and family size is 7.8. All of them were married. Seven of them could not read and write, two of them passed their Kamil and one completed standard 5. Their monthly average income is 11,200 Tk. Four of them were involved with associations and took loan from their business and agriculture purposes.

The total household size of this village is 1,638. In rainy season, the village is over flown by saline water. The village is very near by the sea, so there are no crops during the rainy season. There is no electricity in this village. The rich people of this village use solar energy. In 1991, many people died in a cyclone. There is no cyclone shelter in this village. The villagers want electricity and cyclone shelter for their development and security. They want compensation if there is any damage in their properties due to the establishment of the transmission line.

Outcome of FGD-14 Group- Female (Banshkali Upazila, Chittagong District)

All of the above participants were local citizens of Dongra Village, Khankhanabad Union. Eight female members took part in the conversation. Their average age was 38.0, and average monthly income is 7,938 Tk. All of them were housewives; their average family size is 4.75 per household. Only five of them could read and write and the remaining three were illiterate. Two of them were widows and the remaining six were married. Two of the participants were members of an NGO named ASA. They took loan from ASA for their own personal purposes.

From the meeting, it is known that all of the respondents use and consume arsenic free water. They know nothing about the transmission line.

(2) New Madunaghat SS

1) Key informant Interview

5 community leaders comprised of Union Chairman, Union Parishad member, school teacher, journalist and Mosque Imam were interviewed during the survey period for obtaining their opinions about the Project, and suggestions and recommendations.

Positive impacts

- Our country will be developed
- Agricultural sector will be benefited
- If the 400 Mega Watt transmission line is established then it will bring a permanent remedy to the power shortage in this country
- Our education system will be benefited
- The rate of opportunity in our respective surroundings will increase
- Load shedding will decrease/power shortage will decrease
- Industrial sector will flourish with job opportunities and increase the number of job vacancies
- The lifestyle of local people will be improved
- The demand of everyday electricity consumption will be fulfilled
- It will further improve the technological aspect of this country
- This will aid in societal development

Negative Impacts

- The establishment of the transmission line Sub-Station may result in cutting down of many trees
- Many birds may lose their lives from electrical short-circuit
- Some Crops may be damage
- Day by day Agricultural lands will decrease
- Environment will be polluted due to rapid industrialization
- The natural habitat of mammalian birds will be affected

Suggestions and Recommendations

As the 400 MW T/L SS will go over the populated villages, it has to be kept in mind that its establishment does not create any negative societal, economic and environmental impact. The health issues of the population have to be prioritized and focused so that they do not become a victim from the project. If there is damage to the land acquired trees, houses, then proper compensation has to be provided. The chairman and the community leaders of East Gujra personally motivated and trusted the people for not being deprived of proper compensation**.**

2) Focus Group Discussion

27 people in four different groups were interviewed in East Gujra Union, Raozan Upazila on 19 and 20 November 2014 (see the table below).

Table 12.1-29 Outline of Focus Group Discussion

Division	District	Upazila	Dates	No of interviewees
Chittagong	Chittagong	Raozan	20 Nov 2014	Male Land Owner Group (9 persons)
			19 Nov 2014	Female Group (5 persons)
			20 Nov 2014	Mix Group (6 persons in various occupations)
			19 Nov 2014	Agriculture Laborer Group (7 persons)
TOTAL				27

(Source: JICA Survey Team)

Contents of each group's discussion are described as below:

Outcome of Male Land Owner Group FGD

The total number of land owners and successor present at the discussion were nine. All of them were citizens of Gorib Ullah Para Village under East Gujra Union.

The average monthly income of all the participants were 10,222 Tk. All of them were related to some sort of occupation like four of them were businessman, two of them were farmers, one driver and the remaining participant was a student and a farmer was an old man. Their average age is 42.66. Their average number of household members is 6.44. Among them three are unmarried and six of them are married.

One of the participants finished his Dipolma Engineering and none of the participants did not complete their S.S.C exam. However, all of them could read and write. Four of the participants were associated with a business, and the remaining are three farmers, one driver, one student, one Old man.

All of the participants present at the discussion informed that they drink safe drinking water. They also informed that there is no trace of arsenic in their area. They visit the Upazila Sadar Hospital to receive their medical treatment besides; they also take medical aid from the local M.B.B.S Doctors and pharmacy.

The participants informed that they are now aware of the establishment of the transmission line and substation project. But they also added they welcome the installment of the transmission line since it will develop their area and also decrease the rate of unemployment in their area. They also informed that the people who will likely be affected from the negative impacts from this transmission line should receive proper compensation. Under the decision and urgency of the local chairman and other community leaders, the land owners are motivated about the fact that for the betterment of the nation, this transmission line and substation project is being established and they welcome this prospect. However, they also want proper compensation for the affected land owners.

Outcome of Female Group FGD

All the participants present in the focus group discussion were citizens of Chittagong Zila's Raozan Upazila's East Gujra Union's Village-Goribullah Para. The participants present in the discussion were five in numbers.

All of the four female participants were married, 1 Unmarried and their average age was 36.8. Their average monthly income is 7,800 Tk. They are four housewives and one school teacher, their average family size is 4.20. Among all the participants, four of them know how to read and write properly. One of them could sign her name.

The participants present in the discussion informed that they receive their medical treatment from the local Upazila Shadar Hospital and also from the M.B.B.S and Quack Doctors. Everybody drink safe drinking water. They also informed that there is no arsenic present in their drinking water. None of the female participants are aware of the establishment of the transmission line and substation project. To conclude, they welcomed the establishment of the transmission line substation. They also demanded proper compensation for the affected people

Outcome of Mixed Group FGD

The total number of people taking part in the focus group discussion was six in number. All of them are citizens of Goribullah Para Village.

Among six participants, five were married and the rest of them was unmarried. Their average age is 46 and the average numbers of members in the household were five and their average monthly income is 9,833 Tk. For occupation, five participants were general laborer (who once in a while are involved in agriculture too), one sharecropper and one service holder. Five of them could both read and write and the remaining one was illiterate.

The participants informed that they take their medical treatments from Upazila Sadar Hospital, M.B.B.S Doctors and Pharmacies. They also informed that they drink safe drinking water and there is no trace of arsenic in their area. When asked about the transmission line substation, the participants informed that they have no idea regarding this issue. But, they also added that if there is any damage in the area, especially in the Paddy lands, houses and trees, then the affected people must receive proper compensation.

Outcome of Agriculture Laborer Group FGD

All of the Day Laborers were from Jahajmara Village under Jahajmara Union, Hatiya Upazila, Noyakhali District. Every year they come from other district to cut paddy.

The total numbers of participants present at the discussion were seven. All of them are married. Among them, five participants' education level is class five, class two, and class eight.

The average monthly income was 9,600 Tk. Their average age is 31.14 Their average family size is 4.86.

All of the members take their medical treatments from their own Upazila Health Complex, M.B.B.S doctors and pharmacies. They are not aware of the fact that a transmission line is going to be established. However, they also added that the affected people should receive proper compensation.

12.2 Land Acquisition and Involuntary Resettlement

12.2.1 Necessity of Land Acquisition and Resettlement

There is no involuntary resettlement, either on the transmission line routes or substation sites, anticipated in the Project. However, both permanent and temporary land acquisition is anticipated as described below:

(1) Transmission Line Route

The number of towers constructed for the 400 kV T/L from Meghnaghat to Matarbari is approximately 800 in total. It requires 2 m^2 of land per one suspension tower base (approximately 550 in number) and 3m^2 of land per one tension tower base (approximately 250 in number): in total 1,860 m^2 of paddy land and certain trees will be permanently affected by the tower construction . Construction of one tower base for 230 kV requires 1 m^2 of land per one suspension tower (approximately 20 in number) and 1 m^2 of land per one tension tower (approximately 10 in number). The number of towers for the 230 kV T/L will be 30 in total, and 80 m^2 of land will be permanently acquired. In conclusion, not more than 2,000 m^2 in total is approximately required to acquire the land for tower foundations.

The construction period of each tower is expected to last 30 days, during which the construction site (700 m^2 per tower) and temporary access road (200 m^2) will be blocked and farm activities will be disturbed. It is long enough to lose the income opportunity for land owners for one crop season, and job opportunity and crop share for sharecroppers and cultivators too.

As for the right of way (ROW), wiring work will last 3 weeks per 3 km, which will require safety instruction for local farmers. It is, however, not anticipated to hinder their farming activities. Settlements and homesteads were avoided when the route map was drafted so no land acquisition or involuntary resettlement is anticipated.

(2) Substations

As much as 220 acres (equivalent to 89 ha) of land for the candidate site for the new Meghnaghat SS is within Meghnaghat Power Station Complex, presently owned by BPDB. BPDB and PGCB will take all official procedures for transferring ownership, so no acquisition of private land is anticipated.

In contrast, not more than 20 acres (10 ha) of land will be acquired for the construction of 400 kV / 230 kV Madunaghat Substation, including road expansion in the surrounding area. The affected area is mainly East Gujra Union and Groche Union of Raozan Upazila of Chittagong District. The existing road is planned to be widened by 2m, as far as 1,000 m from the nearest jetty to the substation site, which will require land acquisition of paddy land and gardens of homesteads by the road. The details of losses due to the expansion of the access road have not been finalized yet as the road design including route selection has not been fixed yet as of January 2015.

No land acquisition for the expansion of other substations is anticipated.

12.2.2 Legal Framework for Land Acquisition and Resettlement

(1) Key Legislations in Bangladesh

The Acquisition and Requisition of Immovable Property Ordinance of 1982 and its subsequent amendments in 1993 and 1994 and *Electricity Act 1910* provide the key legal instrument for the acquisition of private land for development activities in Bangladesh.

Salient provisions of the Ordinance which show tangible gaps with the JICA Guidelines for Environmental and Social Considerations are as follows:

Avoiding/minimizing land acquisition: The Ordinance only implicitly discourages unnecessary acquisition, as land acquired for one purpose cannot be used for a different purpose. There are, however, no mechanisms to monitor if this condition is actually adhered to.

Eligibility for compensation: The Ordinance stipulates compensation only for the persons who appear in the land administration records as the owners (i.e., titleholders). It does not recognize the rights of those without legal title to the land, who live on or make a living from it.

Compensation paid for: The Ordinance provides for compensation of land and other objects built and grown on it (structures, trees and orchards, crops and any other developments on the land like ponds, built amenities, etc.). There are no provisions to assess and restore lost income streams or income sources caused by the land acquisition to the project affected persons (PAPs).

Compensation standards: Landowners receive cash compensation under the law (CCL) as

per the market value of the property at the publication date of the notice[11] with a premium of 50% on the assessed price. Any damage to standing crops or trees on the property, expenses incidental to compelled changes to the residence or place of business, and reduction of profits of the property in the acquisition period are also entitled to a sum of 50% on top of such market value[12]. The 1994 amendment made provisions for payment of crop compensation to tenant cultivators (*"bargadar"*).
Although the Ordinance stipulates 'market prices' of the acquired land as just compensation, the legal assessment method almost always results in prices far below the actual market prices. Certain pricing standards, which are regarded as unrealistic, are used to assess other losses like structures and various built amenities, trees, and crops, etc.

Relocation of homestead losers: There is no legal obligation to relocate, or assist with the relocation of, those whose homesteads have been acquired.
Ensuring payment/receipt of compensation: Even with the given legal provision, the compensation process is time-consuming. There is, moreover, no certainty as to when an affected landowner will obtain the stipulated compensation or whether he will obtain it at all.
Land is legally acquired and handed over to the project proponent as soon as the acquisition authority identifies the owners ('awardees') by examining the records, and sends a legal notice advising them to claim compensation ('awards'). And it also turns out that it is an obligation of the PAPs to prove that the acquired land legally belongs to them.

Socio-economic rehabilitation: The provisions are so restricted that the Ordinance shows no concern for the long-term socio-economic changes the PAPs might undergo in the post-acquisition period. Except for the compensation at the legal 'market price', there are no other provisions in the acquisition or other laws that require the government to mitigate the resultant adverse impacts caused by the acquisition. Socio-economic rehabilitation of the involuntarily displaced persons is absent in the legal regime of Bangladesh.

(2) JICA's policy on land acquisition and resettlement
The key principle of JICA policies on involuntary resettlement is summarized below.

a. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.
b. When population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.
c. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.
d. Compensation must be based on the full replacement cost as much as possible.
e. Compensation and other kinds of assistance must be provided prior to displacement.
f. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.
g. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

[11] The average value of the properties of similar description and with similar advantages in the vicinity during the last twelve months prior to the publication date of the notice. (Section 8 (1) of *the Acquisition and Requisition of Immovable Property Ordinance 1982.*)
[12] The market value thus determined does not always reflect the actual market value.

h. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.
i. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

The above principles are complemented by World Bank OP 4.12, since it is stated in the JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principles based on World Bank OP 4.12 are as follows.

a. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefits.
b. Eligibility of Benefits include the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.
c. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.
d. Provide support for the transition period (between displacement and livelihood restoration).
e. Particular attention must be paid to the needs of vulnerable groups among those displaced, especially those below the poverty line, the landless, elderly, women and children, ethnic minorities etc.
f. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, an abbreviated resettlement plan is to be prepared.

In addition to the above core principles of the JICA policy, it also lays emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc.

In terms of categories of PAPs and types of lost assets, the gaps in the existing legal framework of Bangladesh and requirements of the JICA Guidelines are identified as presented in the table below.

Table 12.2-1 Gap Analysis between Bangladeshi Laws and JICA Guidelines

No	Category of PAPs / Types of Lost Assets	Bangladesh Laws	JICA Guidelines
1	For all types of land and other assets for legal land	Acquired by DC as per legal requirements / procedures	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based
2	Land tenants	Compensation for standing crops if harvesting of crops is not possible	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported.
3	Land Users	Squatters, encroachers and unauthorized users / occupiers are not recognized	As above.
4	Owners of temporary structures	Only cash compensation under law (CCL)	Compensation must be based on the full replacement cost as much as possible.
5	Owners of permanent structure buildings	Ditto	As above.
6	Perennial crops	Market prices of the standing crops with value of plants	Compensation must be based on the full replacement cost as much as possible.

No	Category of PAPs / Types of Lost Assets	Bangladesh Laws	JICA Guidelines
7	Timing for payment of entitled compensation to the PAPs	No concern on the part of the project proponent. Land is handed over to the project proponent as soon as the compensation funds are placed with the DC.	On the completion of payment of compensation to the PAPs, the land is to be vacated and handed over to the project proponent.
8	The issue of relocation and income generation activities	No concern about relocation and income generation activities.	People who must be resettled involuntarily and whose livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standards of living, income opportunities and production levels to pre-project levels.
9	Vulnerability of PAPs	No distinction between the PAPs	Particular attention must be paid to the needs of vulnerable groups among those displaced, especially those below the poverty line, the landless, elderly, women and children, ethnic minorities, etc.
10	Role of DC, project proponent and PAPs	DC to acquire land, the project proponent to use the land, and PAPs to seek compensation from the DC.	DC and project proponent to assist the PAPs in getting the compensation, assist in collecting the legal and required documents, and provide support for the transition period between displacement and livelihood restoration.

(Source: JICA Survey Team)

(3) Procedures of land acquisition

Under the Ordinance of 1982 and its subsequent amendments 1989, 1993, and 1994, the Deputy Commissioner (DC) at District level is entrusted to acquire land for agencies requiring land for any public or private infrastructure projects. The procedures of land acquisition will follow the following steps:

Step 1: After identifying and selecting the exact ground locations of the required land, the project proponent will carry out detailed engineering surveys and design the construction work and lay them out on mauza maps. The project proponent will prepare the land acquisition proposals to obtain administrative approval by the line ministry.

Step 2: The project proponent, after obtaining the approval of the administrative ministry, will make a request to the DC, with sufficient information including the amount of land to be acquisitioned from each plot, and the ownership status such as private and public lands, for the acquisition of the land as per the proposal.

Step 3: Within 90 days, the DC will appraise the application through a) site observation, b) consultation with local politicians and residents, c) developing project profiles, and d) cost estimates. The DC will then develop and submit a proposal on land acquisition to the Ministry of Land for an appraisal by the central government within 90 days.

- The DC will publish a notice as stipulated in Section 3 of the Ordinance of 1982 stating that there is a proposal for the property to be acquired. The persons to be displaced may submit an objection to the land acquisition to the DC within 15 days after the notice is served. All the legal titleholders will be advised to show their ID cards and other documents that verify their rights. For those with no registrations, the DC Office will call for circumstantial evidence from community leaders, local elite people, and religious leaders, etc., to add these people to the list.
- The DC will consult with the Public Works Department (PWD), BFD, Department of Agricultural Marketing (DAM) and Department of Fisheries (DOF) to assess DC the value of structures, trees, crops and aqua products for their existing rates.

- Under Section 6, a second public notice will be served stating the GOB's decision on the land acquisition and taking possession thereof. The DC Office will confirm the PAPs, exact land area and size for acquisition, number of relocated houses, agriculture land, forestry and fishing areas that will be lost. The persons to be displaced will be requested to submit their statements of property, amounts and particulars of the claims to compensation not being earlier than 15 days of the second notice being served. The DC Office will respond to any grievances made by the PAPs in order to agree to the assistance package.
- The project proponent shall deposit the estimated amount of the award of compensation with the DC within 60 days from the receipt of the estimate given by the DC.
- Upon serving the last notice (Section 7), the DC shall pay the amount to the owners of the acquired property within a further 60 days from the date of deposit by the project proponent. The DC will take possession of the property after completion of the compensation payment to the PAPs and immediately declare this in the official gazette, and hand the property over to the project proponent.

12.2.3 Scope and Area of Land Acquisition

Type of losses caused by land acquisition, entitled persons, entitlements and organizations responsible for each project component are described below:

(1) Transmission Line Route

The following types of losses (permanent and temporary) are foreseen on the 400 kV and 230 kV / 132 kV TL routes, and entitlements have been drafted based on the legislations in Bangladesh and JICA Guidelines.

Approximately 600 out of approximately 800 tower bases are owned by private land owners, which will be affected permanently. If the land for tower bases is acquired involuntarily, compensation shall be paid at replacement cost. On the other hand, after having fully given an informed consent and power of choice to the land owners for their possible land use for the tower bases, PGCB, together with the contractors for the transmission lines, will conclude agreements in writing with them with regard to the land use to avoid possible misunderstandings and disputes in the future in case they agree to voluntary land acquisition.

Those land owners of the ROW will be temporarily affected during the construction period and compensation for the damage to their standing crops and trees shall be paid. Sharecroppers will temporarily lose their means of livelihoods during the construction period and such losses will also be compensated. PGCB shall restore the land to its original conditions after the construction period is over.

Table 12.2-2 Entitlement Matrix (Transmission Line Route)

	Type of Loss	Entitled Persons (EP)	Entitlements (Compensation Package)	Responsible Organizations
1	Permanent loss of paddy land at tower foundations*	Legal land owner	Cash compensation under Law (CCL) market value of land area plus 50 % premium	Implementation: Deputy Commissioner (DC)'s Office (Land Acquisition Officer, LAO) Monitoring: PGCB
			Top-up grant to cover 1) Gap between the average of last 12 months' sales values of same kind of land, and the current market value of private land 2) Max allowable replacement value (RV) to purchase new land (and	Implementation: contractors Supervision and monitoring: PGCB Advice given by DC

	Type of Loss	Entitled Persons (EP)	Entitlements (Compensation Package)	Responsible Organizations
			trees) with equal productive value, preparation cost, and registration cost (such as stamp duty and tax)	Office (LAO)
			One time assistance for annual cropping volume (3 years)	
2	Permanent loss of trees / perennials / fruit trees at tower foundations*	Owners	- Timber trees: The value equals that of the lumber - Fruit or fodder trees: the value equal to the cumlative value of the fruit crop for its productive life	
3	Temporary loss of access to paddy land and trees during construction period (=Temporary loss of standing crops, trees and job opportunities)	Legal land owner	Profit loss for 1 crop season	
		Cultivator	One time assistance for crop share	
		Sharecropper	One time assistance for 3 months of wages and crop share	

(Source: JICA Survey Team)

(Note) In the case that the land owners, for their possible land use for the tower bases, agree to voluntary land acquisition, the above 1 and 2 will be excluded from the entitlements.

(2) New Madunaghat Substation

Permanent losses of the following types are foreseen for the construction of the new Madunaghat SS and entitlements have been drafted as follows. According to the information given at the East Gujra Union Parishad Office, there are 46 land owners of 82 land plots at the substation site who will lose their land permanently, and their cultivators and sharecroppers will also permanently lose their means of livelihood.

Table 12.2-3 Entitlement Matrix (new Madunaghat Substation)

	Type of Loss	Entitled Persons (EP)	Entitlements (Compensation Package)	Responsible Organizations
1	Permanent loss of paddy land	Legal land owner	Cash compensation under Law (CCL) market value land area plus 50 % premium	Implementation: DC Office (LAO) Monitoring: PGCB
			Top-up grant to cover 3) Gap between the average of last 12 months' sales values of same kind of land, and the current market value of private land 4) Max allowable replacement value (RV) to purchase new land with equal productive value, preparation cost, and registration cost (such as stamp duty and tax)	Implementation: contractors Supervision and monitoring: PGCB Advice given by DC Office (LAO)
			One time assistance for annual cropping volume (3 years)	
2	Permanent loss of access to paddy land (=Permanent loss of income from crop sales and livelihood means)	Legal land owner	- One time assistance for annual cropping volume (3 years) - Support in transitional period	
		Cultivator	- One time assistance for crop share - Support in transitional period	
		Sharecropper	- One time assistance for 3 months of wages - Support in transitional period	

(Source: JICA Survey Team)

(3) Access Road Expansion to New Madunaghat Substation

Permanent and temporary losses of the following types are anticipated for the expansion of the access road to the new Madunaghat SS and entitlements have been drafted as follows. The number of land plots reaches 4 along the access road as far as 1,000 m.

Table 12.2-4 Entitlement Matrix (Road Expansion to Madunaghat Substation)

	Type of Loss	Entitled Persons (EP)	Entitlements (Compensation Package)	Responsible Organizations
1	Permanent loss of paddy land	Legal land owner	Cash compensation under Law (CCL) market value land area plus 50 % premium	Implementation: DC Office (LAO) Monitoring: PGCB
			Top-up grant to cover 5) Gap between the average of last 12 months' sales values of same kind of land, and the current market value of private land 6) Max allowable replacement value (RV) to purchase new land with equal productive value, preparation cost, and registration cost (such as stamp duty and tax)	Implementation: contractors Supervision and monitoring: PGCB Advice given by DC Office (LAO)
2	Permanent loss of access to paddy land (=loss of income from crop sales and livelihood means)	Legal land owner	One time assistance for annual cropping volume (3 years)	
		Sharecropper	One time assistance for 3 months of wages	
3	Permanent loss of trees / perennials / fruit trees*	Owners	- Timber trees: The value equals that of the lumber - Fruit or fodder trees: the value equal to the cumlative value of the fruit crop for its productive life	
4	Permanent loss of certain homestead area*	Legal land owner	Cash compensation under Law (CCL) market value of land area plus 50 % premium	Implementation: DC Office (LAO) Monitoring: PGCB
			Top-up grant to cover 1) Gap between the average of last 12 months' sales values of same kind of land, and the current market value of private land 2) Max allowable replacement value (RV) to purchase new land with equal productive value, preparation cost, and registration cost (such as stamp duty and tax)	Implementation: contractors Supervision and monitoring: PGCB Advice given by DC Office (LAO)
5	Permanent loss of houses and other structures in homestead*	Legal land owner and family members	- Market cost of materials to build a replacement structure with an area and quality up to similar level (or better), or to repair a partially affected structure - Cost of transporting building materials to the site - Cost of labor and contractors' fee - Cost of registration and taxes (if any)	
6	Temporary loss of access to homestead during construction period*	Legal land owner and family members	- Provision of temporary access and relocation where possible - Restoration of access to the land, structure, utilities	

(Source: JICA Survey Team)

(Note) As of 18 November 2014, the inclusion of the above 3, 4, 5 and 6 has not been finalized yet since the socioeconomic survey remains on-going.

12.2.4 Methods of Valuing Affected Assets

Compensation for legal land owners will be based on the principle of replacement costs. Replacement costs are the amounts calculated before displacement which are needed to replace any affected assets without depreciation and without deduction for taxes and/or costs of transaction.

The Land Acquisition Officer (LAO) of the Deputy Commissioner's Office and Land Officer of Upazila Nirbahi Office will support the sub-registrar's office in determining the price of land. Land price averages from the sub-registrar's office for the previous one year from the date of the notice given under Section 3 of the Ordinance of 1982 are considered for the land valuation. The transacted price, recorded price, existing prices and expected prices should be averaged to reach the replacement value (RV).

A land and property valuation survey based on the prices recorded from formal and informal Sources as below will determine the RV of land and structures:

- Government price
- Potential sales price
- Potential buyer price
- Enumerated price collected in the socioeconomic survey
- Price deemed appropriate as quoted by a retired government officer living in the vicinity
- Price deemed appropriate as quoted by local intellectuals
- Price deemed appropriate as quoted by religious leaders

PGCB will allocate budget to fill the difference between the RV and the cash compensation under law (CCL) as the top-up payment. In the case of any depreciation costs deducted from affected structures in the CCL by the DC, PGCB will pay the same as additional construction grants to re-settlers. It will also pay stamp duty and land registration fees when replacement land purchase is confirmed.

12.2.5 Grievance and Redress Mechanism

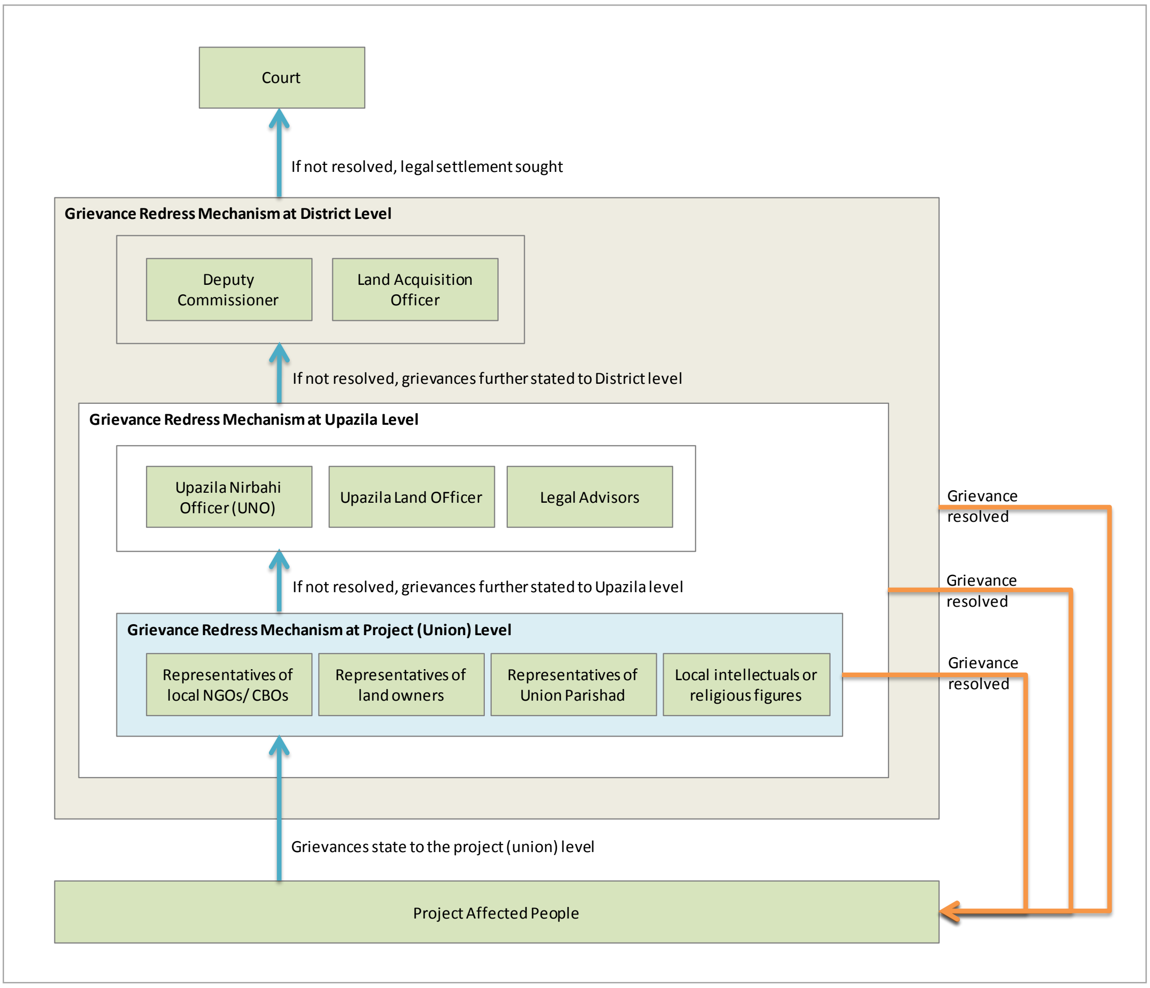
As soon as the budget for land acquisition and livelihood compensation becomes available, PGCB will make a payment to the Deputy Commissioner's Office of Chittagong District to initiate the payment procedure as stipulated in the Ordinance 1982 and Land Acquisition Act 1870.

Endorsed by the Ministry of Power, Energy and Mineral Resources (MPEMR), a formal grievance redress committees (GRC) will be formed then at union level for any grievances involving resettlement benefits, relocation and other assistance. The purpose of establishing GRCs is to promptly address the concerns and complaints using a process that is accessible and transparent to the PAPs. GRCs can be comprised of the following members whose standing is neutral and independent:

- PGCB
- Project staff in charge of the Action Plan for Land Acquisition and Livelihood Compensation
- Local NGO
- Chairman of Union Parishad
- Representatives from the PAPs

- Local intellectuals
- Legal advisors

The structure of GRC is described in the figure below. The core function of GRC will be further discussed and determined in due course.

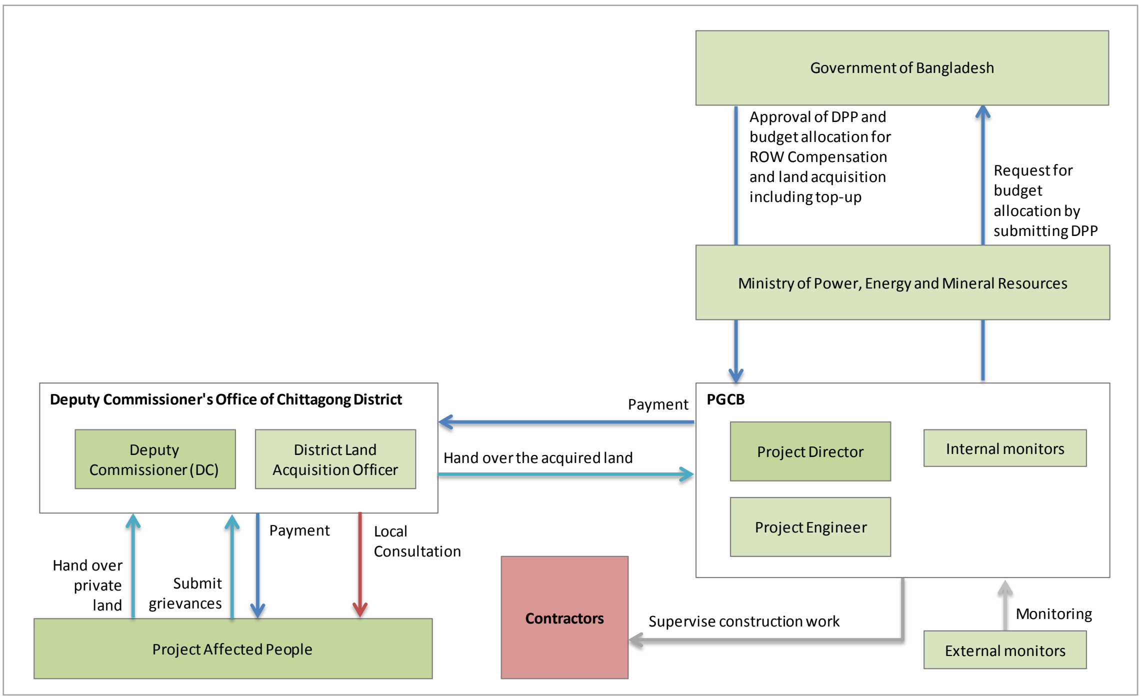


(Source: JICA Survey Team)

Figure 12.2-1 Grievance Redress Mechanism

12.2.6 Implementation Arrangements

The following figure shows the implementation schedule of the Action Plan. Major actions taken by PGCB are summarized below:



(Source: JICA Survey Team)

Figure 12.2-2 Implementation Arrangements

(1) Budget Application for CCL and top-up payment

PGCB is the implementing agency of the project, and the Deputy Commissioner's Office of Chittagong District is the immediate organization for affected people to consult for compensation as stipulated in the Ordinance 1982.

PGCB will prepare and submit an application for administrative approval to MPEMR and make a request to DC of Chittagong for taking necessary actions for estimating the degree of land acquisition and cost. It will also prepare and submit the Action Plan for Land Acquisition and Livelihood Compensation to MPEMR.

PGCB will submit the Development Project Proposal (DPP) to the GOB for allocation of the required budget for CCL and an additional grant for 'top-up payment', which shall be approved by the GOB.

(2) Local consultation and information management

The Deputy Commissioner's Office of Chittagong District will conduct a series of local consultations as stipulated by law to ensure that PAPs are kept informed of the project implementation process, benefits and losses, environmental and social impact, etc.

(3) Implementation of land acquisition

The DC will pay the CCL and top-up payment or the affected lands, structures crops and trees to the PAPs.

A grievance redress mechanism will be established at Union level, Upazila level and District level for the affected people to address grievances .

(4) Monitoring

Appropriate reporting, including auditing and redress functions, monitoring and evaluation mechanisms, will be identified and set in place. In addition to internal monitoring conducted by PGCB, an external monitoring group should be hired that will evaluate the resettlement process and final outcome.

12.2.7 Implementation Schedule

The implementation schedule of ROW compensation and acquisition of land for new Madunaghat SS and its access road is shown from the next page.

12.2.8 Cost and Financial Sources

The total cost for land acquisition and compensation is estimated at 515.98 million Taka. Adequate budgetary support will be fully committed and made available to cover the costs of land acquisition and compensation within the agreed implementation period.

In addition to the compensation stipulated by the Ordinance 1982 and the Electricity Act 1910, all the compensation will be done according to the principle of the replacement cost, which will require PGCB to pay the gap between CCL and the replacement value (top-up).

Table 12.2-5 Land Acquisition and Compensation Cost

(Unit: Bangladesh Taka (BDT))

Division		Land acquisition		Livelihood / ROW Compensation				TOTAL
				Permanent Loss		Temporary Loss		
		CCL	Top-up	Crop	Labor	Crop	Labor	
1	400 kV from Meghnaghat to Madunaghat SS	1,610,703	241,605	74,402	0	8,628,674	8,079,898	18,635,282
2	400 kV from Madunaghat SSn to Matarbari CFPP	435,938	65,391	23,947	0	2,728,933	3,436,113	6,690,322
3	230 kV T/L from new Madunaghat SS - existing Madunaghat SS	56,069	8,410	2,082	0	213,499	287,541	567,601
4	230 kV T/L from LILO at Madunaghat SS from Hathazari-Sikalbaha T/L	32,347	4,852	1,201	0	138,774	186,902	364,076
5	New Madunaghat SS	402,521,898	60,378,285	11,457,784	1,207,672	0	0	475,565,638
6	Road Expansion to Madunaghat SS	11,979,818	1,796,973	341,005	35,943	0	0	14,153,739
TOTAL		416,636,774	62,495,516	11,900,421	1,243,614	11,709,880	11,990,453	**515,976,658**

(Source: JICA Survey Team)

12.2.9 Monitoring Arrangements by Executing Agency and Monitoring Form

Appropriate reporting (including auditing and redress functions), monitoring and evaluation mechanisms, will be identified and set in place as part of the management system of land acquisition and livelihood restoration. An external monitoring group will be hired by the Project and will evaluate the whole process and final outcome.

An Environmental Management Plan (EMaP) has been prepared to provide guidelines for the monitoring during pre-construction, construction and operation activities of 1) transmission lines, 2) substations and 3) access road expansion.

The purposes of creating an EMaP are to:

- Confirm that mitigation measures shall reduce any negative impacts on the environment to allowable levels during the construction and operation phase.
- Set up an organization that is responsible for the implementation of monitoring the plan.
- Perform appropriate monitoring during the construction and operation phase.

The environmental components that will be monitored are those that will be positively or negatively affected, or expected to be affected.

12.2.10 Public Consultation

The PAPs and their communities will be consulted about the project, the rights and options available to them, and proposed mitigation measures for adverse effects, and to all extents possible be involved in the decision-making process concerning the land acquisition.

PAPs will be involved in the process of developing and implementing the Action Plan for Land Acquisition and Livelihood Compensation. The PAPs will receive prior notification of the compensation, relocation and other assistance available to them.

PGCB will be responsible, in close coordination with the DC and contractors, for holding and conducting a number of consultations with primary and secondary stakeholders and information dissemination on the following issues:

- The relevant details of the project
- The Action Plan for Land Acquisiton and Livelihood Compensation and various degrees of project impact
- Details of entitlements under the Action Plan and what is required of PAPs in order to claim their entitlements
- Compensation process and compensation rates
- Relocation and resettlement site development operation in order to obtain agreement and support of affected people in participating in these operations
- Implementation schedule and timetable for the delivery of entitlements

Public participation will be spontaneously performed and information will be made available during preparation and implementations of the Action Plan and, at the minimum, include community meetings and focus group discussions.

12.3 Others

12.3.1 Screening Form

As shown in the Screening Format.

12.3.2 Monitoring Form

As shown in the Monitoring form for Transmission Line, Madunaghat SS, and Road Expansion to Madunaghat SS.

12.3.3 Environmental Checklist

As shown in the Environmental Checklist for both transmission line and substations (common).

Table 12.3-1 Implementation Schedule of ROW Compensation and Land Acquisition of Madunaghat Substation and Access Road

(Note) PD stands for Power Division, DC stands for Deputy Commissioner.

Screening Format

Name of Proposed Project : Dhaka - Chittagong Main Power Grid Strengthening Project
Project Executing Organization : Power Grid Company of Bangladesh Limited (PGCB)
Name, Address, Organization, and Contact Point of a Responsible Officer
Name : Managing Director
Address : IEB Bhaban 3rd/4th Floor, Ramna, Dhaka-1000
Organization : Pgas
Tel/Fax : +880-2-9553663, 9560064
E-Mail :

Date:
Signature:

Check Items

Please write "to be advised (TBA)" when the details of a project are yet to be determined.

Question 1: Address of project site
: Dhaka district and Chittagong district

Question 2: Scale and contents of the project (approximate area, facilities' area, production, electricity generated, etc.)

2-1. Project profile (scale and contents)

This project is comprised of the following components:

1) Construction of 400 kV transmission line (from Meghnaghat to Madunaghat, and from Matarbari to Madunaghat)
2) Expansion of 400 kV / 230 kV substations (Meghnaghat and Madunaghat)
3) Upgrade of 230 kV / 132 kV substation (Madunaghat)
4) Construction of 230 kV and 132 kV transmission lines (from Madunaghat to Old Madunaghat, and LILO at Madunaghat SS from Hathazari to Sikalbaha)
5) Rehabilitation of the Central Load Dispatching Center
6) Related facilities including access roads
7) Consulting Services (detailed design, support for bidding, construction supervision)

2-2. How was the necessity of the project confirmed? Is the project consistent with the higher program/policy?

■ YES: Please describe the higher program/policy.
Power System Master Plan 2010, and the Sixth Five Year Development Plan (2011~2015)
□ NO

2-3. Did the proponent consider alternatives before this request?

■ YES: Please describe outline of the alternatives
Three routes for the proposed 400kV transmission line from Meghnaghat to Matarbari via Madunaghat have been identified from the desktop study and results of partial site survey.

a) Candidate Route-I

Candidate Route-I of 400kV TL started from Meghnaghat 400kV SS at Sonargaon Upazila of Narayanganj District passing through Sonargaon, Gazaria, Daudkandi, Barura, Kachua, Laksam, Feni, Chhagolnaiya, Mirsarai, Fatikchhari, Hathazari, Raozan, Boalkhali, Patiya and Anowara, Banshkhali and Pekua Upazila and ended at the proposed 2x600MW Matarbari Coal Based power plant.
This will cross the 4 major rivers, namely, Meghna, Gomoti, Karnafully and Sangu. This line will also cross a hilly area in Ramgar from Karer hat to Heyako of about 10km long.

b) Candidate Route-II

Candidate Route-II has been proposed to draw along the Dhaka-Chittagong highway

(Sonargaon, Gazarai, Daudkandi, Kachua, Laksam, Feni, Mirsarai and Sitakundu Upazila) up to Kumira and then cross the hill and pass through Hathazari Upazila, Madunaghat substation, Boalkhali, Patiya, Anowara Upazila, Banshkhali and Pekua Upazila and end at the proposed 2x600MW Matarbari Coal Based power plant.

c) Candidate Route-III

Candidate Route-III has been proposed to draw along Candidate Route-I (Sonargaon, Gazarai, Daudkandi, Barura, Kachua, Laksam, Feni, Mirsarai Chhagolnaiya, Fatikchhari, Hathazari, Raozan (Madunaghat), Boalkhali, Patiya, Anowara, Banshkhali, Pekua and Moheshkhali)

The impacts on environmental and social considerations were assessed based on the survey results on nature and social conditions with scoring methods by rating the degree of environmental impacts. As a result, Candidate Route-I is considered to be the most advantageous, best practicable environmental option for transmission lines.

□ NO

2-4. Did the proponent implement meetings with the related stakeholders <u>before</u> this request?

■ Implemented □ Not implemented

■ <u>If implemented</u>, please mark the following stakeholders.

■Administrative body

□ Local residents

□ NGO

□ Others ( )

Question 3: Is the project a new one or an ongoing one? In the case of an ongoing project, have you received strong complaints or other comments from local residents?

■ New ☐ Ongoing (with complaints) ☐ Ongoing (without complaints)

☐ Other ( )

Question 4: Is an Environmental Impact Assessment (EIA), including an Initial Environmental Examination (IEE) required for the project according to a law or guidelines of a host country? If yes, is an EIA implemented or planned? If necessary, please fill in the reason why an EIA is required.

■ Necessary (■ Implemented ☐ Ongoing/planning)

(Reason why EIA is required: Transmission line projects are placed in the RED CATEGORY project list in the Environmental Conservation Rules of Bangladesh, stipulated in 1997. PGCB therefore goes through an Initial Environmental Examination (IEE) for site clearance, a full Environmental Impact Assessment (EIA) for environmental clearance, and an Environmental Monitoring Plan (EMP) prior to the project implementation in the country.)

☐Not necessary

☐Other (please explain)

Question 5: In the case that steps were taken for an EIA, was the EIA approved by the relevant laws of the host country? If yes, please note the date of approval and the competent authority.

☐ Approved without a supplementary condition	☐ Approved with a supplementary condition	■ Under appraisal

(Date of approval: Competent authority:)

☐ Under implementation

☐ Appraisal process not yet started

☐ Other ( )

Question 6: If the project requires a certificate regarding the environment and society other than an EIA, please indicate the title of said certificate. Was it approved?

☐ Already certified

Title of the certificate: ( )

■ Requires a certificate but not yet approved

(Environmental Clearance Certificate (ECC) will be issued by the Department of Environment within 15 days after approval of EIA.)

☐ Not required

☐ Other ( )

Question 7: Are any of the following areas present either inside or surrounding the project site?

☐ Yes ■ No

If yes, please mark the corresponding items.

☐ National parks, protection areas designated by the government (coastline, wetlands, reserved area for ethnic or indigenous people, cultural heritage)

☐ Primeval forests, tropical natural forests

☐ Ecologically important habitats (coral reefs, mangrove wetlands, tidal flats, etc.)

☐ Habitats of endangered species for which protection is required under local laws and/or international treaties

☐ Areas that run the risk of a large scale increase in soil salinity or soil erosion

☐ Remarkable desertification areas

☐ Areas with special values from an archaeological, historical, and/or cultural points of view

☐ Habitats of minorities, indigenous people, or nomadic people with a traditional lifestyle, or areas with special social value

Question 8: Does the project include any of the following items?

☐ Yes ■ No

If yes, please mark the appropriate items.

☐ Involuntary resettlement (scale: households persons)

☐ Groundwater pumping (scale: m3/year)

☐ Land reclamation, land development, and/or land-clearing (scale: hectors)

☐ Logging (scale: hectors)

Question 9: Please mark related adverse environmental and social impacts, and describe their outlines.

■ Air pollution

■ Water pollution

☐ Soil pollution

■ Waste

■ Noise and vibrations

☐ Ground subsidence

☐ Offensive odors

☐ Geographical features

☐ Bottom sediment

☐ Biota and ecosystems

■ Water usage

■ Accidents

☐ Global warming

☐ Involuntary resettlement

■ Local economies, such as employment, livelihood, etc.

■ Land use and utilization of local reSource:s

■ Social institutions such as social infrastructure and local decision-making institutions

☐ Existing social infrastructures and services

■ Poor, indigenous, or ethnic people

■ Misdistribution of benefits and damages

■ Local conflicts of interest

☐ Gender

☐ Children's rights

☐ Cultural heritage

■ Infectious diseases such as HIV/AIDS

■ Other (Right of Way)

Outline of related impact:

Impact may be caused during the construction period of transmission lines and towers in relation to ambient air, water, waste, noise and vibration, topographic and geology, poor people, local economy, land use, water usage and right of way. In the said period, infectious diseases and accidents may also occur if measures are not taken. During the operation period too, water usage may be disturbed and accidents may occur if measures are not taken. However, the degree of negative impacts will remain to some extent, or will be prevented, if normal countermeasures are applied.

As for substation construction and road expansion, ambient air, waste, noise and vibration, poor people, local economy, and land use will be affected, for which normal countermeasures can be applied during the construction period. Land acquisition may cause disturbance to poor people, land use, and social institutions. Deterioration of local economy, misdistribution of benefits and compensation, and local conflicts of interest might also occur if appropriate action is not taken.

Question 10: In the case of a loan project such as a two-step loan or a sector loan, can sub-projects be specified at the present time?

☐ Yes ☐ No ■ Not Applicable

Question 11: Regarding information disclosure and meetings with stakeholders, if JICA's environmental and social considerations are required, does the proponent agree to information disclosure and meetings with stakeholders through these guidelines?

■ Yes ☐No

Monitoring form (Transmission Line)

The following items should be monitored periodically during each phase.

(1) Pre-Construction phase

1) Land acquisition (Quarterly during the official process)
- Monitor the progress of Government procedure for land acquisition of tower basis
- Monitor whether the compensation for the above land acquisition is being paid, including top-up payment and livelihood compensation for the entitled people.

2) ROW Compensation (Quarterly during the official process)
- Monitor the progress of Government procedure for general notification of ROW.

(2) Construction phase

1) Air quality

(Date) (Parameter: PM10, Unit μg/m3)

Parameter	Ave. time	Results							Ambient air quality standards	Remarks
		St1	St2	St3	St4	St5	St6	St7		
SO_2	(1hr)								350 (1hr)	
	(24hr)								125 (24hr)	
NO_2	(1hr)								200 (1hr)	
	(24hr)								100 (24hr)	
PM_{10}	(24hr)								150 (24hr)	

(Meteorological Condition)

Location (Date)	Time		Temperature (°C)		Moisture (%)	Wind	
			Dry	Wet		Direction	Speed
St.1	AM	:					m/sec
	PM	:					m/sec
St.2	AM	:					m/sec
	PM	:					m/sec
St.3	AM	:					m/sec
	PM	:					m/sec
St.4	AM						m/sec
	PM						m/sec
St.5	AM						m/sec
	PM						m/sec
St.6	AM						m/sec
	PM						m/sec
St.7	AM						m/sec
	PM						m/sec

Notice: St.1 to St.7 means the sampling station defined at stage of survey on natural reSource:s.

2) Water quality (Discharge wastewater)

(Date)

Parameter	Unit	Result	Wastewater discharge standards			Remarks (Measurements method)
Temperature	°C.		-	-	-	
pH	-		6-9	6-9	6-9	
BOD	mg/L		50	250	100	
COD	mg/L		200	400	400	
TSS	mg/L		150	500	200	
Oil & grease	mg/L		10	20	10	
As	mg/L		0.2	0.05	0.2	
Cd	mg/L		0.05	0.5	0.5	
T-Cr	mg/L		0.5	1.0	1.0	
Cu	mg/L		0.5	3.0	3.0	
Fe	mg/L		2	2	2	
Pad	mg/L		0.1	1.0	0.1	
Hg	mg/L		0.01	0.01	0.01	
Total fecal coliform	MPN/100mL		-	-	-	

Notice: Monitoring should be carried out at discharge site of wastewater treatment facility.

3) Waste

(Unit: ton/gm)

Month	Sample Date	Kinds of Waste (Quality)		Rate of recycle/Reuse (%)		Remarks
		Industrial	Domestic	Industrial	Domestic	
		(A)	(B)	(A)	(B)	

4) Noise

(Date)

(Unit: dBA)

Location	Result	Noise standards					Remarks
		A	B	C	D	E	
St.1		Day (6AM-9PM): 45 Night (9PM-6AM): 35	Day: 50 Night: 40	Day: 60 Night: 50	Day: 70 Night: 60	Day: 70 Night: 70	
St.2							
St.3							
St.4							
St.5							
St.6							
St.7							

Notes: Category of areas is as follows: A: Silent zone, B: Residential area, C: Mixed area (mainly residential area, and also simultaneously used for commercial and industrial purposes), D: Commercial area, E: Industrial area.

(Meteorological Condition)

Location (Date)	Time		Temperature (°C)		Moisture (%)	Wind	
			Dry	Wet		Direction	Speed
St.1	AM	:					m/sec
	PM	:					m/sec
St.2	AM	:					m/sec

	PM	:					m/sec
St.3	AM	:					m/sec
	PM	:					m/sec
St.4	AM						m/sec
	PM						m/sec
St.5	AM						m/sec
	PM						m/sec
St.6	AM						m/sec
	PM						m/sec
St.7	AM						m/sec
	PM						m/sec

Notice:St.1 to St.7 means the sampling station defined at stage of survey on natural reSource:s

5) Ecosystem
a. Endangered species
(Date)

Scientific name	Local name	English name	Total No. of individuals	Conservation Status		Remarks
				IUCN	Local	

6) Disturbance to the poor (simultaneously)
- Interview with the affected people

7) Deterioration of local economy (simultaneously)
- Interview with the affected people

8) Land use
- Interview with the affected people (simultaneously)

9) Infectious diseases (once a year)
- Monitor the health record through medical check-ups

10) Work Environment (once a year)
- Monitor the record of accidents

11) ROW Compensation (simultaneously)
- Monitor the payment of ROW Compensation by the contractor for the entitled people.

12) Accidents (once a year)
- Monitor the record of accidents

(3) Operation stage

1) Ecosystem

a. Endangered species

(Date)

Scientific name	Local name	English name	Total No. of individuals	Conservation Status		Remarks
				IUCN	Local	

2) Work Environment (once a year)

- Monitor the record of accidents

3) Accidents (once a year)

- Monitor the record of accidents

Monitoring form (Madunaghat Substation)

The following items should be monitored periodically during each phase.

(1) Pre-Construction phase

1) Land acquisition (Quarterly during the official process)

- Monitor the progress of Government procedure for land acquisition
- Monitor whether the compensation for the above land acquisition is being paid, including top-up payment and livelihood compensation for the entitled people.
- Interviewing affected people about their livelihood means.

(2) Construction phase

1) Air quality

(Date)

(Parameter: PM10, Unit μg/m3)

Parameter	Ave. time	Site				Ambient air quality standards	Remarks
		St1	St2	St3	St4		
SO_2	(1hr)					350 (1hr)	
	(24hr)					125 (24hr)	
NO_2	(1hr)					200 (1hr)	
	(24hr)					100 (24hr)	
PM_{10}	(24hr)					150 (24hr)	

Notice: St1, St2, St3, and St4 will be defined after drawing up of site location.

(Meteorological Condition)

Location (Date)	Time		Temperature (°C)		Moisture (%)	Wind	
			Dry	Wet		Direction	Speed
St.1	AM	:					m/sec
	PM	:					m/sec
St.2	AM	:					m/sec
	PM	:					m/sec
St.3	AM	:					m/sec
	PM	:					m/sec
St.4	AM						m/sec
	PM						m/sec

Notice: St1, St2, St3, and St4 will be defined after drawing up of site location.

2) Water quality (Discharge wastewater)

(Date)

Parameter	Unit	Result	Wastewater discharge standards			Remarks (Measurements method)
			Inland surface water	Public sewer	Irrigated land	
Temperature	°C.		-	-	-	
pH	-		6-9	6-9	6-9	
BOD	mg/L		50	250	100	
COD	mg/L		200	400	400	
TSS	mg/L		150	500	200	
Oil & grease	mg/L		10	20	10	
As	mg/L		0.2	0.05	0.2	
Cd	mg/L		0.05	0.5	0.5	
T-Cr	mg/L		0.5	1.0	1.0	

Cu	mg/L		0.5	3.0	3.0	
Fe	mg/L		2	2	2	
Pad	mg/L		0.1	1.0	0.1	
Hg	mg/L		0.01	0.01	0.01	
Total fecal coliform	MPN/100mL		-	-	-	

Notice: Monitoring should be carried out at discharge site of wastewater treatment facility.

3) Waste

(Unit: ton/gm)

Month	Sample Date	Kinds of Waste (Quality)		Rate of recycling/Reuse (%)		Remarks
		Industrial	Domestic	Industrial	Domestic	
		(A)	(B)	(A)	(B)	

4) Noise

(Date)

(Unit: dBA)

Location	Result	Noise standards					Remarks
		A	B	C	D	E	
St.1		Day (6AM-9PM): 45 Night (9PM-6AM): 35	Day: 50 Night: 40	Day: 60 Night: 50	Day: 70 Night: 60	Day: 70 Night: 70	
St.2							
St.3							
St.4							

Notes: Category of areas is as follows: A: Silent zone, B: Residential area, C: Mixed area (mainly residential area, and also simultaneously used for commercial and industrial purposes), D: Commercial area, E: Industrial area.

(Meteorological Condition)

Location (Date)	Time		Temperature (°C)		Moisture (%)	Wind	
			Dry	Wet		Direction	Speed
St.1	AM	:					m/sec
	PM	:					m/sec
St.2	AM	:					m/sec
	PM	:					m/sec
St.3	AM	:					m/sec
	PM	:					m/sec
St.4	AM						m/sec
	PM						m/sec

Notice: St1, St2, St3, and St4 will be defined after drawing up of site location.

5) Disturbance to the poor (simultaneously)
- Interview with the affected people

6) Deterioration of local economy (simultaneously)
- Interview with the affected people

7) Social Institutions (once after compensation)
- Interview with the affected people

8) Misdistribution of benefits and compensation (once after compensation)
- Monitor the progress of Government procedure for land acquisition
- Interview with the affected people

9) Local conflicts of interest (once after compensation)
- Interview with the affected people

10) Infectious diseases (once a year)
- Monitor the health record through medical check-ups

11) Work Environment (once a year)
- Monitor the record of accidents

12) Accidents (once a year)
- Monitor the record of accidents

(3) Operation stage
2) Waste

(Unit: ton/gm)

Month	Sample Date	Kinds of Waste (Quality)		Rate of recycling/Reuse (%)		Remarks
		Industrial	Domestic	Industrial	Domestic	
		(A)	(B)	(A)	(B)	

2) Disturbance to the poor (simultaneously)
- Interview with the affected people

3) Work Environment (once a year)
- Monitor the record of accidents

4) Accidents (once a year)
- Monitor the record of accidents

Monitoring form (Road Expansion to Madunaghat Substation)

The following items should be monitored periodically during each phase.

(1) Pre-Construction phase

1) Land acquisition (Quarterly during the official process)
- Monitor the progress of Government procedure for land acquisition
- Monitor whether the compensation for the above land acquisition is being paid, including top-up payment and livelihood compensation for the entitled people.
- Interviewing affected people about their livelihood means.

(2) Construction phase

1) Air quality

(Date)

(Parameter: PM10, Unit μg/m3)

Parameter	Ave. time	Site				Ambient air quality standards	Remarks
		St1	St2	St3	St4		
SO_2	(1hr)					350 (1hr)	
	(24hr)					125 (24hr)	
NO_2	(1hr)					200 (1hr)	
	(24hr)					100 (24hr)	
PM_{10}	(24hr)					150 (24hr)	

Notice: St1, St2, St3, and St4 will be defined after drawing up of site location.

(Meteorological Condition)

Location (Date)	Time		Temperature (°C)		Moisture (%)	Wind	
			Dry	Wet		Direction	Speed
St.1	AM	:					m/sec
	PM	:					m/sec
St.2	AM	:					m/sec
	PM	:					m/sec
St.3	AM	:					m/sec
	PM	:					m/sec
St.4	AM						m/sec
	PM						m/sec

Notice: St1, St2, St3, and St4 will be defined after drawing up of site location.

2) Waste

(Unit: ton/gm)

Month	Sample Date	Kinds of Waste (Quality)		Rate of recycling/Reuse (%)		Remarks
		Industrial	Domestic	Industrial	Domestic	
		(A)	(B)	(A)	(B)	

3) Noise

(Date)

(Unit: dBA)

Location	Result	Noise standards					Remarks
		A	B	C	D	E	

St.1		Day (6AM-9PM): 45 Night (9PM-6AM): 35	Day: 50 Night: 40	Day: 60 Night: 50	Day: 70 Night: 60	Day: 70 Night: 70	
St.2							
St.3							
St.4							

Notes: Category of areas is as follows: A: Silent zone, B: Residential area, C: Mixed area (mainly residential area, and also simultaneously used for commercial and industrial purposes), D: Commercial area, E: Industrial area.

(Meteorological Condition)

Location	Time		Temperature (°C)		Moisture	Wind	
(Date)			Dry	Wet	(%)	Direction	Speed
St.1	AM	:					m/sec
	PM	:					m/sec
St.2	AM	:					m/sec
	PM	:					m/sec
St.3	AM	:					m/sec
	PM	:					m/sec
St.4	AM						m/sec
	PM						m/sec

Notice: St1, St2, St3, and St4 will be defined after drawing up of site location.

4) Disturbance to the poor (simultaneously)
- Interview with the affected people

5) Deterioration of local economy (simultaneously)
- Interview with the affected people

6) Social Institutions (once after compensation)
- Interview with the affected people

7) Misdistribution of benefits and compensation (once after compensation)
- Monitor the progress of Government procedure for land acquisition
- Interview with the affected people

8) Local conflicts of interest (once after compensation)
- Interview with the affected people

9) Infectious diseases (once a year)
- Monitor the health record through medical check-ups

10) Work Environment (once a year)
- Monitor the record of accidents

11) Accidents (once a year)
- Monitor the record of accidents

(3) Operation stage
N/A

Environmental Checklist (common for transmission line and substations)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports already been prepared in official process?	(a) Not yet	It is being prepared for official approval.
		(b) Have EIA reports been approved by authorities of the host country's government?	(b) Not yet	Not submitted yet. Taking into account comments on the IEE (Initial Environmental Examination) from DOE, PGCB is currently working on the EIA, of which a draft is available for prior appraisal as attached (draft EIA report).
		(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?	(c) Not yet	Under development
		(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(d) Y	IEE was approved by the Department of Environment as of 1 Sep 2014 with the approval number DoE/Clearance/5339/2014/229.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected in the project design?	(a) Y (b) Y	Project outline was explained to the local stakeholders through (i) key informant interview with local government authorities (81 people of 18 *Upazilas*, 6 *Zilas* (Districts) of 2 Divisions (Dhaka and Chittagong) from 15 Jul to 18 Aug 2014, (ii) focus group discussion with 124 local residents of 7 *Upazipas*, 4 *Zilas* of 2 Divisions from 24 Jul to 5 Sep 2014, and (iii) socioeconomic survey with 184 local people of 6 *Upazilas*, 6 *Zilas* of 2 Divisions residing along with the TL route from 13 to 23 Aug 2014 and some more who are the landowners of new Madunaghat SS site from 8 to 16 Oct 2014. Most of the comments obtained from the local stakeholders are anxieties and concerns without proper knowledge or understanding about the environmental issues. The anticipated impacts caused by the project were properly explained to them as they were for their appropriate understanding.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	Three alternative plans have been discussed to minimize adverse impacts on the natural and social environment.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
2 Pollution Control	(1) Water Quality	(a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? If the water quality degradation is anticipated, are adequate measures considered?	(a) Y	Adequate measures preventing soil runoff caused by earthmoving activities have been adopted.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) It is not anticipated that the project will affect the protected areas.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	(a) N	Surroundings of project site are mainly rice fields and man-made plain-forest.
		(b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	(b) N	Not included.
		(c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?	(c) N	It is not anticipated that the project will affect the ecosystem.
		(d) Are adequate measures taken to prevent disruption of migration routes and habitat fragmentation of wildlife and livestock?	(d) N	It is not anticipated that the project will obstruct animals' behavior or habitats.
		(e) Is there any possibility that the project will cause negative impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, or disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered?	(e) N	It is not anticipated that this project will cause adverse impact on the ecosystem.
		(f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments?	(f) N	The project site is located in agriculture area occupied mainly by rice fields and man-made forest of ornamental and fruit trees.
3 Natural Environment	(3) Topography and Geology	(a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed?	(a) N	No possibility of erosion as project site is flat and stable slope area.
		(b) Is there any possibility that civil works, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides?	(b) N	No cutting or earth filling

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	(c) N	No major cutting or earth filling
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?	(a) N	Approximately 7 ha of land will be acquired for the construction of new Madunaghat SS, which will cause no resettlement.
		(b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement?	(b) Y	Entitlement matrix for the project affected people has been drafted for budget request to the GOB in case there are resettlers on TL route and new Madunaghat SS site.
		(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	(c) Y	A series of socioeconomic surveys was conducted with 184 local people of 6 *Upazilas*, 6 *Zilas* of 2 Divisions residing along with the TL route from 13 to 23 Aug 2014 and some more who are the landowners of new Madunaghat SS site from 8 to 16 Oct 2014. The RFP has reflected the findings of the above survey.
		(d) Are the compensations going to be paid prior to the resettlement?	(d) Y	DPP has been drafted for the approval of GOB for the next fiscal year starting July 2015, which includes the budget for land acquisition and compensation.
		(e) Are the compensation policies prepared in a document?	(e) Y	It is reflected in the EM (and RFP).
		(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	(f) Y	In addition to the socioeconomic survey, focus group discussion was held with 124 local residents. FGD were split into men's groups and women's comprised of various ages residing along the TL to collect specific concerns and local issues. Key informant interview with local government authorities was also conducted with 184 people to lseek and ascertain opinions of the vulnerable. It is anticipated that there are no ethnic minority groups in and around the TL route and SS sites.
		(g) Are agreements with the affected people obtained prior to resettlement?	(g) N	Not yet, as the detailed design (DD) of the project will fix the route for TL and sites for SS.
		(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	(h) Y	*The Ordinance 1982* stipulates that it is the Deputy Commissioner's Office of the concerned district that is responsible for handling the land acquisition and compensation on behalf of the project owner. PGCB will follow the official framework for any possible resettlement in order not to do any harm to other similar resettlement cases. The Project Management Unit (PMU) will keep in close touch with DC Office and monitor the procedure. PGCB will secure the budget for the Financial Year (FY) 2015. DPP is under GOB's

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				appraisal.
		(i) Are any plans developed to monitor the impacts of resettlement?	(i) Y	PMU will work in accordance with the Ordinance 1982 and the Electricity Act 1910, and keep in close touch with DC Office.
		(j) Is the grievance redress mechanism established?	(j) Y	Grievance is legitimately mentioned in the Ordinance 1982, and PGCB will be in close touch with DC Office to handle it. PMU will be the entry point for any grievance from the project affected people.
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	(a) Y	By acquiring land for new Madunaghat SS, land owners and sharecroppers will lose their means of livelihood.
		(b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary?	(b) Y	Local people will be recruited for simple work to the extent possible, which will lower the potential risk of infectious diseases transmitted from external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc.). Occupational health and safety guidance will be given to them in accordance with the domestic law in Bangladesh.
		(c) Is there any possibility that installation of structures, such as power line towers will cause radio interference? If any significant radio interference is anticipated, are adequate measures considered?	(c) N	TL route has been drafted with care to avoid homesteads to avoid doing harm to local residents.
		(d) Are the compensations for transmission wires given in accordance with the domestic law?	(d) N	It is not legitimately required. TL route has been drafted with care to avoid homesteads to avoid doing harm to local residents.
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country’s laws?	(a) N	There are no such religious heritage places etc., in and around TL route and SS sites.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	There are no such places designated by law in and around TL route and SS sites.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?	(a) N/A	There is no ethnic minority or indigenous people confirmed in the TL route nor SS sites.
		(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and reSource:s respected?	(b) N/A	It is not applicable for the project.
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?	(a) N	PGCB will not violate any laws and ordinances associated with the working conditions of Bangladesh.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?	(b) Y	The construction company shall establish a work safety plan and submit it to PGCB for prior approval. The work safety plan will include mitigation measures on safety training, etc. and on provision of appropriate protective equipment to the workers, etc.
		(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?	(c) Y	
		(d) Are appropriate measures taken to ensure that security guards involved in the project do not violate the safety of other individuals involved, or local residents?	(d) Y	
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and waste)?	(a) Y	Air pollution, noise, water contamination and waste are anticipated during construction stage, but watering on road, using low noise/vibration equipment, setting sedimentation ponds or promoting recycling and reuse will decrease its impacts
		(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts?	(b) N	No impact on surrounding nature is anticipated as the project will not cause large civil work.
		(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(c) N	- The employment of local people will be promoted for increased employment opportunities for various subcontract work resulting from the TL extension and SS construction activity. - Local people will be employed to the maximum extent possible. Lodgings of project workers will be equipped with sufficient living facilities so that workers remain at the project site as much as possible. - Labor contracts between the construction industry and children shall be prohibited. Regular patrols to check for child workers will be conducted Local people will be recruited for simple work to the extent possible, which will lower the potential risk of infectious diseases transmitted from external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc.).
	(2) Monitoring	(a) Does the proponent develop and implement a monitoring program for the environmental items that are considered to have potential impacts?	(a) Y	Compiling the environmental monitoring plan and its implementation is mandatory, and items with possible adverse impact will be monitored
		(b) What are the items, methods and frequencies of the monitoring program?	(b)Y	Specific items will be described in the final EIA report

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?	(c) Y	PGCB will examine measures for monitoring based on the final EIA report.
		(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(d)Y	These items are identified by Laws and Guidelines
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a) N	Impacts on existing roads are not anticipated
	Note on Using Environmental Checklist	(a) If necessary, the impacts on trans-boundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as trans-boundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	No impacts on global issues, as exhaust gas from construction of TL will remain at a negligible level.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made. In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

Chapter 13
Estimated Cost of the Project

Chapter 13 Estimated Cost of the Project

13.1 Construction Cost of the Transmission Lines

13.1.1 Share of FC and LC

The construction cost of the transmission lines of the Project would be estimated as the multiplication of standard unit prices of the materials, equipment, or civil & tower erection works, and those coefficient quantities calculated in the Chapter 9. The standard unit prices were prepared referring to the recent contract prices of international competitive bidding (ICB) projects such as the 400 kV Bibiyana - Kaliakoir Transmission Line Project as well as the various ICB price data owned by the JICA Survey Team. The Project costs were estimated in foreign currency (USD) portion (FC) and local currency (USD conversion) portion (LC) based on the following table.

Table 13.1-1 Share of FC and LC for the Project

	Items	FC	LC
CIF	Tower, Conductor, OPGW, Ground-wire, Insulator, Accessories	100 %	0 %
LTE	Survey & Soil investigation, Land clearing, Foundation work, Tower erection, Insulator erection, Stringing, Inland transportation, Miscellaneous	20 %	80 %

13.1.2 Construction Cost of the Transmission Lines

The estimated construction costs of the transmission lines are summarized in the following table.

Table 13.1-2 Estimated Construction Costs of the Transmission Lines

[1,000 USD]

Package No.	Item	FC	LC	Total
TL-1	- 400 kV Meghnaghat - Madunaghat T/L	147,343	47,795	195,138
TL-2	- 400 kV Madunaghat - Matarbari T/L	68,245	24,077	92,322
TL-1	- 230 kV LILO at Madunaghat SS from Hathazari – Sikalbaha T/L	8,542	1,821	10,364
TL-3	- 230 kV Madunaghat - Old Madunaghat T/L	5,020	1,776	6,796

And breakdowns of the estimated construction cost of each transmission line are shown in Table 13.1-3, Table 13.1-4, Table 13.1-5, and Table 13.1-6.

Table 13.1-3 Construction Cost Breakdown of the 400 kV Meghnaghat – Madunaghat T/L

Category	No.	Items	Unit	Quantity	Unit Rate [USD]	Amount [USD]	FC [USD]	LC [USD]
COST, INSURANCE AND FREIGHT	1	Tower	ton	22,111	2,000	44,222,200	44,222,200	0
	2	LL-ACSR 560mm^2	km	5,393	10,000	53,930,000	53,930,000	0
	3	OPGW 158 mm^2	km	236	5,800	1,368,800	1,368,800	0
	4	ACSR Dorking 153 mm^2	km	225	2,500	562,500	562,500	0
	5	Suspension string (210kN)	set	2,352	3,600	8,467,200	8,467,200	0
	6	Tension string (300kN)	set	2,076	8,300	17,230,800	17,230,800	0
	7	Jumper support string (210kN)	set	1,038	1,400	1,453,200	1,453,200	0
	8	Accessories	lot	1	5%	6,361,735	6,361,735	0
	9	Spare parts	lot	1	2%	2,671,929	2,671,929	0
		Sub total				136,268,364	136,268,364	0
COST OF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & Soil investigation	km	214	3,500	749,000	149,800	599,200
	2	Land clearing	km	214	3,600	770,400	0	770,400
	3	Foundation (suspension, pad and chimney)	unit	41	33,700	1,381,700	276,340	1,105,360
	4	Foundation (suspension, pile)	unit	201	60,600	12,180,600	2,436,120	9,744,480
	5	Foundation (suspension, pile length: over 15 m)	unit	150	68,700	10,305,000	2,061,000	8,244,000
	6	Foundation (tension, pad and Chimney)	unit	0	50,300	0	0	0
	7	Foundation (tension, pile)	unit	101	115,300	11,645,300	2,329,060	9,316,240
	8	Foundation (tension, pile length: over 15 m)	unit	72	130,600	9,403,200	1,880,640	7,522,560
	9	Tower erection	ton	22,111	70	1,547,777	309,555	1,238,222
	10	Insulator erection (suspension)	set	2,352	100	235,200	47,040	188,160
	11	Insulator erection (tension)	set	2,076	100	207,600	41,520	166,080
	12	Insulator erection (jumper)	set	1,038	40	41,520	8,304	33,216
	13	Stringing	km	214	7,600	1,626,400	325,280	1,301,120
	14	Stringing (GW)	km	214	1,200	256,800	51,360	205,440
	15	Stringing (OPGW)	km	214	1,500	321,000	64,200	256,800
	16	Inland transportation	lot	1	2%	2,725,367	0	2,725,367
	17	Miscellaneous	lot	1	5%	2,669,843	533,969	2,135,875
	18	General expenses	lot	1	5%	2,803,335	560,667	2,242,668
		Sub total				58,870,043	11,074,855	47,795,188
		Total				195,138,407	147,343,219	47,795,188

Table 13.1-4 Construction Cost Breakdown of the 400 kV Madunaghat – Matarbari T/L

Category	No.	Items	Unit	Quantity	Unit Rate [USD]	Amount [USD]	FC [USD]	LC [USD]
COST, INSURANCE AND FREIGHT	1	Tower	ton	10,881	2,000	21,762,000	21,762,000	0
	2	LL-ACSR 560mm^2	km	2,319	10,000	23,190,000	23,190,000	0
	3	OPGW 158 mm^2	km	102	5,800	591,600	591,600	0
	4	ACSR Dorking 153 mm^2	km	97	2,500	242,500	242,500	0
	5	Suspension string (210kN)	set	930	3,800	3,534,000	3,534,000	0
	6	Tension string (300kN)	set	1,008	8,300	8,366,400	8,366,400	0
	7	Jumper support string (210kN)	set	504	1,400	705,600	705,600	0
	8	Accessories	lot	1	5%	2,919,605	2,919,605	0
	9	Spare parts	lot	1	2%	1,226,234	1,226,234	0
		Sub total				62,537,939	62,537,939	0
COST OF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & Soil investigation	km	92	3,500	322,000	64,400	257,600
	2	Land clearing	km	92	3,600	331,200	66,240	264,960
	3	Foundation (suspension, pile length: over 15 m)	unit	127	72,700	9,232,900	1,846,580	7,386,320
	4	Foundation with raised chimney (suspension, pile length: over 15 m)	unit	28	80,000	2,240,000	448,000	1,792,000
	5	Foundation (tension, pile length: over 15 m)	unit	77	138,300	10,649,100	2,129,820	8,519,280
	6	Foundation with raised chimney (tension, pile length: over 15 m)	unit	7	152,200	1,065,400	213,080	852,320
	7	Tower erection	ton	10,881	70	761,670	152,334	609,336
	8	Insulator erection (suspension)	set	930	100	93,000	18,600	74,400
	9	Insulator erection (tension)	set	1,008	100	100,800	20,160	80,640
	10	Insulator erection (jumper)	set	504	40	20,160	4,032	16,128
	11	Stringing	km	92	7,600	699,200	139,840	559,360
	12	Stringing (GW)	km	92	1,200	110,400	22,080	88,320
	13	Stringing (OPGW)	km	92	1,500	138,000	27,600	110,400
	14	Inland transportation	lot	1	2%	1,250,759	0	1,250,759
	15	Miscellaneous	lot	1	5%	1,350,729	270,146	1,080,584
	16	General expenses	lot	1	5%	1,418,266	283,653	1,134,613
		Sub total				29,783,584	5,706,565	24,077,019
		Total				92,321,523	68,244,504	24,077,019

Table 13.1-5 Construction Cost Breakdown of the 230 kV LILO at Madunaghat SS from Hathazari – Sikalbaha T/L

Category	No.	Items	Unit	Quantity	Unit Rate [USD]	Amount [USD]	FC [USD]	LC [USD]
COST, INSURANCE AND FREIGHT	1	Tower	ton	1,725	2,000	3,450,600	3,450,600	0
	2	LL-ACSR 560 mm^2	km	252	10,000	2,520,000	2,520,000	0
	3	OPGW 90 mm^2	km	6	3,200	19,200	19,200	0
	4	AC 90 mm^2	km	6	1,700	10,200	10,200	0
	5	Suspension string (210kN)	set	96	3,000	288,000	288,000	0
	6	Tension string (300kN)	set	120	6,000	720,000	720,000	0
	7	Jumper support string (210kN)	set	60	1,100	66,000	66,000	0
	8	Accessories	lot	1	5%	353,700	353,700	0
	9	Spare parts	lot	1	2%	148,554	148,554	0
		Sub total				7,576,254	7,576,254	0
COST OF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & Soil investigation	km	5	2,800	14,000	2,800	11,200
	2	Land clearing	km	5	2,900	14,500	2,900	11,600
	3	Foundation (suspension, pile length: over 15 m)	unit	8	90,900	727,200	145,440	581,760
	4	Foundation (tension, pile length: over 15 m)	unit	5	172,900	864,500	172,900	691,600
	5	Tower erection	ton	1,725	70	120,771	24,154	96,617
	6	Insulator erection (Sus.)	set	96	100	9,600	1,920	7,680
	7	Insulator erection (Ten.)	set	120	100	12,000	2,400	9,600
	8	Insulator erection (Jumper)	set	60	40	2,400	480	1,920
	9	Stringing	km	5	15,200	76,000	15,200	60,800
	10	Stringing (GW)	km	5	300	1,500	300	1,200
	11	Stringing (OPGW)	km	5	300	1,500	300	1,200
	12	Inland transportation	lot	1	2%	151,525	0	151,525
	13	Miscellaneous	lot	1	5%	99,775	19,955	79,820
	14	General expenses	lot	1	5%	104,764	20,953	83,811
		Sub total				2,200,034	409,702	1,790,333
		Total				9,776,288	7,985,956	1,790,333

Table 13.1-6 Construction Cost Breakdown of the 230 kV Madunaghat – Old Madunaghat T/L

Category	No.	Items	Unit	Quantity	Unit Rate [USD]	Amount [USD]	FC [USD]	LC [USD]
COST, INSURANCE AND FREIGHT	1	Tower	ton	693	2,000	1,385,400	1,385,400	0
	2	LL-ACSR 560 mm^2	km	202	10,000	2,020,000	2,020,000	0
	3	OPGW 90 mm^2	km	9	3,200	28,800	28,800	0
	4	AC 90 mm^2	km	9	1,700	15,300	15,300	0
	5	Suspension string (210kN)	set	72	3,000	216,000	216,000	0
	6	Tension string (300kN)	set	96	6,000	576,000	576,000	0
	7	Jumper support string (210kN)	set	48	1,100	52,800	52,800	0
	8	Accessories	lot	1	5%	214,715	214,715	0
	9	Spare parts	lot	1	2%	90,180	90,180	0
		Sub total				4,599,195	4,599,195	0
COST OF LABOUR, INLAND TRANSPORTATION AND EXPENSES	1	Survey & Soil investigation	km	8	2,800	22,400	4,480	17,920
	2	Land clearing	km	8	2,900	23,200	4,640	18,560
	3	Foundation (suspension, pile length: over 15 m)	unit	10	60,600	606,000	121,200	484,800
	4	Foundation with raised chimney (suspension, pile length: over 15 m)	unit	2	66,700	133,400	26,680	106,720
	5	Foundation (tension, pile length: over 15 m)	unit	8	115,300	922,400	184,480	737,920
	6	Tower erection	ton	693	70	48,489	9,698	38,791
	7	Insulator erection (Sus.)	set	72	100	7,200	1,440	5,760
	8	Insulator erection (Ten.)	set	96	100	9,600	1,920	7,680
	9	Insulator erection (Jumper)	set	48	40	1,920	384	1,536
	10	Stringing	km	8	15,200	121,600	24,320	97,280
	11	Stringing (GW)	km	8	300	2,400	480	1,920
	12	Stringing (OPGW)	km	8	300	2,400	480	1,920
	13	Inland transportation	lot	1	2%	91,984	0	91,984
	14	Miscellaneous	lot	1	5%	99,650	19,930	79,720
	15	General expenses	lot	1	5%	104,632	20,926	83,706
		Sub total				2,197,275	421,058	1,776,217
		Total				6,796,470	5,020,253	1,776,217

13.2 Construction Cost of the Substations

13.2.1 Estimation Precondition

The construction cost of the substations for the Project would be estimated based on the following.

- All equipment will be procured from abroad, and the price is estimated in USD for Cost, insurance and freight (CIF) price.
- The standard unit prices of ICB are based on the recent contract prices of ICB projects in PGCB such as the 400 kV Kaliakoir SS and 230kV Old Airport SS Project as well as the various ICB price data owned by the JICA Survey Team.
- The procurement cost for spare parts and test equipment is estimated to account for 3% of total equipment cost.
- The inland transportation cost is estimated to account for 2% of equipment cost with spare parts.
- The insurance cost is estimated to account for 1.5% of equipment cost with spare parts and civil work.
- The civil and erection cost, such as foundations, buildings, land development and fences, is estimated based on the Development Project Proposal in PGCB.
- The removal cost for the existing Madunaghat SS is estimated to account for 10% of total equipment cost with spare parts and civil work.
- Costs such as replacement cost and tools are estimated as miscellaneous cost. It would be estimated to account for 1% of the total costs.

13.2.2 Construction Cost of the Substations

The estimated construction costs of the Substations are summarized in Table 13.2-1.

Table 13.2-1 Estimated Construction Costs of the Substations

unit: 1000USD

		SS-1		SS-2		SS-3	
		400/230 kV Meghnaghat SS		400/230 kV Madunaghat SS		230/132 kV Madunaghat SS	
		FC	LC	FC	LC	FC	LC
Phase1	Equipment	12,369		14,386		0	
	Spare, Test Equipment	371		432		0	
	Civil and Erection	2,255	5,585	2,342	4,518	0	0
	Inland Transportation (Equ * 2%)		255		296		0
	Insurance (Equ+Civ * 1.5%)	225	84	257	68	0	0
	Miscellaneous (Equ+Civ * 1%)	150	56	172	45	0	0
	Sub total	15,370	5,980	17,588	4,927	0	0
Phase2	Equipment	25,220		51,908		18,927	
	Spare, Test Equipment	757		1,557		568	
	Civil and Erection	966	2,394	1,004	1,936	760	2,640
	Removal cost for Existing Mad S/S: 10%						1,893
	Inland Transportation (Equ * 2%)		520		1,069		390
	Insurance (Equ+Civ * 1.5%)	404	36	817	29	304	40
	Miscellaneous (Equ+Civ * 1%)	269	24	545	19	203	26
	Sub total	27,617	2,973	55,831	3,054	20,761	4,988
Total		**51,939**		**81,401**		**25,749**	
		42,986	8,953	73,419	7,981	20,761	4,988

And breakdowns of the estimated construction cost of each package are shown in Table 13.2-2, Table 13.2-3, Table 13.2-4, Table 13.2-5, and Table 13.2-6.

Table 13.2-2 Construction Cost Breakdown of the 400/230 kV Meghnaghat SS for Phase I

<Phase 1>

	Name	object	Nos	unit	unit price (1000USD)	price (1000USD)	note
1	**400kV Switchgear yard**						
1.1	Bus structure		1	set	1,140	1,140	
1.2	Insulator, clamp		1	set	1,040	1,040	
1.3	Bus conductor		2	set	240	480	
	Sub-total					**2,660**	
2	**230kV Switchgear Yard**						
2.1	230kV Gas Circuit Breaker with BCT	Bus*16	17	set	32	544	1for stby
2.2	230kV Disconnecting Switch	Bus*32,T/L*8, Tr*1	43	set	7	301	2for stby
2.3	230kV Voltage Transformer	Bus*2, T/L*8, Tr*1	11	set	14	157	
2.4	230kV Current Transformer	Bus*32, Tr*1	33	set	19	634	
2.5	230kV Lightening Arrestor	Tr*1, T/L*8	9	set	1	9	
2.6	Earth Switch	Bus*2	2	set	7	14	
2.7	Bus structure		1	set	800	800	
2.8	Insulator, clamp	Bus, circuits	1	set	520	520	
2.9	Bus conductor	Bus bar	2	set	120	240	
	Sub-total					**3,219**	
3	**Control Panel, Protection Relay**						
3.1	Control Panel		17	panel	40	680	
3.2	Protection Relay	230kV Transmission line	4	set	40	160	
3.3	Protection Relay	230kV Bus Protection	2	set	80	160	
3.4	SCADA system		1	LS	2,000	2,000	
3.5	RTU (for connection to NLDC)		1	set	90	90	
3.6	Optic fiber communication system		1	set	700	700	
3.7	PLC communication system		1	set	900	900	
3.8	DC Charger, battery		2	set	400	800	
3.9	Miscellaneous panels		1	set	1,000	1,000	
	Sub-total					**6,490**	
	Total					**12,369**	

Table 13.2-3 Construction Cost Breakdown of the 400/230 kV Meghnaghat SS for Phase II

<Phase 2>

	Name	object	Nos	unit	unit price (1000USD)	price (1000USD	note
1	**400kV Switchgear yard**						
1.1	400kV GCB	Bus*10, ShR*4	15	set	110	1,650	1for stby
1.2	400kV Disconnecting Switch with Earth Switch	T/L*4	4	set	13	52	
1.3	400kV Disconnecting Switch without Earth Switch	ShR*4, Bus*20, Tr*2	28	set	12	336	2for stby
1.4	Earth Switch	Bus*2	2	set	7	14	
1.5	400kV Voltage Transformer	Tr*2, Bus*2, T/L*4	8	set	90	720	
1.6	400kV Current Transformer	ShR*4, Bus*14, Tr*2	20	set	160	3,200	
1.7	400kV Lightening Arrestor	T/L*4, Tr*2	6	set	26	156	
1.8	400kV Line Trap with coupling Filter	for PLC	4	set	21	84	
	Sub-total					**6,212**	
2	**Transformer Yard**						
2.1	Main Transformer with On load tap changer		2	bank	4,590	9,180	
2.2	Stand-by Transformer		1	phase	1,530	1,530	
2.3	Reactor		4	bank	1,280	5,120	
2.4	33kV Switchgears		2	set	16	32	
2.5	Station Transformer		1	bank	360	360	
	Sub-total					**16,222**	
3	**Control Panel, Protection Relay**						
3.1	Control Panel		16	panel	40	640	
3.2	Protection Relay	400kV Transmission line	2	set	40	80	
3.3	Protection Relay	Transformer	2	set	35	70	
3.4	Protection Relay	400kV Reactor	4	set	35	140	
3.5	Protection Relay	400kV Bus Protection	2	set	93	186	
3.5	RTU (for connection to NLDC)		1	set	90	90	
3.6	Firefighting Equipment		1	set	300	300	
3.7	Miscellaneous panels		1	set	1,000	1,000	
	Sub-total					**2,506**	
4	**Temporary Tower, Restringing**						
3.1	Temporary Tower	For 230kVTL Switching	2	set	120	240	
3.2	Conductor, insulators		1	lot	40	40	
	Sub-total					**280**	
	Total					**25,220**	

Table 13.2-4 Construction Cost Breakdown of the 400/230 kV Madunaghat SS for Phase I

<Phase 1>

	Name	object	Nos	unit	unit price (1000USD)	price (1000USD)	note
1	**230kV Switchgear Yard**						
1.1	230kV GIS	T/L*6, Bus*4	10	set	450	4,500	
1.2	230kV Power Cable	T/L*6	6	feeder	320	1,920	length 200
1.3	Bus structure	Incoming line	1	set	620	620	
1.4	Insulator, clamp	Incoming line	1	set	520	520	
1.5	Station Transformer		1	bank	360	360	
1.6	33kV Switchgears	Temporary power	1	set	16	16	
	Sub-total					**7,936**	
2	**Control Panel, Protection Relay**						
2.1	Control Panel		10	panel	40	400	
2.2	Protection Relay	230kV Transmission Line	6	set	40	240	
2.3	Protection Relay	230kV Bus Protection	4	set	80	320	
2.4	SCADA system		1	LS	2,000	2,000	
2.5	RTU (for connection to NLDC)		1	set	90	90	
2.6	Optic fiber communication system		1	set	700	700	
2.7	PLC communication system		1	set	900	900	
2.8	DC Charger, battery		2	set	400	800	
2.9	Miscellaneous panels		1	set	1,000	1,000	
	Sub-total					**6,450**	
	Total					**14,386**	

Table 13.2-5 Construction Cost Breakdown of the 400/230 kV Madunaghat SS for Phase II

<Phase 2>

	Name	object	Nos	unit	unit price (1000USD)	price (1000USD	note
1	**400kV Switchgear yard**						
1.1	400kV GIS	T/L*4, Tr*3, Bustie*4	11	set	1,580	17,380	
1.2	400kV GCB	Reactor	4	set	110	440	
1.3	400kV Disconnecting Switch without Earth Switch	Reactor	4	set	80	320	
1.4	400kV Lightening Arrestor	Line	4	set	30	120	
1.5	400kV Line Trap with coupling Filter	for PLC	4	set	21	84	
1.6	DS, ES, VT, CT, LA, LT frame structure		8	set	18	144	
1.7	400kV GIB	(T/L-GIS)	4	set	800	3,200	
1.8	400kV power cable, terminals	For Transmission Lines	4	feeder	370	1,480	length 100m
1.9	Bus conductor	Reactor	4	span	100	400	
	Sub-total					**23,568**	
2	**Transformer Yard**						
2.1	Main Transformer with On load tap changer		3	bank	4,590	13,770	
2.2	Stand-by Transformer		1	phase	1,530	1,530	
2.3	Reactor		4	bank	1,280	5,120	
2.4	33kV Switchgears		2	set	16	32	
2.5	Station Transformer		1	bank	360	360	
2.6	400kV GIB	(GIS-Tr)	3	feeder	800	2,400	
2.7	230kV Power Cable	(GIS-Tr)	3	feeder	257	771	length 60m
	Sub-total					**23,983**	
3	**230kV Switchgear Yard**						
	230kV GIS	Tr*3	3	set	450	1,350	
	Sub-total					**1,350**	
4	**Control Panel, Protection Relay**						
4.1	Control Panel		21	panel	40	840	
4.2	Protection Relay	400kV Transmission line	4	set	40	160	
4.3	Protection Relay	Transformer	3	set	35	105	
4.4	Protection Relay	400kV Reactor	4	set	35	140	
4.5	Protection Relay	400kV Bus Protection	4	set	93	372	
4.6	RTU (for connection to NLDC)		1	set	90	90	
4.7	Firefighting Equipment		1	set	300	300	
4.8	Miscellaneous panels		1	set	1,000	1,000	
	Sub-total					**3,007**	
	Total					**51,908**	

Table 13.2-6 Construction Cost Breakdown of the 230/132 kV Madunaghat SS for Phase II

<Phase 2>

	Name	object	Nos	unit	unit price (1000USD)	price (1000USD)	note
1	**Transformer Yard**						
1.1	Main Transformer with On load tap changer		3	bank	1580	4740	
1.2	Stand-by Transformer		1	phase	527	527	
1.3	33kV Switchgears		3	set	20	60	
1.4	Station Transformer		2	bank	360	720	
1.5	230kV Power Cable	(Tr-GIS)*3	3	feeder	275	825	length 100m
1.6	132kV Power Cable	(Tr-GIS)*3	3	feeder	260	780	length 100m
	Sub-total					**7652**	
2	**230kV Switchgear Yard**						
2.1	230kV GIS	T/L*2, Tr*3, Bus*1	6	set	450	2700	
2.2	Steel structure	For incoming line	1	set	310	310	
2.3	Insulator, clamp	For incoming line	1	set	260	260	
2.4	230kV Power Cable	(Incoming line-GIS)*2	2	feeder	275	550	length 100
	Sub-total					**3820**	
3	**132kV Switchgear Yard**						
3.1	132kV GIS	Tr*3	3	set	350	1050	
	Sub-total					**1050**	
4	**Control Panel, Protection Relay**						
4.1	Control Panel		12	panel	40	480	
4.2	Protection Relay	Transformer	3	set	35	105	
4.3	Protection Relay	230kV Transmission Line	2	set	40	80	
4.4	Protection Relay	230kV Bus Protection	2	set	80	160	
4.5	SCADA system		1	LS	2000	2000	
4.6	RTU (for connection to NLDC)		1	set	180	180	
4.7	Optic fiber communication system		1	set	700	700	
4.8	DC Charger, battery		1	set	400	400	
4.9	Firefighting Equipment		1	set	300	300	
4.10	Miscellaneous panels		1	set	2000	2000	
	Sub-total					**6405**	
	Total					**18927**	

13.3 Total Cost of the Project

The conditions for estimation of the total Project cost are as follows:

(a) Land acquisition cost, compensation cost and environment monitoring cost are included in LC portion of the total cost.
(b) Consultant service fee is estimated in both FC and LC portions.
(c) Physical contingency for both FC and LC portions are estimated at 5.0% of each portion of the total construction cost and consultant service fee.
(d) Price escalation for FC portion is estimated at 2.0% of the total construction cost and consultant service fee, and, for LC portion, is estimated at 4.9% of the total construction cost and consultant service fee.

Table 13.3-1 Total Cost of the Project

[FC & Total: mil Japanese Yen (JPY), LC: mil TAKA]

Breakdown	FC	LC	Total
Transmission Line Cost	24,695	5,849	32,766
Substation Facilities Cost	14,813	1,700	17,158
Access Road	0	47	65
Price Escalation	3,726	1,730	6,113
Physical Contingency	2,162	466	2,805
Consulting Services Fee	1,153	609	1,994
Land Aquisition Cost	-	582	804
Administration Cost	-	2,236	3,085
VAT	-	1,560	2,153
Import Tax	-	9,868	13,618
Interest during construction	35	-	35
Total	46,583	24,647	80,595

13.4 Disbursement Schedule of the Costs

The commencement of work for the transmission lines' construction of phase 1 is planned for 2016 and the construction will be carried out in 34 months. As for phase 2, the commencement of work for the transmission lines' construction is planned for 2018 and the construction will be carried out in 30 months.

The assumed disbursement schedule of the construction costs for transmission lines and substations and consulting service fee is shown in Table 13.4-1.

Table 13.4-1 Disbursement Schedule for the Project

Item		2014		2015		2016		2017		2018		2019		2020		2021		2022	
		FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC
TL-1	400kV Meghnaghat-Madunaghat T/L and 230kV LILO T/L	0%	0%	0%	0%	25%	25%	30%	30%	30%	30%	10%	10%	5%	5%	0%	0%	0%	0%
TL-2	400kV Madunaghat-Matarbari T/L	0%	0%	0%	0%	0%	0%	0%	0%	10%	10%	35%	35%	35%	35%	15%	15%	5%	5%
SS-1	400kV Meghnaghat SS (JICA)	0%	0%	0%	0%	10%	30%	20%	30%	70%	40%	0%	0%	0%	0%	0%	0%	0%	0%
	400kV Meghnaghat SS (PGCB)	0%	0%	0%	0%	0%	0%	0%	0%	20%	20%	30%	20%	35%	20%	7%	25%	8%	15%
SS-2	400kV Madunaghat SS	0%	0%	0%	0%	2%	19%	5%	19%	27%	27%	23%	8%	30%	12%	8%	12%	5%	5%
TL-3	230kV Madunaghat-Old Madunaghat T/L	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	45%	45%	45%	45%	5%	5%	5%	5%
SS-3	Old Madunaghat SS	0%	0%	0%	0%	0%	0%	0%	0%	10%	30%	20%	30%	35%	20%	30%	15%	5%	5%
AR-1	Access Road	0%	0%	0%	30%	0%	50%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Land Acquisition	0%	0%	0%	50%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Consultanting Service	0%	0%	10%	9%	25%	24%	21%	19%	14%	15%	13%	12%	10%	12%	7%	9%	1%	1%

13.5 Estimated Cost of NLDC

Some of the detailed specifications of the Project components are now being discussed, therefore, only the tentative estimation of the Project Cost could be presented here.

For the replacement of NLDC's EMS/SCADA system, the following sub-projects must be done in advance. The following budget price represents necessary investment amount for hardware and relevant software, thus it does not include corresponding capacity building of NLDC opertors, the amendment and development of relevant operational regulations & rules , data collections of generator parameters, all of which can be conducted as another capacity building project.

Table 13.5-1 Tentative estimation of the Project Cost

	Description of sub-project	Target Facility	Budget (MUSD)
1	Automatic Frequency Control (AFC) Function test of Current System	NLDC EMS/SCADA system	1.4
2	Addition of remote monitoring and AGC function in Power Plants	Control panel and control units of Power Plants	0.35 /PP
3	Telecommunication Route	PGCB's Telecom route	0.05/PP
4	Replacement and Expansion of NLDC system	NLDC EMS/SCADA system	16.00*

[unit] PP: Power Plant

* Assumption of EMS/SCADA system replacement

- SCADA Systems in Master Station and Stand-by master station are replaced
- All necessary functions specified in 10.1.2 are included

Chapter 14
Economic and Financial Analysis of the Project

Chapter 14 Economic and Financial Analysis of the Project

14.1 Background and Methodology

The economic and financial analyses of the project are conducted by calculating the economic and financial internal rates of return, EIRR and FIRR.

The Project serves different purposes before and after the commissioning of the "Matarbari Ultra Super Critical Coal-fired Power Project" which is also funded by JICA and planned for commissioning in 2021. As the transmission line to be constructed under the project will have different uses in the periods before and after 2021, there are separate economic benefits for each period requiring separate cost-benefit analysis. At the same time, financial benefits will fully depend on the wheeling charge level and financial analysis will be conducted over the entire project lifetime.

Before the Matarbari Power Plant completion, power supply deficiency in the Chittagong region is crucial, whereas the Dhaka region has excess supply. Power from Dhaka is currently supplied to Chittagong along 230 kV double circuit transmission lines; however, with insufficient current conductor capacity, quick response in enhancing transmission line capacity is crucial. Therefore, the Project's objective before completion of the Matarbari Project is to supply Chittagong with the excess power supply of Dhaka.

At the time of the commissioning of the planned Matarbari Project, in contrast, power deficiency in Dhaka is expected to become very serious, while the Chittagong Region will have excess power supply. Therefore, the Project's objective after completion of the Matarbari Project is to supply high voltage power from Matarbari Power Plant to the Dhaka region in response to the expected supply deficiency there, by means of a 400 kV high-voltage transmission line.

During the first phase (2015 - 2019), the following components of the project will be completed:

- 400 kV transmission line between Meghnaghat SS and Madunaghat SS
- 230 kV Line in Line Out to 230 kV transmission line between Hathazari and Sikalbaha
- 230/132 kV Madunaghat Sub Station related 230 kV transmission line
- Switchyard for 400/230 kV SS in Meghnaghat
- Switchyard for 400/230 kV SS in Madunaghat

The implementation of the first phase will allow a gradual increase in the power transmission capacity from Dhaka to Chittagong, starting in 2017. The first Phase will be completed by 2019 and will make available an additional 353 MW of transmission capacity. For the purpose of economic analysis, this is considered to be Stage 1.

The second phase of the project will commence construction in 2018 and will be completed by 2021 to allow for power evacuation from the Matarbari Power Plant to Chittagong and Dhaka on the 400 kV transmission line. It is assumed that 60% of all electricity will be sent to Chittagong, and the remaining 40% to Dhaka.

In 2020 it is expected that the Dhaka region will start experiencing shortages of electricity and the 400 kV transmission line between Meghnaghat SS and Madunaghat SS will be used for supplying electricity from Chittagong to Dhaka. During this period the line will be utilized at 230 kV capacity. (This is considered to be Stage 2.) After the completion of the second phase of the project in 2021, it will be possible to utilize the new transmission line at its full capacity and evacuate power from Matarbari Power Plant and other power plants in the Chittagong Area to Chittagong and Dhaka, reaching a total capacity of 1,900 MW. (This is Stage 3 of the project.)

Both the economic and the financial analyses are conducted over the entire project lifetime of 35 years up to the year 2049. It is noted that, in this chapter, years signify the Bangladeshi financial year. For example, "year 2015" means "the financial year ending on 30 June 2015".

14.2 Economic Analysis

The economic analysis will concentrate on the overall impact of the project on the Bangladesh economy. As the implementation of the project is part of the implementation of an overall plan for increasing the power supply to the Dhaka and Chittagong areas, the project boundary will include not only the transmission line, but also the Matarbari power plant and the new power plant that is planned to be launched by Singaporean investors. In this way, economic costs will include both the costs of the transmission line construction and the costs of the new power plants, while the economic benefit will be costs of the scenario “without the project”. The economic analysis is conducted separately for the three stages described above.

The most conservative way to evaluate the economic benefits at each stage is through the Willingness-to-Pay (WTP), i.e. the minimum economic price at which consumers of the electricity from the new transmission line (i.e. distribution companies) are willing to purchase the additional amount of electricity. One approach to estimate the WTP is by establishing two alternative scenarios, a “high scenario” and a “low scenario” and taking the average value of both.

The “high scenario” is the generation cost by the alternative generation mix that would most probably occur in the absence of the project to deliver the same amount of electricity to the distribution companies in each of the stages. In the absence of the transmission line, the Matarbari power plant and the Singapore-funded power plant, the alternative will be generation by rental power plants. The average generation price for rental power plants (HFO and diesel-fired) was calculated as 19.23 BDT/kWh[13]. Natural gas-fired rental power plants were excluded as natural gas availability in Bangladesh is forecast to decrease in the future and new rental power plants are expected to use either natural gas of HFO.

The “low scenario” is the bulk supply tariff that users, i.e. distribution companies, are paying for the additionally delivered electricity in Chittagong and Dhaka respectively. In Dhaka, there are two distribution companies, DPDC and DESCO. Therefore, the Willingness to Pay is calculated as the average wholesale tariff for both companies, 5.37 BDT/kWh. In Chittagong, BPDB is in charge of electricity distribution and is paying an average wholesale tariff of 5.15125 BDT/kWh. These values will be used for the “low scenario”.

Concentrating only on the “high scenario” may result in an overestimate of the WTP, especially because the alternative generation mix includes rental power plants, which are paid higher tariff than other generation facilities. At the same time, looking only at the “low scenario” may underestimate the willingness to pay, as the level of bulk supply tariff is partially subsidized. Thus, the average value is deemed to be a conservative and realistic estimate of the WTP. The economic benefits for each of the three stages are described below.

[13] Based on a World Bank Study. Calculated as the weighted average (84:16) of HFO (17.95 BDT/kWh) and diesel power plant (25.9 BDT/kWh) generation costs.

1) 2017 – 2019: The construction of the new transmission lines and substations will allow for a gradual increase of electricity transmission capacity from Dhaka to Chittagong. In the absence of the project, the most plausible scenario for meeting the energy demand in Chittagong is the construction of new diesel and HFO-based rental power plants. Under the current Bangladesh Government policy, rental power plants receive higher than the average tariffs for power generation, making them also attractive business opportunities. In addition to that, rental power plants can be put into operation within a shorter period compared to other options, such as new large scale coal or natural gas fired power plants. Therefore, rental power plants are considered the most plausible short-term option. An average generation price for rental power plants (HFO, diesel and natural gas fired) was calculated as 8.93 BDT/kWh.

2) 2020: This is the period after the completion of Phase I, but before the start of the Mathabari Power plant operation. As this period coincides with a growing electricity shortage in Dhaka, the transmission line will start being used for transmission of electricity from the Chittagong area to the Chittagong (60%) and Dhaka (40%) areas. In this period, other alternatives to the project will emerge in addition to the rental power plants. As already explained at the beginning of this report, in 2010 the Government of Bangladesh has launched the rental power plant program as a short-term solution for meeting the increasing demand for power. However, a number of new large-scale power plants are expected to be put into operation by 2020, which will virtually mean a reduction in the number of new rental power plants. Moreover, rental power plants are a much more costly solution to meeting energy demand in Bangladesh, compared to other power plants, so they cannot be a plausible alternative in the medium to long term. Therefore, in the absence of the Project, a new generation mix in the Chittagong and Dhaka areas is considered to be the alternative to the project.

   The generation mix may consist of a variety of power plants; however, the most conservative way to evaluate this new generation mix in the absence of the project is through the WTP, as the minimum price at which the additional amount of electricity can be sold. As this is a transmission project, instead of using the electricity tariff paid by end users, the wholesale tariff paid by distribution companies to BPDB will be used. In Dhaka, there are two distribution companies, DPDC and DESCO. Therefore, the WTP is calculated as the average wholesale tariff for both companies, 5.37 BDT/kWh. In Chittagong, BPDB is in charge of electricity distribution and is paying an average wholesale tariff of 5.15125 BDT/kWh.

3) (2021 -) The third stage is the stage after the construction of the Matarbari power plant. In the project case, the generated electricity will be evacuated through the 400 kV transmission line to Dhaka and Chittagong. The economic costs of the project will be the underutilization of the Matarbari power plant, i.e. its construction costs, as well as the need for construction of new power plants in the Chittagong and Dhaka areas to meet the growing power demand. For the sake of conservativeness, the economic benefit in this stage of the project will be also assessed using the WTP (5.37 BDT/kWh for Dhaka and 5.15125 BDT/kWh for Chittagong).

A summary of the economic benefits for each stage is provided below:

Table 14.2-1 Economic Benefits of the Project

Stage	Economic Benefits
2015 - 2019	Willingness To Pay 12.19 BDT/kWh
2020	Willingness to Pay Dhaka: 12.30 BDT/kWh Chittagong: 12.19 BDT/kWh
2021 -	Willingness to Pay Dhaka: 12.30 BDT/kWh Chittagong: 12.19 BDT/kWh

(Source: JICA Survey Team)

Based on the above and the transmission capacity availability, the economic benefits for each stage are estimated. As the payments to PGCB are made based on the amount of electricity delivered to distribution companies, auxiliary electricity consumption and transmission losses are also taken into consideration. The newly added transmission capacity is calculated as per the table below.

Table 14.2-2 Transmission Capacity Availability during the Project Lifetime

Year	Capacity	Power Transmission					
		Total	Dhaka - Chittagon (230 kV)	Chittagon - Dhaka (230 kV)		Chittagon - Dhaka (400 kV)	
			To Dhaka	*To Chittagon*	*To Dhaka*	*To Chittagon*	*To Dhaka*
	MW	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**
2015	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0
2017	177	1 085 364	1 085 364	0	0	0	0
2018	260	1 594 320	1 594 320	0	0	0	0
2019	353	2 161 530	2 161 530	0	0	0	0
2020	450	2 759 400	0	1 655 640	1 103 760	0	0
2021	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2022	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2023	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2024	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2025	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2026	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2027	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2028	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2029	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2030	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2031	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2032	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2033	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2034	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2035	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2036	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2037	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2038	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2039	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2040	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2041	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2042	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2043	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2044	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2045	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2046	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2047	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2048	1 900	11 650 800	0	0	0	6 990 480	4 660 320
2049	1 900	11 650 800	0	0	0	6 990 480	4 660 320

(Source: JICA Survey Team)

Thus, the economic benefit is calculated as follows:

Table 14.2-3 Economic Benefit of the Project

Year	Economic Benefit						
	Dhaka - Chittagon (230 kV)	Chittagon - Dhaka (230 kV)		Chittagon - Dhaka (400 kV)		Total	
	To Dhaka	*To Chittagon*	*To Dhaka*	*To Chittagon*	*To Dhaka*		
	million BDT	**million BGT**	**million BDT**	**million BDT**	**million BDT**	**million BDT**	**million JPY**
2015	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0
2017	12,076	0	0	0	0	12,076	18,598
2018	17,739	0	0	0	0	17,739	27,319
2019	24,051	0	0	0	0	24,051	37,038
2020	0	18,324	12,323	0	0	30,647	47,196
2021	0	0	0	88,419	59,463	147,882	227,739
2022	0	0	0	88,419	59,463	147,882	227,739
2023	0	0	0	88,419	59,463	147,882	227,739
2024	0	0	0	88,419	59,463	147,882	227,739
2025	0	0	0	88,419	59,463	147,882	227,739
2026	0	0	0	88,419	59,463	147,882	227,739
2027	0	0	0	88,419	59,463	147,882	227,739
2028	0	0	0	88,419	59,463	147,882	227,739
2029	0	0	0	88,419	59,463	147,882	227,739
2030	0	0	0	88,419	59,463	147,882	227,739
2031	0	0	0	88,419	59,463	147,882	227,739
2032	0	0	0	88,419	59,463	147,882	227,739
2033	0	0	0	88,419	59,463	147,882	227,739
2034	0	0	0	88,419	59,463	147,882	227,739
2035	0	0	0	88,419	59,463	147,882	227,739
2036	0	0	0	88,419	59,463	147,882	227,739
2037	0	0	0	88,419	59,463	147,882	227,739
2038	0	0	0	88,419	59,463	147,882	227,739
2039	0	0	0	88,419	59,463	147,882	227,739
2040	0	0	0	88,419	59,463	147,882	227,739
2041	0	0	0	88,419	59,463	147,882	227,739
2042	0	0	0	88,419	59,463	147,882	227,739
2043	0	0	0	88,419	59,463	147,882	227,739
2044	0	0	0	88,419	59,463	147,882	227,739
2045	0	0	0	88,419	59,463	147,882	227,739
2046	0	0	0	88,419	59,463	147,882	227,739
2047	0	0	0	88,419	59,463	147,882	227,739
2048	0	0	0	88,419	59,463	147,882	227,739
2049	0	0	0	44,210	29,731	73,941	113,870

(Source: JICA Survey Team)

The economic costs of the project include the costs of the transmission line project, as well as the costs of the Matarbari Power Plant and the Singapore investors-funded power plant, and in the period up to 2019 – the generation costs of existing power plants. The costs of Matarbari power plant are based on the feasibility study for that project, while the costs for the other power plant are estimated based on the assumptions of the Matarbari project. The average generation cost of existing power plants (5.36 BDT/kWh) is based on a report14 by the International Institute of Sustainable Development for fiscal year 2012. For the Matarbari – Megnaghat transmission line project, the costs are calculated based on the actual construction costs of the project net of VAT, import duties, escalation and other transfer payments, as well as the project O&M costs. O&M cost are estimated from the overall O&M costs level of PGCB. Based on the annual reports of the company for the period 2010-11 to 2012-13, it was estimated that the operating (transmission) expenses are approximately 1.9% of the total non-current assets (mainly transmission lines and substations), as shown below. This value is also close to

[14] https://www.iisd.org/gsi/sites/default/files/ffs_stakeholders_bangladesh.pdf

the O&M costs of some Japanese transmission lines operators, thus they are considered to be a good approximation of the actual O&M costs.

Table 14.2-4 Calculation of O&M Costs

Unit: BDT

Financial Year	2009-10	2010-11	2011-12	2012-13
Fixed Assets	51,156,354,076	59,226,762,780	74,410,438,008	90,629,598,577
Expenses				
Transmission Expenses	3,331,724,343	4,574,983,949	4,320,538,770	4,718,696,940
Depreciation	2,459,073,279	2,588,731,615	2,903,245,042	3,106,738,900
Bad debt	0	5,439,000	0	0
Cash defalcation		637,536,768		
Total	872,651,064	1,343,276,566	1,417,293,728	1,611,958,040
O&M Costs	1.71%	2.27%	1.90%	1.78%
Average O&M				1.91%

(Source: PGCB Annual Reports)

Therefore, for the purpose of this analysis, O&M costs of the project are assumed to be 1.91% of the construction costs.

Following the established practice in Bangladesh, all costs used in the economic analysis are multiplied by standard conversion factors (SCF) as shown in the table below.

Table 14.2-5 O&M Cost Rate and Standard Conversion Factors

Item	Value	Unit	Source
O&M Cost Rate	1.9%	percent	Calculated
SCF LC	0.82		PGCB
SCF FC	1.29		PGCB
SCF O&M	1.34		PGCB

The total economic costs of the project are estimated as follows:

Table 14.2-6 Economic Costs of the Project

Unit: M JPY

	Generation Costs (Existsing plants)	Matarbari Power Plant (Based on Matarbari FF)			Power Plant (Singapore) (Estimated based on Matarbari FS)			Transmission of this Project (Matarbari to Megnaghat)							Total
Item	Total Costs (M JPY)	Capital Cost (M BDT)	OM Cost (M BDT)	Total cost (M JPY)	Capital Cost (M BDT)	OM Cost (M BDT)	Total cost (M JPY)	Capital Costs (FC)	Capital Costs (FC) at border price	Capital Costs (LC) in M BDT	Capital Costs (LC)	Capital Costs (LC) at border price	O&M Costs	O&M Costs at border price	
2014	0.00	360.26	0.00	554.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	554.80
2015	0.00	6,603.54	0.00	10,169.46	257.25	0.00	396.17	102.15	131.30	316.18	486.91	399.27	0.00	0.00	11,096.19
2016	0.00	56,681.25	0.00	87,289.12	507.50	0.00	781.55	5,332.63	6,854.28	1,612.04	2,482.54	2,035.69	0.00	0.00	96,960.64
2017	8,175.58	30,652.62	0.00	47,205.04	9,522.33	0.00	14,664.39	6,627.12	8,518.15	1,506.04	2,319.30	1,901.83	331.40	442.52	80,907.51
2018	12,009.33	50,317.01	0.00	77,488.19	8,061.67	0.00	12,414.97	11,186.01	14,377.90	1,926.69	2,967.10	2,433.02	601.72	803.48	119,526.88
2019	16,281.87	55,149.15	0.00	84,929.69	15,443.17	0.00	23,782.48	8,615.42	11,073.81	1,366.12	2,103.82	1,725.13	806.46	1,076.87	138,869.85
2020	0.00	34,990.44	0.00	53,885.27	30,233.00	0.00	46,558.82	8,857.46	11,384.92	1,161.55	1,788.79	1,466.81	1,009.80	1,348.39	114,644.21
2021	0.00	34,631.10	0.00	53,331.89	27,277.83	0.00	42,007.86	2,968.46	3,815.50	517.21	796.51	653.14	1,081.71	1,444.41	101,252.80
2022	0.00	61,122.70	0.00	94,128.96	26,814.08	0.00	41,293.69	1,271.60	1,634.45	188.65	290.52	238.23	1,111.55	1,484.25	138,779.58
2023	0.00	9,793.84	0.00	15,082.52	26,814.08	0.00	41,293.69	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	57,860.46
2024	0.00	1,047.09	16,933.00	27,689.33	19,343.92	9,877.58	45,001.11	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	74,174.70
2025	0.00	815.55	32,947.00	51,994.32	0.00	19,219.08	29,597.39	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	83,075.96
2026	0.00	0.00	34,073.00	52,472.42	0.00	19,875.92	30,608.91	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	84,565.59
2027	0.00	0.00	34,353.00	52,903.62	0.00	20,039.25	30,860.45	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	85,248.32
2028	0.00	0.00	33,787.00	52,031.98	0.00	19,709.08	30,351.99	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	83,868.22
2029	0.00	0.00	34,067.00	52,463.18	0.00	19,872.42	30,603.52	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	84,550.96
2030	0.00	0.00	37,737.00	58,114.98	0.00	22,013.25	33,900.41	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	93,499.64
2031	0.00	0.00	38,017.00	58,546.18	0.00	22,176.58	34,151.94	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	94,182.37
2032	0.00	0.00	34,907.00	53,756.78	0.00	20,362.42	31,358.12	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	86,599.16
2033	0.00	0.00	34,987.00	53,879.98	0.00	20,409.08	31,429.99	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	86,794.22
2034	0.00	0.00	36,113.00	55,614.02	0.00	21,065.92	32,441.51	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	89,539.79
2036	0.00	0.00	35,827.00	55,173.58	0.00	20,899.08	32,184.59	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	88,842.42
2037	0.00	0.00	36,107.00	55,604.78	0.00	21,062.42	32,436.12	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	89,525.16
2038	0.00	0.00	42,405.00	65,303.70	0.00	24,736.25	38,093.83	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	104,881.78
2039	0.00	0.00	42,685.00	65,734.90	0.00	24,899.58	38,345.36	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	105,564.51
2040	0.00	0.00	36,947.00	56,898.38	0.00	21,552.42	33,190.72	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	91,573.36
2041	0.00	0.00	37,227.00	57,329.58	0.00	21,715.75	33,442.26	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	92,256.09
2042	0.00	0.00	38,353.00	59,063.62	0.00	22,372.58	34,453.78	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	95,001.65
2043	0.00	0.00	38,633.00	59,494.82	0.00	22,535.92	34,705.31	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	95,684.39
2044	0.00	0.00	38,067.00	58,623.18	0.00	22,205.75	34,196.86	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	94,304.29
2045	0.00	0.00	38,347.00	59,054.38	0.00	22,369.08	34,448.39	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	94,987.02
2046	0.00	0.00	42,017.00	64,706.18	0.00	24,509.92	37,745.27	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	103,935.71
2047	0.00	0.00	42,297.00	65,137.38	0.00	24,673.25	37,996.81	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	104,618.44
2048	0.00	0.00	38,551.00	59,368.54	0.00	22,488.08	34,631.65	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	95,484.44
2049	0.00	0.00	19,722.00	30,371.88	0.00	11,504.50	17,716.93	0.00	0.00	0.00	0.00	0.00	1,111.55	1,484.25	49,573.06

(Source: JICA Survey Team)

Based on the above results, the EIRR is calculated to be 20.33% as shown in the next table.

Table 14.2-7 Economic IRR Calculations

Year	Generation Costs (Existsing plants)	Matarbari Power Plant (Based on Matarbari FF)		Power Plant (Singapore) (Estimated based on Matarbari FS)		Transmission of this Project (Matarbari to Megnaghat)		Total Costs	Benefit	Net Benefit
	Total Costs	Construction Costs	O&M Costs	Construction Costs	O&M Costs	Construction Costs	O&M Costs			
2014	0.00	554.80	0.00	0.00	0.00	0.00	0.00	554.80	0	-554.80
2015	0.00	10,169.46	0.00	396.17	0.00	530.57	0.00	11,096.19	0	-11,096.19
2016	0.00	87,289.12	0.00	781.55	0.00	8,889.97	0.00	96,960.64	0	-96,960.64
2017	8,175.58	47,205.04	0.00	14,664.39	0.00	10,419.98	442.52	80,907.51	18,598	-62,309.72
2018	12,009.33	77,488.19	0.00	12,414.97	0.00	16,810.92	803.48	119,526.88	27,319	-92,208.10
2019	16,281.87	84,929.69	0.00	23,782.48	0.00	12,798.94	1,076.87	138,869.85	37,038	-101,831.88
2020	0.00	53,885.27	0.00	46,558.82	0.00	12,851.73	1,348.39	114,644.21	47,196	-67,448.30
2021	0.00	53,331.89	0.00	42,007.86	0.00	4,468.63	1,444.41	101,252.80	227,739	126,486.20
2022	0.00	94,128.96	0.00	41,293.69	0.00	1,872.68	1,484.25	138,779.58	227,739	88,959.42
2023	0.00	15,082.52	0.00	41,293.69	0.00	0.00	1,484.25	57,860.46	227,739	169,878.54
2024	0.00	1,612.51	26,076.82	29,789.63	15,211.48	0.00	1,484.25	74,174.70	227,739	153,564.31
2025	0.00	1,255.94	50,738.38	0.00	29,597.39	0.00	1,484.25	83,075.96	227,739	144,663.04
2026	0.00	0.00	52,472.42	0.00	30,608.91	0.00	1,484.25	84,565.59	227,739	143,173.42
2027	0.00	0.00	52,903.62	0.00	30,860.45	0.00	1,484.25	85,248.32	227,739	142,490.68
2028	0.00	0.00	52,031.98	0.00	30,351.99	0.00	1,484.25	83,868.22	227,739	143,870.78
2029	0.00	0.00	52,463.18	0.00	30,603.52	0.00	1,484.25	84,550.96	227,739	143,188.05
2030	0.00	0.00	58,114.98	0.00	33,900.41	0.00	1,484.25	93,499.64	227,739	134,239.36
2031	0.00	0.00	58,546.18	0.00	34,151.94	0.00	1,484.25	94,182.37	227,739	133,556.63
2032	0.00	0.00	53,756.78	0.00	31,358.12	0.00	1,484.25	86,599.16	227,739	141,139.85
2033	0.00	0.00	53,879.98	0.00	31,429.99	0.00	1,484.25	86,794.22	227,739	140,944.78
2034	0.00	0.00	55,614.02	0.00	32,441.51	0.00	1,484.25	89,539.79	227,739	138,199.22
2035	0.00	0.00	56,045.22	0.00	32,693.05	0.00	1,484.25	90,222.52	227,739	137,516.48
2036	0.00	0.00	55,173.58	0.00	32,184.59	0.00	1,484.25	88,842.42	227,739	138,896.58
2037	0.00	0.00	55,604.78	0.00	32,436.12	0.00	1,484.25	89,525.16	227,739	138,213.85
2038	0.00	0.00	65,303.70	0.00	38,093.83	0.00	1,484.25	104,881.78	227,739	122,857.22
2039	0.00	0.00	65,734.90	0.00	38,345.36	0.00	1,484.25	105,564.51	227,739	122,174.49
2040	0.00	0.00	56,898.38	0.00	33,190.72	0.00	1,484.25	91,573.36	227,739	136,165.65
2041	0.00	0.00	57,329.58	0.00	33,442.26	0.00	1,484.25	92,256.09	227,739	135,482.91
2042	0.00	0.00	59,063.62	0.00	34,453.78	0.00	1,484.25	95,001.65	227,739	132,737.35
2043	0.00	0.00	59,494.82	0.00	34,705.31	0.00	1,484.25	95,684.39	227,739	132,054.62
2044	0.00	0.00	58,623.18	0.00	34,196.86	0.00	1,484.25	94,304.29	227,739	133,434.71
2045	0.00	0.00	59,054.38	0.00	34,448.39	0.00	1,484.25	94,987.02	227,739	132,751.98
2046	0.00	0.00	64,706.18	0.00	37,745.27	0.00	1,484.25	103,935.71	227,739	123,803.30
2047	0.00	0.00	65,137.38	0.00	37,996.81	0.00	1,484.25	104,618.44	227,739	123,120.56
2048	0.00	0.00	59,368.54	0.00	34,631.65	0.00	1,484.25	95,484.44	227,739	132,254.56
2049	0.00	0.00	30,371.88	0.00	17,716.93	0.00	1,484.25	49,573.06	113,870	64,296.44
EIRR								**20.33%**		

(Source: JICA Survey Team)

The high economic IRR reflects the existing economic inefficiencies in the Bangladesh power sector that the project is aiming to address, namely insufficient transmission and generation capacity that is currently compensated for by costly HFO and diesel based rental power plants.

14.2.1 EIRR Sensitivity Analysis

Sensitivity analysis was conducted for the EIRR by varying the Capital Costs and O&M Costs of the various costs components. The results are presented in the table below.

Table 14.2-8 EIRR Sensitivity Analysis

Variable	Change	EIRR
Construction Costs	-10%	22.68%
Construction Costs	10%	18.35%
O&M Costs	-10%	20.93%
O&M Costs	10%	19.71%

(Source: JICA Survey Team)

14.3 Financial Analysis

The financial IRR (FIRR) of the project is calculated as part of the financial analysis. The costs and benefits (financial revenue) are estimated taking into consideration the actual project costs, escalation, VAT, import duties and others as per the JICA Common Terms of Appraisal. For details of the costs estimates, please refer to the preceding section.

Table 14.3-1 Common Terms of Appraisal

Common terms for Appraisal

Name of Local Currency

			Taka	
(1)	Yen/$	US$ 1 =	119	Yen
(2)	LC/$	US$ 1 =	77.5	Taka
(3)	Yen/Taka	Taka 1 =	1.54	Yen

Price Escalation

(1)	FC	2.0%	LC	4.9%

Physical Contingency

Construction	5.0%	Consultant	5.0%

Base Year for Cost Estimation: 2014/9

Schedule

Start	2014/11	End	2024/02

Billing Rate of Consultant

	FC Yen	LC Taka
Pro-(A)	2,895,000	0
Pro-(B)	0	350,000
Supporting Staff	0	100,000

Others

Rate of Tax

VAT	15.0%	Import Tax	30.0%

Rate of Administration Cost

5.0%

Rate of Interest During Construction

Construction	0.01%	Consultant	0.01%

Rate of Commitment Charges

0.0%

Payment Method for Interest during construction and Commitment charge

loan-covered

Fiscal Year

Jul - Jun

(Source: JICA)

The only Source: of revenue for PGCB is wheeling charges, which currently stay at 0.2291 BDT/kWh. Based on that and the annual transmission capacity availability, the financial revenue of the project is estimated as follows:

Table 14.3-2 Financial Revenue of the Project

Year	Capacity	Load Factor	Transmission Loss	Auxiliary Electricity Consumption	Power Transmission Volume						Financial Benefit	
					Total	Dhaka - Chittagon (230 kV)	Chittagon - Dhaka (230 kV)		Chittagon - Dhaka (400 kV)			
						To Dhaka	*To Chittagon*	*To Dhaka*	*To Chittagon*	*To Dhaka*		
	MW	**-**	**%**	**%**	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**MWh**	**million BDT**	**million JPY**
2015	0				0	0	0	0	0	0	0	0
2016	0				0	0	0	0	0	0	0	0
2017	177	0.7	2.92%	6.00%	990,451	990,451	0	0	0	0	227	349
2018	260	0.7	2.92%	6.00%	1,454,900	1,454,900	0	0	0	0	333	513
2019	353	0.7	2.92%	6.00%	1,972,509	1,972,509	0	0	0	0	452	696
2020	450	0.7	2.92%	6.50%	2,504,702	0	1,502,821	1,001,881	0	0	574	884
2021	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2022	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2023	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2024	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2025	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2026	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2027	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2028	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2029	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2030	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2031	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2032	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2033	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2034	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2035	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2036	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2037	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2038	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2039	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2040	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2041	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2042	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2043	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2044	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2045	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2046	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2047	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2048	1,900	0.8	2.92%	6.50%	12,086,180	0	0	0	7,251,708	4,834,472	2,769	4,264
2049	950	0.8	2.92%	6.50%	6,043,090	0	0	0	3,625,854	2,417,236	1,384	2,132

(Source: JICA Survey Team)

The costs consist of the project construction costs and the O&M costs of the project. O&M costs are calculated as per the assumptions in the preceding section, i.e. 1.9 % of the construction costs. The total financial cost estimates are provided below:

Table 14.3-3 Financial Costs

Unit: M JPY

Item	Capital Costs	O&M Costs	Total
2014	0.00	0.00	0.00
2015	692.83	0.00	692.83
2016	11,154.67	0.00	11,154.67
2017	13,272.85	479.80	13,752.65
2018	21,645.00	893.22	22,538.22
2019	16,810.01	1,214.29	18,024.30
2020	17,112.03	1,541.13	18,653.16
2021	6,216.79	1,659.87	7,876.66
2022	2,650.93	1,710.50	4,361.43
2023	5.85	1,710.61	1,716.47
2024	5.85	1,710.73	1,716.58
2025	0.00	1,710.73	1,710.73
2026	0.00	1,710.73	1,710.73
2027	0.00	1,710.73	1,710.73
2028	0.00	1,710.73	1,710.73
2029	0.00	1,710.73	1,710.73
2030	0.00	1,710.73	1,710.73
2031	0.00	1,710.73	1,710.73
2032	0.00	1,710.73	1,710.73
2033	0.00	1,710.73	1,710.73
2034	0.00	1,710.73	1,710.73
2036	0.00	1,710.73	1,710.73
2037	0.00	1,710.73	1,710.73
2038	0.00	1,710.73	1,710.73
2039	0.00	1,710.73	1,710.73
2040	0.00	1,710.73	1,710.73
2041	0.00	1,710.73	1,710.73
2042	0.00	1,710.73	1,710.73
2043	0.00	1,710.73	1,710.73
2044	0.00	1,710.73	1,710.73
2045	0.00	1,710.73	1,710.73
2046	0.00	1,710.73	1,710.73
2047	0.00	1,710.73	1,710.73
2048	0.00	1,710.73	1,710.73
2049	0.00	1,710.73	1,710.73

(Source: JICA Survey Team)

Based on the above, the FIRR is estimated.

Table 14.3-4 FIRR Estimation at 0.2291 BDT/kWh

Year	Construction Costs	O&M Costs	Total Costs	Revenue	Net Benefit
2015	692.83	0.00	692.83	0.00	-692.83
2016	11,154.67	0.00	11,154.67	0.00	-11,154.67
2017	13,272.85	479.80	13,752.65	349.45	-13,403.20
2018	21,645.00	893.22	22,538.22	513.31	-22,024.91
2019	16,810.01	1,214.29	18,024.30	695.93	-17,328.37
2020	17,112.03	1,541.13	18,653.16	883.69	-17,769.47
2021	6,216.79	1,659.87	7,876.66	4,264.17	-3,612.49
2022	2,650.93	1,710.50	4,361.43	4,264.17	-97.26
2023	5.85	1,710.61	1,716.47	4,264.17	2,547.71
2024	5.85	1,710.73	1,716.58	4,264.17	2,547.59
2025	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2026	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2027	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2028	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2029	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2030	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2031	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2032	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2033	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2034	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2035	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2036	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2037	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2038	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2039	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2040	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2041	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2042	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2043	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2044	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2045	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2046	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2047	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2048	0.00	1,710.73	1,710.73	4,264.17	2,553.45
2049	0.00	1,710.73	1,710.73	2,132.09	421.36

(Source: JICA Survey Team)

It can be confirmed from the above calculations that with the current wheeling charge level of 0.2291 BDT/kWh, the FIRR cannot be defined, showing that the project is not financially viable.

Discussions with PGCB confirmed that the current wheeling charge level is not sustainable, as it cannot cover PGCB's operational costs. As it can be further confirmed from the analysis of the financial statements in the ensuing section, the cost-revenue gap in PGCB is often covered by additional equity provided by the government of Bangladesh, without raising the wheeling charge.

To rectify that situation, PGCB has recently submitted and application to BERC for an increase in the wheeling charges to a level of 0.38 BDT/kWh in line with BERCs tariff rules. Using this newly proposed wheeling charge value, the FIRR is estimated to be 3.57%, which is, however, far below the PGCB internal benchmark of 12%.

Table 14.3-5 FIRR Estimation at 0.38 BDT/kWh

Year	Construction Costs	O&M Costs	Total Costs	Revenue	Net Benefit
2015	692.83	0.00	692.83	0.00	-692.83
2016	11,154.67	0.00	11,154.67	0.00	-11,154.67
2017	13,272.85	479.80	13,752.65	579.61	-13,173.04
2018	21,645.00	893.22	22,538.22	851.41	-21,686.81
2019	16,810.01	1,214.29	18,024.30	1,154.31	-16,869.99
2020	17,112.03	1,541.13	18,653.16	1,465.75	-17,187.41
2021	6,216.79	1,659.87	7,876.66	7,072.83	-803.83
2022	2,650.93	1,710.50	4,361.43	7,072.83	2,711.40
2023	5.85	1,710.61	1,716.47	7,072.83	5,356.37
2024	5.85	1,710.73	1,716.58	7,072.83	5,356.25
2025	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2026	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2027	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2028	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2029	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2030	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2031	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2032	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2033	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2034	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2035	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2036	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2037	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2038	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2039	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2040	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2041	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2042	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2043	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2044	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2045	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2046	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2047	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2048	0.00	1,710.73	1,710.73	7,072.83	5,362.11
2049	0.00	1,710.73	1,710.73	3,536.42	1,825.69

(Source: JICA Survey Team)

In order to make the project financially viable, it is proposed to introduce an annual wheeling charge indexation of at least 6%, once the wheeling charges are raised to 0.38 BDT/kWh. This will result in an FIRR of 12.88% as shown in the table below.

Table 14.3-6 FIRR Estimation at 0.38 BDT/kWh and 6% Annual Indexation

Year	Construction Costs	O&M Costs	Total Costs	Revenue	Net Benefit
2015	692.83	0.00	692.83	0.00	-692.83
2016	11,154.67	0.00	11,154.67	0.00	-11,154.67
2017	13,272.85	479.80	13,752.65	651.25	-13,101.40
2018	21,645.00	893.22	22,538.22	1,014.04	-21,524.18
2019	16,810.01	1,214.29	18,024.30	1,457.29	-16,567.01
2020	17,112.03	1,541.13	18,653.16	1,961.51	-16,691.65
2021	6,216.79	1,659.87	7,876.66	10,032.95	2,156.29
2022	2,650.93	1,710.50	4,361.43	10,634.93	6,273.49
2023	5.85	1,710.61	1,716.47	11,273.02	9,556.55
2024	5.85	1,710.73	1,716.58	11,949.40	10,232.82
2025	0.00	1,710.73	1,710.73	12,666.37	10,955.64
2026	0.00	1,710.73	1,710.73	13,426.35	11,715.62
2027	0.00	1,710.73	1,710.73	14,231.93	12,521.20
2028	0.00	1,710.73	1,710.73	15,085.84	13,375.12
2029	0.00	1,710.73	1,710.73	15,991.00	14,280.27
2030	0.00	1,710.73	1,710.73	16,950.46	15,239.73
2031	0.00	1,710.73	1,710.73	17,967.48	16,256.76
2032	0.00	1,710.73	1,710.73	19,045.53	17,334.81
2033	0.00	1,710.73	1,710.73	20,188.26	18,477.54
2034	0.00	1,710.73	1,710.73	21,399.56	19,688.83
2035	0.00	1,710.73	1,710.73	22,683.53	20,972.81
2036	0.00	1,710.73	1,710.73	24,044.54	22,333.82
2037	0.00	1,710.73	1,710.73	25,487.22	23,776.49
2038	0.00	1,710.73	1,710.73	27,016.45	25,305.72
2039	0.00	1,710.73	1,710.73	28,637.44	26,926.71
2040	0.00	1,710.73	1,710.73	30,355.68	28,644.96
2041	0.00	1,710.73	1,710.73	32,177.02	30,466.30
2042	0.00	1,710.73	1,710.73	34,107.65	32,396.92
2043	0.00	1,710.73	1,710.73	36,154.11	34,443.38
2044	0.00	1,710.73	1,710.73	38,323.35	36,612.63
2045	0.00	1,710.73	1,710.73	40,622.75	38,912.03
2046	0.00	1,710.73	1,710.73	43,060.12	41,349.39
2047	0.00	1,710.73	1,710.73	45,643.72	43,933.00
2048	0.00	1,710.73	1,710.73	48,382.35	46,671.62
2049	0.00	1,710.73	1,710.73	25,642.64	23,931.92

(Source: JICA Survey Team)

The financial analysis demonstrates that the project is not financially viable under the current level of wheeling charges and, unless they are increased, it cannot be implemented on a business as usual basis.

An alternative approach for evaluating the FIRR is by calculating the Weighted Average Cost of Capital (WACC) of PGCB. This approach is just presented for reference, as PGCB applies a different benchmark approach.

The main sources of funding for PGCB is debt and equity. For the calculation of the WACC, debt and equity data for fiscal year 2012-13 is used. For simplification, the relending rate of 4% prescribed by the Finance Division is applied for the cost of debt, while for equity the costs of 10% is used, as applied in similar analysis by the ADB15. The costs of capital are adjusted for inflation. The results are presented below.

[15] http://www.adb.org/sites/default/files/linked-documents/42378-014-ban-oth-02.pdf

Table 14.3-7 WACC for PGCB

	Equity	Debt
Amount (BDT)	29,356,947,170	65,212,625,989
Nominal Costs	10%	4%
Weighting	31%	69%
Income Tax Rate	37.5%	37.5%
Tax-Adjusted Nominal Costs	6.3%	2.5%
Weighted component	1.94%	1.72%
WACC	**3.66%**	

(Source: JICA Survey Team)

It is evident that even using WACC as a benchmark does not render the project financially feasible under the current wheeling charge or the proposed increased wheeling charge level.

14.4 Summary of the Economic and Financial Analyses

The results of the economic and financial analyses are summarized below.

Table 14.4-1 Summary of the Economic and Financial Analyses

	Economic Analysis	Financial Analysis
Project Lifetime	35 Years	
Costs	Project Cost, Generation Costs of Existing Power Plants and Newly Built Plants, Operation and Maintenance Cost (adjusted at border prices)	Project Cost, Operation and Maintenance Cost, Tax and Duties, Administration Costs, Depreciation
Benefits	Stage 1 (2014 - 2019) – Willingness to Pay Stage 2 (2020) - Willingness to Pay Stage 3 (2021 - 2048) - Willingness to Pay	Wheeling charge (at 0.38 BDT/kWh with an annual indexation of 6 %)
IRR	EIRR = 20.33 %	FIRR = 12.88 %

(Source: JICA Survey Team)

It can be concluded that the project is not financially viable under the current tariff, due to the low level of wheeling charges. At the same time, the project brings very high economic benefits by providing means for efficient electric energy transmission to the Dhaka and Chittagong areas and substituting costly rental power and on-site diesel generation, thus resulting in an EIRR = 20.33%.

14.5 Estimation of the Greenhouse Gas (GHG) Emission Reductions from the Project

14.5.1 Methodology

GHG emission reduction calculations are conducted within the boundary of the project by comparing the GHG emissions of the project in the baseline (a hypothetical scenario describing the situation without the project) and in the project scenario. For the purpose of the GHG emission reduction analysis, project boundary will be defined as the geographic boundary of the project transmission line, the power generation facilities connected to the transmission line and the end users of transmission line services, i.e. the distribution companies and individual large scale users, if any.

Similar to the economic and financial analysis, GHG emission reduction analysis is conducted for each of the following three stages:

1) 2017 – 2019: The construction of the new transmission lines and substations will allow for a gradual increase of electricity transmission capacity from Dhaka to Chittagong

2) 2020: This is the period after the completion of Phase I, but before the start of the Mathabari Power plant operation. As this period coincides with a growing electricity shortage in Dhaka, the transmission line will start being used for transmission of electricity from the Chittagong area to the Chittagong (60%) and Dhaka (40%) areas.

3) (2021 -) The third stage is the stage after the construction of the Matarbari power plant. In the project case, the generated electricity will be evacuated through the 400 kV transmission line to Dhaka and Chittagong.

The analysis will rely on the approach of established methodologies for GHG emission reduction estimation, such as the methodologies under the Clean Development Mechanism of the Kyoto Protocol[16], Verified Carbon Standard (VCS[17]), Gold Standard[18] and others. National values for emission factors and net calorific values will be used, wherever possible; otherwise, 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy[19] will be referred to.

14.5.2 Baseline and Project Scenario

In the first stage (2017-2019), the project delivers electricity from Dhaka to the Chittagong area. The GHG emissions resulting from the transmitted electricity are described by the grid emission factor (GEF) of Bangladesh. The GEF is calculated annually by the Department of Environment of Bangladesh[20] which also serves as a Secretariat to the Designated National Authority for the Clean Development Mechanism (CDM) in the country. For 2013, the GEF is estimated to be 0.67 tCO_2e/MWh, based on the Tool to calculate the emission factor for an electricity system (ver. 3.0.0)[21]. This emission factor is corrected for the transmission losses, which are assumed to be 1%. Thus, project emissions are equal to:

$$PE_y = EL_y \times GEF_y \times (1 + TL_y)$$

[16] http://cdm.unfccc.int/methodologies/index.html
[17] http://www.v-c-s.org/
[18] http://www.goldstandard.org/
[19] http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
[20] http://www.doe.gov.bd/home/
[21] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v3.0.0.pdf

Where:

Parameters	Description	Unit	Value
PE_y	Project emissions in year *y*	tCO_2e	
EL_y	Electricity transmitted in year *y*	MWh	
GEF_y	Grid Emission Factor	tCO_2e/MWh	0.67
TL_y	Transmission loss in year *y*	%	1

In the absence of the project, the same amount of electricity will be delivered to the distribution systems in the respective areas by rental power plants in line with the on-going policy of the government of Bangladesh to cover the increase in demand by HFO and diesel fired rental power plants. HFO power plants have an emission factor of 0.705 tCO_2/MWh[22], while diesel power plants have an emission factor of 0.800 tCO_2/MWh[23]. For the sake of conservativeness, it is assumed that all generators in the baseline will be HFO hired, as they have a lower emission factor. Thus, baseline emissions are calculated as follows:

$$BE_y = EL_y \times EF_{HFO,y}$$

Where:

Parameters	Description	Unit	Value
BE_y	Baseline emissions in year *y*	tCO_2e	
EL_y	Electricity transmitted in year *y*	MWh	
$EF_{HFO,y}$	Emission Factor of an HFO-fired Rental Power Plant	tCO_2e/MWh	0.705

From 2020 onwards, the project will start transmission of electricity from the Chittagong Area to Dhaka. As the Matarbari Power Plant will not have been put into operation by the end of 2020, in the second stage the baseline is assumed to remain the same and baseline and project emissions are calculated as explained above.

The commissioning of the Matarbari Power Plant marks the third stage of the project as well as an overall change in the baseline and project conditions. By that time, it is expected that the Government of Bangladesh will start launching highly efficient coal power plants operating on super-critical parameters. Therefore, the project emissions will be associated with the transmission of power from such power plants. Supercritical power plants, like the Matarbari Power Plant, are estimated to have an emission factor of 0.757 tCO_2e/MWh[24]. Transmission losses are assumed to remain approximately 1%. Then,

$$PE_y = EL_y \times EF_{SCCP,y} \times (1 + TL_y)$$

Where:

[22] Department of Environment, GEF Calculations. Assumes generator efficiency of 39.5 % and emission factor of 0.0774 tCO_2/GJ.
[23] CDM Methodology AMS-I.F. (http://cdm.unfccc.int/UserManagement/FileStorage/41JF08WD9MSEB5YLHTZ6KVAPUC7XNQ). A modern efficient diesel generator with capacity of 200 kW or more is assumed.
[24] It is assumed that supercritical coal power plants have an efficiency of 45 %. Emission factor of coal is 0.0946 tCO_2/GJ (Source: Department of Environment).

Parameters	Description	Unit	Value
PE_y	Project emissions in year *y*	tCO_2e	
EL_y	Electricity transmitted in year *y*	MWh	
$EF_{SCCP,y}$	Emission Factor of a Supercritical Coal Power Plant	tCO_2e/MWh	0.757
TL_y	Transmission loss in year *y*	%	1

In the baseline (or in the absence of the project), households and industries will use cheaper diesel generators that will either be connected to the distribution network or will be supplying electricity directly to users. Such generators are assumed to have emission factors of 0.8 tCO_2e/MWh, as explained above. Then,

$$BE_y = EL_y \times EF_{diesel,y}$$

Where:

Parameters	Description	Unit	Value
BE_y	Baseline emissions in year *y*	tCO_2e	
EL_y	Electricity transmitted in year *y*	MWh	
$EF_{diesel,y}$	Emission Factor of a Diesel Generator	tCO_2e/MWh	0.8

Emission reductions in every year will be calculated as the difference between the baseline and project emissions, as follows.

Where:

Parameters	Description	Unit	Value
ER_y	Emission Reductions in year *y*	tCO_2e	
BE_y	Baseline emissions in year *y*	tCO_2e	
PE_y	Project Emissions in year *y*	tCO_2e	

The results are shown in the table below:

Table 14.5-1 Emission Reduction Calculations

Year	Capacity	Power Transmission Volume						Baseline Emissions	Project Emissions	Emission Reductions
		Total	Dhaka - Chittagon (230 kV)	Chittagon - Dhaka (230 kV)		Chittagon - Dhaka (400 kV)				
			To Dhaka	To Chittagon	To Dhaka	To Chittagon	To Dhaka			
	MW	MWh	MWh	MWh	MWh	MWh	MWh	tCO2e	tCO2e	tCO2e
2014	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0
2017	177	1,085,364	1,085,364	0	0	0	0	765,182	728,985	36,197
2018	260	1,594,320	1,594,320	0	0	0	0	1,123,996	1,070,825	53,171
2019	353	2,161,530	2,161,530	0	0	0	0	1,523,879	1,451,792	72,087
2020	450	2,759,400	0	1,655,640	1,103,760	0	0	1,945,377	1,853,351	92,026
2021	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2022	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2023	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2024	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2025	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2026	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2027	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2028	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2029	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2030	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2031	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2032	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2033	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2034	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2035	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2036	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2037	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2038	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2039	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2040	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2041	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2042	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2043	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2044	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2045	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2046	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2047	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2048	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
2049	1,900	11,650,800	0	0	0	6,990,480	4,660,320	9,320,640	8,907,852	412,788
						TOTAL		275,656,993	263,432,665	12,224,328

Once the project is put into full operation, it is expected to bring approximately 412,788 tCO_2e of emission reductions annually, or 12,224,328 tCO_2e over the project lifetime by avoiding power generation by HFO-fired and diesel power plants and transmitting electricity from highly-efficient coal-fired power plants.

Chapter 15
Framework for the Project Implementation and O&M

Chapter 15 Framework for the Project Implementation and O&M

15.1 Project Approval Procedure by the Government of Bangladesh

The official development assistance (ODA) project approval process follows the general approval steps for development projects described in the figure below.

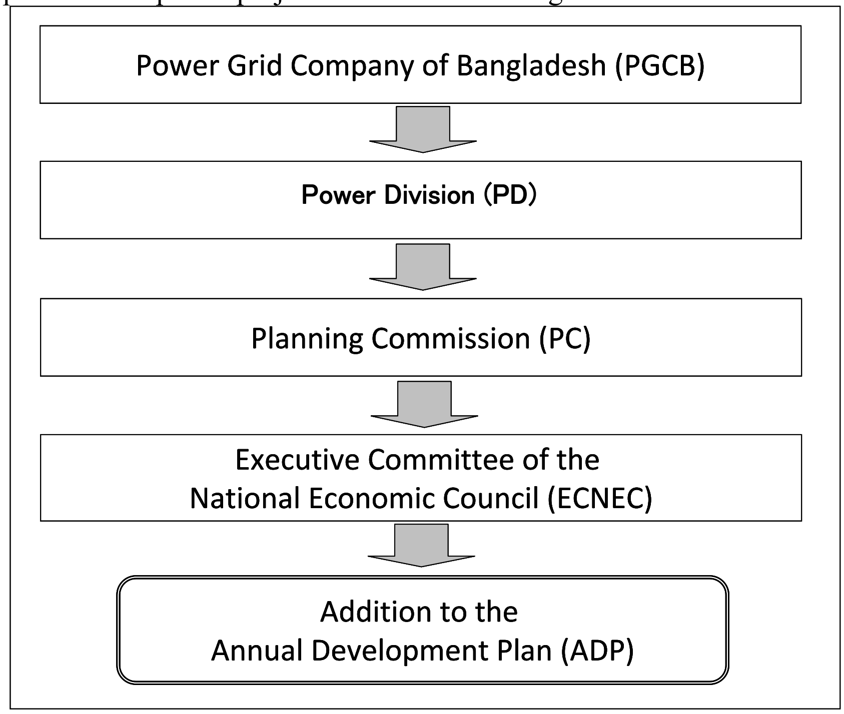


Figure 15.1-1 Project Approval Process

Once the executing agency (e.g. PGCB) has formulated a particular project for which it seeks support from a funding agency (e.g. JICA), it needs to prepare a Development Project Proforma/Proposal (DPP) and submit it to the PD. The PD reviews the DPP and, if satisfactory and in line with PD's priorities, submits it to the Planning Commission (PC). At the next step, the DPP is reviewed by the ECNEC and only if approved at that level, the project is added to the ADP.

When the project is added to the ADP, the project budget and the funding Source:s are also determined as part of the annual development budget of Bangladesh. Generally, projects that involve only international support, a loan or grant, are treated more favorably, while projects for which local Bangladeshi contribution is required are subjected to more rigorous scrutiny.

For approved projects, the Government of Bangladesh represented by the Ministry of Finance, Finance Division signs a loan agreement with donors. Based on the lending agreement, the Finance Division will also enter into a Subsidiary Loan Agreement (SLA) with the executing agency. The relending terms are determined in a special document issued by the Finance Division called "Lending and Relending Terms of Local/Foreign Currency Loans". Currently, the relending terms for PGCB for foreign loans are as follows:

1) Interest rate: 4%
2) Repayment period: 20 years
3) Grace period: 5 years

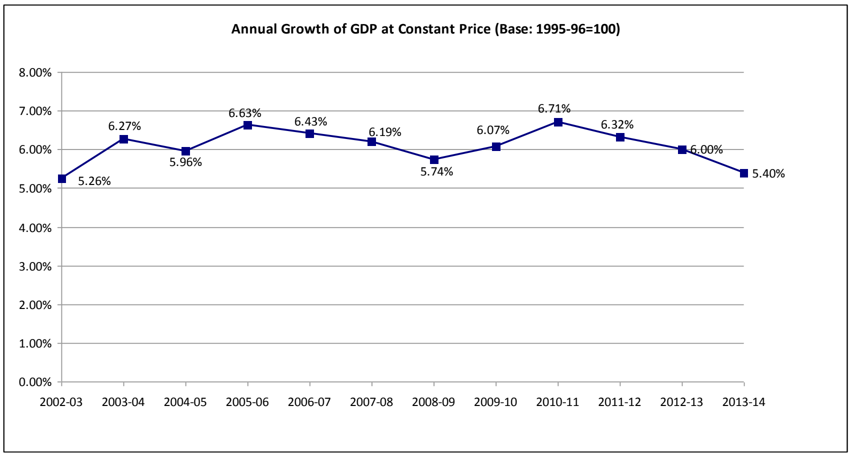
Although these are standard terms, preferential lending terms can be renegotiated on a case by case basis depending on the project type, the investment amount involved and the financial status of the executing agency.

15.2 Analysis of the Need for Extending Preferential Lending Terms

15.2.1 Macroeconomic Environment in Bangladesh

This section provides a brief overview of the macroeconomic environment of Bangladesh in order to identify any possible future developments that might adversely affect the loan repayment capability of PGCB.

The latest "Bangladesh Development Update", which was published by the World Bank in April 2014, concludes that Bangladesh has sustained healthy Gross Domestic Product (GDP) growth and moderate single digit inflation for the past one year. The growth is higher than the average for developing countries, but has been exhibiting a downward trend for the past four years.



(Source: Statistical Book of Bangladesh 2012)

Figure 15.2-1 Bangladesh GDP Growth Rate

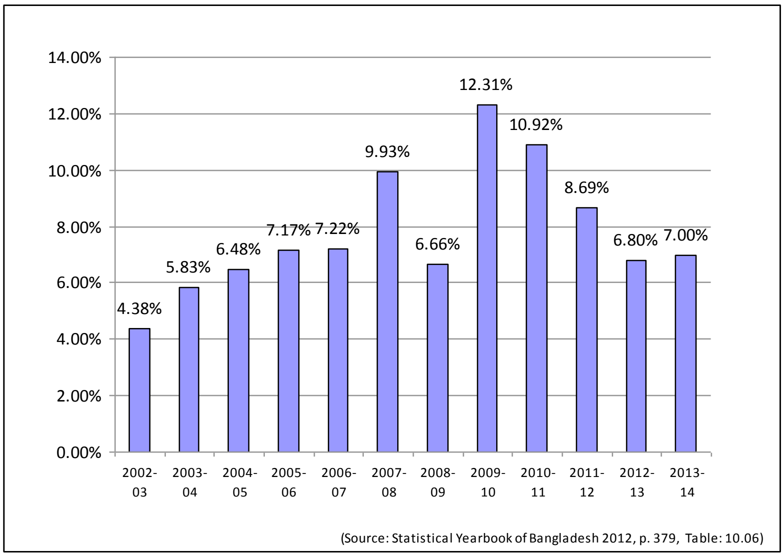


Figure 15.2-2 Inflation Rate

At the same time, growth was affected by the political turmoil in the country in the last quarter of 2013, which is estimated to have resulted in USD 1.4 billion of GDP loss (World Bank). The IMF projects that the current account will record a surplus in FY 2014, but it is expected to turn into a moderate deficit in 2015, mainly as a result of decreased foreign remittances. Official foreign exchange reserves have also increased as a result of the Bangladesh Bank interventions to keep the exchange rate stability, i.e. prevent appreciation of the BDT.

Although, both the International Monetary Fund (IMF) and the World Bank conclude that the Bangladesh economy is on a sustainable short-term track, several challenges remain for the future that can negatively affect the economy and the power sector, in particular.

Fiscal deficit as a percentage of GDP has been increasing slightly and is expected to reach 5.1% in FY 2014. The government revenue is also failing to meet the budget target, due both to the political turmoil and the overall economic slowdown.

In the energy sector, the government has implemented unsustainable short-term solutions and signed 3-5 year contracts with private suppliers of 2,851 MW of generation capacity in diesel and HFO ‘rented’ plants (as of January 2015) [25]. As the contracts provided were extremely generous, peak power costs have significantly increased. It is estimated that the equivalent of USD 684 million was provided to the power sector in the form of subsidies in FY 2011, and USD 1,041 million – in 2012, thus creating a significant fiscal burden[26].

Several issues related to development policy are also worth mentioning. First of all, one of the fundamental pillars for the development of the Bangladesh energy sector is the construction of new imported coal-fired power plants, oil-fired and LNG-fired power plants. There are ongoing discussions on the construction of nuclear power plants, but there is no concrete decision taken yet. In any cases, the foreign currency expenses related to fuel imports will put downward pressure on the current account. If the construction of such new generation capacities is not matched with the development of stronger export-oriented industry, maintaining the current account surplus may not be possible.

Additionally, as the government becomes more import fuel-dependent in the future, BDT will be under heavier depreciatory pressure. In such an environment, Bangladesh Bank will have the pivotal role in carrying out a prudent foreign exchange policy that will not hamper export growth, while keeping the costs of fuel imports in check. However, it is not clear to what extent this will be possible in view of the current plans for gradual liberalization of the foreign exchange regulations that may limit the ability of the Central Bank to control the exchange rate.

The above risk indicates that as per the current economic development scenarios, further BDT depreciation seems very likely, and this should be clearly incorporated in any analysis of the foreign currency debt service potential of Bangladeshi borrowers, such as PGCB.

Technically, BERC has the option of factoring the increasing fuel prices and exchange rate fluctuations into the electricity tariffs, making it easier for power companies to service foreign debts. However, such a move may further trigger inflation and will be difficult to accept politically. Although BERC has been gradually increasing tariffs, they do not reflect the actual generation, transmission and distribution costs and the energy sector in general still remains heavily subsidized, with BDT-based revenue stream and with no clear indications of a possible change to a more sustainable direction.

[25] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=150&Itemid=16
[26] http://www.iisd.org/gsi/sites/default/files/ffs_bangladesh_agenda.pdf

15.2.2 Foreign Currency Loan Repayment Scenarios

This section analyzes several cash flow scenarios to assess how fluctuations in the exchange rate, as well as different levels of interest rate, can influence the project economy. Based on that, a set of subsidiary loan conditions are proposed to allow PGCB to service the loan, without an excessive burden on their balance sheet.

The analysis uses the information for the costs and benefits available as of November 17, 2014. The project is expected to borrow approximately 41,738.23 million JPY, while the rest of the project costs will be contributed in the form of equity by PGCB. The operating costs are estimated to be 1.91% of the total construction costs, based on the past annual reports of PGCB. For details, please refer to the Economic and Financial Analysis in the preceding section.

Evaluation Criteria

Before starting the evaluation of any cash flow scenarios, it is important to have criteria against which the scenarios are assessed. The criteria proposed below are based on the business logic of private enterprises and are a minimum requirement for projects to operate smoothly and avoid loss generation by the executing agency, PGCB.

1) The grace period should cover the period up to the end of construction. Negative cash flow in any year during construction should not exceed the before-tax profit of PGCB.

2) Negative cash flow should be avoided after project commissioning. Exception should be made only for the year after the end of the grace period. However, the negative cash flow in that year should not exceed the before-tax profit of PGCB.

3) The repayment period cannot exceed the project lifetime.

The rationale for these conditions is explained below.

Grace period is generally established to avoid excessive financial burden on a particular project during construction, while the project is still not able to generate sufficient revenue. Ending the grace period before the project completion can result in significant cash outlays and have negative impact on the overall financial performance of the executing agency. This should be avoided by all means if the negative cash flow exceeds the pre-tax revenue of the company, as this will result in PGCB generating a loss in that particular year.

The table below shows the before-tax profit of PGCB for the past two years, which is approximately 1,918.5 million BDT. It is suggested to use this value as a benchmark for maximum acceptable negative cash flow in a year, reflecting the capacity of PGCB to break even.

Table 15.2-1 PGCB Pre-Tax Profit

Year	Pre-Tax Profit (million BDT)
2011-12	1,822
2012-13	2,015
Average for the Period	1,919

(Source: PGCB Annual Report 2012-13)

Regarding the second condition, negative cash flow after construction is not desirable for the operation of any business as it requires subsidization of the project activity from other sources.

In some cases, negative cash flow may still occur in the first year after the commissioning of the project. One such case is repayment of interest rates accumulated during a grace period for the project loan. Another reason can be due to the project's inability to reach full operational capacity immediately after commissioning. In cases like this, negative cash flow can be permitted, but only for the first year after project commissioning. Similar to the first condition, the negative cash flow exceeds the pre-tax revenue of the company; otherwise, this will result in PGCB generating a loss in that particular year.

Finally, the repayment of the loan should not be extended beyond the project lifetime, as it will result in cash outlays after the project lifetime that cannot be matched with any revenue from the project.

Simulations of Various Scenarios

First of all, the cash flow will be analyzed under the standard SLA conditions that apply to PGCB. In addition to that, the sensitivity of the cash flow to exchange rate fluctuations and decrease of the interest rate will be examined.

The tables below summarize the cases when exchange rate fluctuations are borne by PGCB (at 10%, 5% and 2% of annual exchange rate depreciation) as well as the case when these fluctuations are covered by the Government of Bangladesh. The tables present the cash flow at the interest rates of 4%, 3% and 2%. A grace period of 5 years and repayment period of 20 years (including grace period) are assumed.

It is further assumed that the loan installments are paid on December 31 every year and the interest rate for the particular year is charged against the outstanding balance as of December 30 the same year.

Table 15.2-2 Cash Flow Simulation with 20 Years Repayment Period including 5 Year Grace Period at 4% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	4.0%											
Base Year	2014											
Year		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
		0	1	2	3	4	5	6	7	8	9	10
Disbursement		0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Outstanding Loan as of December 31		0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	26,754.46	25,560.46	23,610.46	21,645.38	19,680.30
Principle Repayment (annually on December 31)		0.00	0.00	0.00	0.00	0.00	0.00	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment		*0.00*	*6.00*	*221.55*	*488.70*	*865.95*	*1,014.70*	1,148.90	1,101.14	1,023.14	944.54	865.93
Repayment depreciation (2 %)								720.87	456.34	513.46	568.22	620.62
Repayment depreciation (5 %)								1,943.25	1,249.46	1,428.15	1,605.78	1,782.26
Repayment depreciation (10 %)								4,408.56	2,911.77	3,420.67	3,955.11	4,516.61
Total Repayment & Interest Payment								**5,713.82**	**3,069.17**	**2,991.17**	**2,912.57**	**2,833.96**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)								**6,434.69**	**3,525.51**	**3,504.63**	**3,480.79**	**3,454.59**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)								**7,657.07**	**4,318.63**	**4,419.32**	**4,518.35**	**4,616.23**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)								**10,122.39**	**5,980.94**	**6,411.84**	**6,867.68**	**7,350.57**
Project Revenue		**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs		**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**
Project Income (Revenue - O&M Costs)		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**
Cash flow		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-6,109.14**	**-1,493.74**	**-1,428.71**	**-1,350.16**	**-1,271.61**
Cash flow at 2% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-6,830.01**	**-1,950.08**	**-1,942.17**	**-1,918.38**	**-1,892.23**
Cash flow at 5% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-8,052.38**	**-2,743.20**	**-2,856.86**	**-2,955.94**	**-3,053.88**
Cash flow at 10% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-10,517.70**	**-4,405.51**	**-4,849.37**	**-5,305.27**	**-5,788.22**

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2033
	11	12	13	14	15	16	17	18	19	20
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	17,712.27	15,744.24	13,776.21	11,808.18	9,840.15	7,872.12	5,904.09	3,936.06	1,968.03	0.00
Principle Repayment (annually on December 31)	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment	787.21	708.49	629.77	551.05	472.33	393.61	314.88	236.16	157.44	78.72
Repayment depreciation (2 %)	670.56	717.95	762.73	804.79	844.04	880.38	913.72	943.94	970.94	994.61
Repayment depreciation (5 %)	1,957.16	2,130.13	2,300.74	2,468.53	2,632.97	2,793.52	2,949.57	3,100.46	3,245.49	3,383.89
Repayment depreciation (10 %)	5,105.79	5,723.55	6,370.51	7,047.12	7,753.62	8,490.02	9,256.01	10,050.94	10,873.73	11,722.77
Total Repayment & Interest Payment	**2,755.24**	**2,676.52**	**2,597.80**	**2,519.08**	**2,440.36**	**2,361.64**	**2,282.92**	**2,204.19**	**2,125.47**	**2,046.75**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**3,425.80**	**3,394.48**	**3,360.53**	**3,323.87**	**3,284.40**	**3,242.02**	**3,196.63**	**3,148.13**	**3,096.41**	**3,041.37**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**4,712.40**	**4,806.65**	**4,898.54**	**4,987.60**	**5,073.33**	**5,155.16**	**5,232.48**	**5,304.66**	**5,370.96**	**5,430.64**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**7,861.03**	**8,400.07**	**8,968.31**	**9,566.20**	**10,193.98**	**10,851.66**	**11,538.93**	**12,255.14**	**12,999.20**	**13,769.52**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-1,192.89**	**-1,114.17**	**-1,035.45**	**-956.73**	**-878.01**	**-799.28**	**-720.56**	**-641.84**	**-563.12**	**-484.40**
Cash flow at 2% exchange rate depreciation	**-1,863.45**	**-1,832.12**	**-1,798.18**	**-1,761.52**	**-1,722.05**	**-1,679.67**	**-1,634.28**	**-1,585.78**	**-1,534.06**	**-1,479.01**
Cash flow at 5% exchange rate depreciation	**-3,150.05**	**-3,244.30**	**-3,336.19**	**-3,425.25**	**-3,510.98**	**-3,592.80**	**-3,670.13**	**-3,742.30**	**-3,808.61**	**-3,868.29**
Cash flow at 10% exchange rate depreciation	**-6,298.68**	**-6,837.72**	**-7,405.96**	**-8,003.85**	**-8,631.63**	**-9,289.30**	**-9,976.58**	**-10,692.79**	**-11,436.85**	**-12,207.17**

(Source: JICA Survey Team)

Table 15.2-3 Cash Flow Simulation with 20 Years Repayment Period including 5 Year Grace Period at 3% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	3.0%											
Base Year	2014											
Year		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
		0	1	2	3	4	5	6	7	8	9	10
Disbursement		0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Outstanding Loan as of December 31		0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	26,754.46	25,560.46	23,610.46	21,645.38	19,680.30
Principle Repayment (annually on December 31)		0.00	0.00	0.00	0.00	0.00	0.00	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment		*0.00*	*4.50*	*166.16*	*366.52*	*649.46*	*761.03*	861.67	825.85	767.35	708.40	649.45
Repayment depreciation (2 %)								602.73	415.41	469.55	522.15	573.21
Repayment depreciation (5 %)								1,624.76	1,137.39	1,306.02	1,475.59	1,646.12
Repayment depreciation (10 %)								3,686.04	2,650.61	3,128.16	3,634.46	4,171.59
Total Repayment & Interest Payment								**4,777.38**	**2,793.89**	**2,735.39**	**2,676.43**	**2,617.48**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)								**5,380.10**	**3,209.30**	**3,204.94**	**3,198.59**	**3,190.69**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)								**6,402.14**	**3,931.28**	**4,041.41**	**4,152.03**	**4,263.60**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)								**8,463.41**	**5,444.49**	**5,863.54**	**6,310.89**	**6,789.07**
Project Revenue		**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs		**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**
Project Income (Revenue - O&M Costs)		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**
Cash flow		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-5,172.69**	**-1,218.45**	**-1,172.92**	**-1,114.02**	**-1,055.13**
Cash flow at 2% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-5,775.41**	**-1,633.86**	**-1,642.48**	**-1,636.18**	**-1,628.34**
Cash flow at 5% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-6,797.45**	**-2,355.84**	**-2,478.95**	**-2,589.62**	**-2,701.25**
Cash flow at 10% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-8,858.72**	**-3,869.06**	**-4,301.08**	**-4,748.48**	**-5,226.72**

	2025	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2033**
	11	12	13	14	15	16	17	18	19	20
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	17,712.27	15,744.24	13,776.21	11,808.18	9,840.15	7,872.12	5,904.09	3,936.06	1,968.03	0.00
Principle Repayment (annually on December 31)	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment	590.41	531.37	472.33	413.29	354.25	295.20	236.16	177.12	118.08	59.04
Repayment depreciation (2 %)	622.66	670.44	716.51	760.78	803.20	843.70	882.21	918.65	952.96	985.05
Repayment depreciation (5 %)	1,817.36	1,989.16	2,161.30	2,333.53	2,505.57	2,677.12	2,847.86	3,017.41	3,185.39	3,351.35
Repayment depreciation (10 %)	4,741.09	5,344.79	5,984.42	6,661.73	7,378.45	8,136.27	8,936.84	9,781.72	10,672.36	11,610.05
Total Repayment & Interest Payment	**2,558.44**	**2,499.40**	**2,440.36**	**2,381.32**	**2,322.28**	**2,263.24**	**2,204.19**	**2,145.15**	**2,086.11**	**2,027.07**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**3,181.10**	**3,169.84**	**3,156.86**	**3,142.10**	**3,125.48**	**3,106.94**	**3,086.40**	**3,063.81**	**3,039.07**	**3,012.12**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**4,375.80**	**4,488.56**	**4,601.66**	**4,714.84**	**4,827.84**	**4,940.36**	**5,052.05**	**5,162.57**	**5,271.50**	**5,378.42**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**7,299.53**	**7,844.18**	**8,424.78**	**9,043.05**	**9,700.72**	**10,399.50**	**11,141.03**	**11,926.87**	**12,758.47**	**13,637.12**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-996.09**	**-937.05**	**-878.01**	**-818.97**	**-759.92**	**-700.88**	**-641.84**	**-582.80**	**-523.76**	**-464.72**
Cash flow at 2% exchange rate depreciation	**-1,618.75**	**-1,607.49**	**-1,594.51**	**-1,579.75**	**-1,563.13**	**-1,544.59**	**-1,524.05**	**-1,501.46**	**-1,476.72**	**-1,449.77**
Cash flow at 5% exchange rate depreciation	**-2,813.45**	**-2,926.21**	**-3,039.31**	**-3,152.49**	**-3,265.49**	**-3,378.01**	**-3,489.70**	**-3,600.22**	**-3,709.15**	**-3,816.07**
Cash flow at 10% exchange rate depreciation	**-5,737.18**	**-6,281.83**	**-6,862.43**	**-7,480.70**	**-8,138.37**	**-8,837.15**	**-9,578.68**	**-10,364.52**	**-11,196.12**	**-12,074.77**

(Source: JICA Survey Team)

Table 15.2-4 Cash Flow Simulation with 20 Years Repayment Period including 5 Year Grace Period at 2% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	2.0%											
Base Year	2014											
Year		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
		0	1	2	3	4	5	6	7	8	9	10
Disbursement		0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Outstanding Loan as of December 31		0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	26,754.46	25,560.46	23,610.46	21,645.38	19,680.30
Principle Repayment (annually on December 31)		0.00	0.00	0.00	0.00	0.00	0.00	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment		*0.00*	*3.00*	*110.77*	*244.35*	*432.97*	*507.35*	574.45	550.57	511.57	472.27	432.97
Repayment depreciation (2 %)								484.58	374.48	425.65	476.08	525.80
Repayment depreciation (5 %)								1,306.28	1,025.32	1,183.90	1,345.41	1,509.97
Repayment depreciation (10 %)								2,963.51	2,389.44	2,835.64	3,313.80	3,826.57
Total Repayment & Interest Payment								**3,840.93**	**2,518.60**	**2,479.60**	**2,440.30**	**2,401.00**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)								**4,325.51**	**2,893.08**	**2,905.25**	**2,916.38**	**2,926.80**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)								**5,147.21**	**3,543.92**	**3,663.50**	**3,785.70**	**3,910.97**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)								**6,804.44**	**4,908.04**	**5,315.24**	**5,754.10**	**6,227.57**
Project Revenue		**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs		**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**
Project Income (Revenue - O&M Costs)		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**
Cash flow		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-4,236.24**	**-943.17**	**-917.14**	**-877.89**	**-838.65**
Cash flow at 2% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-4,720.82**	**-1,317.65**	**-1,342.78**	**-1,353.97**	**-1,364.45**
Cash flow at 5% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-5,542.52**	**-1,968.49**	**-2,101.03**	**-2,223.30**	**-2,348.62**
Cash flow at 10% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-7,199.75**	**-3,332.61**	**-3,752.78**	**-4,191.69**	**-4,665.22**

	2025	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2033**
	11	12	13	14	15	16	17	18	19	20
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	17,712.27	15,744.24	13,776.21	11,808.18	9,840.15	7,872.12	5,904.09	3,936.06	1,968.03	0.00
Principle Repayment (annually on December 31)	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment	393.61	354.25	314.88	275.52	236.16	196.80	157.44	118.08	78.72	39.36
Repayment depreciation (2 %)	574.76	622.93	670.28	716.77	762.36	807.02	850.70	893.37	934.98	975.49
Repayment depreciation (5 %)	1,677.56	1,848.20	2,021.86	2,198.53	2,378.17	2,560.73	2,746.15	2,934.37	3,125.29	3,318.82
Repayment depreciation (10 %)	4,376.39	4,966.02	5,598.33	6,276.34	7,003.27	7,782.52	8,617.67	9,512.50	10,471.00	11,497.33
Total Repayment & Interest Payment	**2,361.64**	**2,322.28**	**2,282.92**	**2,243.55**	**2,204.19**	**2,164.83**	**2,125.47**	**2,086.11**	**2,046.75**	**2,007.39**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**2,936.40**	**2,945.21**	**2,953.19**	**2,960.32**	**2,966.56**	**2,971.85**	**2,976.18**	**2,979.48**	**2,981.73**	**2,982.88**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**4,039.20**	**4,170.47**	**4,304.78**	**4,442.08**	**4,582.36**	**4,725.56**	**4,871.62**	**5,020.48**	**5,172.04**	**5,326.21**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**6,738.02**	**7,288.30**	**7,881.24**	**8,519.90**	**9,207.47**	**9,947.35**	**10,743.14**	**11,598.61**	**12,517.75**	**13,504.72**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-799.28**	**-759.92**	**-720.56**	**-681.20**	**-641.84**	**-602.48**	**-563.12**	**-523.76**	**-484.40**	**-445.04**
Cash flow at 2% exchange rate depreciation	**-1,374.05**	**-1,382.86**	**-1,390.84**	**-1,397.97**	**-1,404.20**	**-1,409.50**	**-1,413.82**	**-1,417.13**	**-1,419.38**	**-1,420.53**
Cash flow at 5% exchange rate depreciation	**-2,476.85**	**-2,608.12**	**-2,742.43**	**-2,879.73**	**-3,020.01**	**-3,163.21**	**-3,309.27**	**-3,458.13**	**-3,609.69**	**-3,763.85**
Cash flow at 10% exchange rate depreciation	**-5,175.67**	**-5,725.95**	**-6,318.89**	**-6,957.54**	**-7,645.11**	**-8,385.00**	**-9,180.79**	**-10,036.26**	**-10,955.40**	**-11,942.37**

(Source: JICA Survey Team)

The most important observation is that under the above described conditions, no matter whether the exchange rate fluctuations are borne by PGCB or not, the cash outflow remains higher than the project revenue in any year of the project operation, i.e. PGCB has to internally subsidize the project implementation and operation from other Source:s during the entire 20 year period. This result is independent of the level of interest rates. The second observation is that the negative cash flow significantly increases from 2020, surpassing the pre-tax profit benchmark (1,919 million BDT).

Two reasons for these unfavorable conditions exist. The first is the duration of the grace period, which ends during project construction. Thus, the repayment of the interest rates accumulated during the grace period put very strong pressure on the PGCB finances in 2020. The continuing negative cash flow is a result of the high level of annual installments. This can be reduced by extending the repayment period.

In order to address the above issues, another set of simulations is conducted. In the first stage, the effect of grace period extension is examined by increasing it to six years, so that the start of the loan repayment coincides with the project commissioning. All other conditions remain the same as in the previous simulation set.

Table 15.2-5 Cash Flow Simulation with 20 Years Repayment Period including 6 Year Grace Period at 4% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	4.0%											
Base Year	2014											
Year		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
		0	1	2	3	4	5	6	7	8	9	10
Disbursement		0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Outstanding Loan as of December 31		0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	28,722.49	27,528.49	25,578.49	23,613.41	21,648.34
Principle Repayment (annually on December 31)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment		*0.00*	*6.00*	*221.55*	*488.70*	*865.95*	*1,014.70*	*1,148.90*	1,179.86	1,101.86	1,023.26	944.65
Repayment depreciation (2 %)									1,024.99	526.98	583.58	637.86
Repayment depreciation (5 %)									2,806.42	1,465.74	1,649.18	1,831.77
Repayment depreciation (10 %)									6,540.16	3,510.69	4,062.01	4,642.07
Total Repayment & Interest Payment									**6,893.68**	**3,069.89**	**2,991.29**	**2,912.69**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)									**7,918.68**	**3,596.87**	**3,574.87**	**3,550.55**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)									**9,700.11**	**4,535.63**	**4,640.47**	**4,744.46**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)									**13,433.84**	**6,580.58**	**7,053.30**	**7,554.75**
Project Revenue		**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs		**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**
Project Income (Revenue - O&M Costs)		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**
Cash flow		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-5,318.25**	**-1,507.43**	**-1,428.88**	**-1,350.33**
Cash flow at 2% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-6,343.24**	**-2,034.40**	**-2,012.46**	**-1,988.20**
Cash flow at 5% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-8,124.67**	**-2,973.16**	**-3,078.06**	**-3,182.11**
Cash flow at 10% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-11,858.41**	**-5,018.12**	**-5,490.89**	**-5,992.40**

2025	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2033**
11	12	13	14	15	16	17	18	19	20
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19,680.30	17,712.27	15,744.24	13,776.21	11,808.18	9,840.15	7,872.12	5,904.09	3,936.06	1,968.03
1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
865.93	787.21	708.49	629.77	551.05	472.33	393.61	314.88	236.16	157.44
689.71	739.07	785.84	829.94	871.27	909.73	945.22	977.65	1,006.90	1,032.87
2,013.08	2,192.78	2,370.46	2,545.67	2,717.91	2,886.64	3,051.28	3,211.19	3,365.69	3,514.04
5,251.67	5,891.89	6,563.56	7,267.34	8,003.74	8,773.02	9,575.19	10,409.91	11,276.46	12,173.65
2,833.96	**2,755.24**	**2,676.52**	**2,597.80**	**2,519.08**	**2,440.36**	**2,361.64**	**2,282.92**	**2,204.19**	**2,125.47**
3,523.68	**3,494.31**	**3,462.37**	**3,427.74**	**3,390.35**	**3,350.09**	**3,306.86**	**3,260.57**	**3,211.09**	**3,158.34**
4,847.04	**4,948.02**	**5,046.98**	**5,143.47**	**5,236.98**	**5,326.99**	**5,412.91**	**5,494.11**	**5,569.89**	**5,639.51**
8,085.63	**8,647.13**	**9,240.08**	**9,865.14**	**10,522.82**	**11,213.38**	**11,936.82**	**12,692.82**	**13,480.65**	**14,299.12**
2,669.20	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
1,106.85	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
1,562.35	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
-1,271.61	**-1,192.89**	**-1,114.17**	**-1,035.45**	**-956.73**	**-878.01**	**-799.28**	**-720.56**	**-641.84**	**-563.12**
-1,961.33	**-1,931.96**	**-1,900.01**	**-1,865.39**	**-1,828.00**	**-1,787.74**	**-1,744.51**	**-1,698.21**	**-1,648.74**	**-1,595.99**
-3,284.69	**-3,385.67**	**-3,484.63**	**-3,581.12**	**-3,674.63**	**-3,764.64**	**-3,850.56**	**-3,931.76**	**-4,007.54**	**-4,077.16**
-6,523.28	**-7,084.78**	**-7,677.73**	**-8,302.79**	**-8,960.47**	**-9,651.03**	**-10,374.47**	**-11,130.47**	**-11,918.30**	**-12,736.77**

(Source: JICA Survey Team)

Table 15.2-6 Cash Flow Simulation with 20 Years Repayment Period including 6 Year Grace Period at 3% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	3.0%											
Base Year	2014											
Year		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
		0	1	2	3	4	5	6	7	8	9	10
Disbursement		0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Outstanding Loan as of December 31		0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	28,722.49	27,528.49	25,578.49	23,613.41	21,648.34
Principle Repayment (annually on December 31)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment		*0.00*	*4.50*	*166.16*	*366.52*	*649.46*	*761.03*	*861.67*	884.90	826.40	767.44	708.49
Repayment depreciation (2 %)									841.90	479.69	533.67	586.14
Repayment depreciation (5 %)									2,305.11	1,334.21	1,508.14	1,683.25
Repayment depreciation (10 %)									5,371.89	3,195.67	3,714.63	4,265.69
Total Repayment & Interest Payment									**5,662.27**	**2,794.43**	**2,735.47**	**2,676.52**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)									**6,504.17**	**3,274.12**	**3,269.14**	**3,262.66**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)									**7,967.38**	**4,128.64**	**4,243.62**	**4,359.77**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)									**11,034.16**	**5,990.10**	**6,450.10**	**6,942.21**
Project Revenue		**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs		**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**
Project Income (Revenue - O&M Costs)		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**
Cash flow		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-4,086.84**	**-1,231.96**	**-1,173.07**	**-1,114.17**
Cash flow at 2% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-4,928.74**	**-1,711.65**	**-1,706.74**	**-1,700.31**
Cash flow at 5% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-6,391.95**	**-2,566.18**	**-2,681.21**	**-2,797.42**
Cash flow at 10% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-9,458.73**	**-4,427.64**	**-4,887.70**	**-5,379.86**

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2033
	11	12	13	14	15	16	17	18	19	20
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	19,680.30	17,712.27	15,744.24	13,776.21	11,808.18	9,840.15	7,872.12	5,904.09	3,936.06	1,968.03
Principle Repayment (annually on December 31)	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment	649.45	590.41	531.37	472.33	413.29	354.25	295.20	236.16	177.12	118.08
Repayment depreciation (2 %)	637.03	686.28	733.84	779.64	823.62	865.71	905.84	943.94	979.93	1,013.74
Repayment depreciation (5 %)	1,859.30	2,036.15	2,213.59	2,391.38	2,569.27	2,746.96	2,924.14	3,100.46	3,275.54	3,448.96
Repayment depreciation (10 %)	4,850.50	5,471.04	6,129.20	6,826.90	7,566.03	8,348.52	9,176.22	10,050.94	10,974.41	11,948.21
Total Repayment & Interest Payment	**2,617.48**	**2,558.44**	**2,499.40**	**2,440.36**	**2,381.32**	**2,322.28**	**2,263.24**	**2,204.19**	**2,145.15**	**2,086.11**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**3,254.51**	**3,244.72**	**3,233.24**	**3,220.00**	**3,204.94**	**3,187.99**	**3,169.08**	**3,148.13**	**3,125.08**	**3,099.85**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**4,476.78**	**4,594.59**	**4,712.99**	**4,831.74**	**4,950.59**	**5,069.24**	**5,187.38**	**5,304.66**	**5,420.70**	**5,535.08**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**7,467.98**	**8,029.48**	**8,628.60**	**9,267.25**	**9,947.35**	**10,670.80**	**11,439.45**	**12,255.14**	**13,119.56**	**14,034.32**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-1,055.13**	**-996.09**	**-937.05**	**-878.01**	**-818.97**	**-759.92**	**-700.88**	**-641.84**	**-582.80**	**-523.76**
Cash flow at 2% exchange rate depreciation	**-1,692.16**	**-1,682.37**	**-1,670.89**	**-1,657.65**	**-1,642.59**	**-1,625.64**	**-1,606.72**	**-1,585.78**	**-1,562.73**	**-1,537.50**
Cash flow at 5% exchange rate depreciation	**-2,914.43**	**-3,032.24**	**-3,150.64**	**-3,269.39**	**-3,388.24**	**-3,506.89**	**-3,625.02**	**-3,742.30**	**-3,858.34**	**-3,972.73**
Cash flow at 10% exchange rate depreciation	**-5,905.63**	**-6,467.13**	**-7,066.25**	**-7,704.90**	**-8,385.00**	**-9,108.44**	**-9,877.10**	**-10,692.79**	**-11,557.21**	**-12,471.97**

(Source: JICA Survey Team)

Table 15.2-7 Cash Flow Simulation with 20 Years Repayment Period including 6 Year Grace Period at 2% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	2.0%											
Base Year	2014											
Year		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
		0	1	2	3	4	5	6	7	8	9	10
Disbursement		0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Outstanding Loan as of December 31		0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	28,722.49	27,528.49	25,578.49	23,613.41	21,648.34
Principle Repayment (annually on December 31)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment		*0.00*	*3.00*	*110.77*	*244.35*	*432.97*	*507.35*	*574.45*	589.93	550.93	511.63	472.33
Repayment depreciation (2 %)									658.81	432.40	483.76	534.42
Repayment depreciation (5 %)									1,803.80	1,202.69	1,367.11	1,534.73
Repayment depreciation (10 %)									4,203.63	2,880.66	3,367.25	3,889.30
Total Repayment & Interest Payment									**4,430.86**	**2,518.96**	**2,479.66**	**2,440.36**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)									**5,089.66**	**2,951.36**	**2,963.42**	**2,974.78**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)									**6,234.66**	**3,721.65**	**3,846.77**	**3,975.09**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)									**8,634.49**	**5,399.62**	**5,846.91**	**6,329.66**
Project Revenue		**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs		**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**
Project Income (Revenue - O&M Costs)		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**
Cash flow		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-2,855.42**	**-956.50**	**-917.25**	**-878.01**
Cash flow at 2% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-3,514.23**	**-1,388.90**	**-1,401.01**	**-1,412.43**
Cash flow at 5% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-4,659.23**	**-2,159.19**	**-2,284.36**	**-2,412.73**
Cash flow at 10% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-7,059.05**	**-3,837.15**	**-4,284.50**	**-4,767.31**

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2033
	11	12	13	14	15	16	17	18	19	20
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	19,680.30	17,712.27	15,744.24	13,776.21	11,808.18	9,840.15	7,872.12	5,904.09	3,936.06	1,968.03
Principle Repayment (annually on December 31)	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03	1,968.03
Interest Payment	432.97	393.61	354.25	314.88	275.52	236.16	196.80	157.44	118.08	78.72
Repayment depreciation (2 %)	584.34	633.49	681.84	729.34	775.97	821.69	866.46	910.23	952.96	994.61
Repayment depreciation (5 %)	1,705.52	1,879.52	2,056.72	2,237.10	2,420.63	2,607.29	2,797.00	2,989.73	3,185.39	3,383.89
Repayment depreciation (10 %)	4,449.33	5,050.19	5,694.85	6,386.45	7,128.33	7,924.02	8,777.25	9,691.98	10,672.36	11,722.77
Total Repayment & Interest Payment	**2,401.00**	**2,361.64**	**2,322.28**	**2,282.92**	**2,243.55**	**2,204.19**	**2,164.83**	**2,125.47**	**2,086.11**	**2,046.75**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**2,985.34**	**2,995.13**	**3,004.11**	**3,012.26**	**3,019.53**	**3,025.89**	**3,031.29**	**3,035.70**	**3,039.07**	**3,041.37**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**4,106.52**	**4,241.16**	**4,379.00**	**4,520.02**	**4,664.19**	**4,811.48**	**4,961.84**	**5,115.20**	**5,271.50**	**5,430.64**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**6,850.33**	**7,411.83**	**8,017.13**	**8,669.37**	**9,371.88**	**10,128.21**	**10,942.09**	**11,817.45**	**12,758.47**	**13,769.52**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-838.65**	**-799.28**	**-759.92**	**-720.56**	**-681.20**	**-641.84**	**-602.48**	**-563.12**	**-523.76**	**-484.40**
Cash flow at 2% exchange rate depreciation	**-1,422.99**	**-1,432.77**	**-1,441.76**	**-1,449.91**	**-1,457.18**	**-1,463.53**	**-1,468.94**	**-1,473.35**	**-1,476.72**	**-1,479.01**
Cash flow at 5% exchange rate depreciation	**-2,544.17**	**-2,678.81**	**-2,816.65**	**-2,957.66**	**-3,101.84**	**-3,249.13**	**-3,399.49**	**-3,552.85**	**-3,709.15**	**-3,868.29**
Cash flow at 10% exchange rate depreciation	**-5,287.97**	**-5,849.48**	**-6,454.77**	**-7,107.02**	**-7,809.53**	**-8,565.86**	**-9,379.74**	**-10,255.10**	**-11,196.12**	**-12,207.17**

(Source: JICA Survey Team)

The main observation is that the extension of the grace periods allows smoothing of the impact of loan and interest repayment on PGCB in 2021, the year of project commissioning. However, even with a 2% interest rate, the negative cash flow in 2021 remains higher than the pre-tax profit benchmark (1,919 million BDT). At the same time, the negative annual cash flow during the project construction stays under the benchmark. Thus, it can be concluded that no further extension of the grace period is required.

At the next step, the repayment period is increased to 30 years (including 6 year grace period) as shown in the following tables.

Table 15.2-8 Cash Flow Simulation with 30 Years Repayment Period including 6 Year Grace Period at 2% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	2.0%											
Base Year	2014											
Year		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
		0	1	2	3	4	5	6	7	8	9	10
Disbursement		0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Outstanding Loan as of December 31		0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	28,722.49	28,266.51	27,054.52	25,827.45	24,600.38
Principle Repayment (annually on December 31)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,230.02	1,230.02	1,230.02	1,230.02
Interest Payment		*0.00*	*3.00*	*110.77*	*244.35*	*432.97*	*507.35*	*574.45*	589.93	565.69	541.15	516.61
Repayment depreciation (2 %)									549.07	308.25	345.54	382.50
Repayment depreciation (5 %)									1,503.36	857.37	976.50	1,098.44
Repayment depreciation (10 %)									3,503.47	2,053.55	2,405.15	2,783.67
Total Repayment & Interest Payment									**3,692.85**	**1,795.71**	**1,771.17**	**1,746.63**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)									**4,241.92**	**2,103.96**	**2,116.71**	**2,129.13**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)									**5,196.21**	**2,653.08**	**2,747.66**	**2,845.07**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)									**7,196.31**	**3,849.26**	**4,176.32**	**4,530.30**
Project Revenue		**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs		**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**
Project Income (Revenue - O&M Costs)		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**
Cash flow		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-2,117.41**	**-233.25**	**-208.76**	**-184.28**
Cash flow at 2% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-2,666.49**	**-541.50**	**-554.30**	**-566.78**
Cash flow at 5% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-3,620.77**	**-1,090.62**	**-1,185.26**	**-1,282.72**
Cash flow at 10% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-5,620.88**	**-2,286.80**	**-2,613.91**	**-2,967.95**

Year	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
	11	12	13	14	15	16	17	18	19	20
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	23,370.36	22,140.34	20,910.32	19,680.30	18,450.29	17,220.27	15,990.25	14,760.23	13,530.21	12,300.19
Principle Repayment (annually on December 31)	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02
Interest Payment	492.01	467.41	442.81	418.21	393.61	369.01	344.41	319.80	295.20	270.60
Repayment depreciation (2 %)	419.10	455.32	491.15	526.57	561.56	596.09	630.15	663.71	696.74	729.22
Repayment depreciation (5 %)	1,223.22	1,350.91	1,481.54	1,615.15	1,751.77	1,891.45	2,034.19	2,180.01	2,328.94	2,480.98
Repayment depreciation (10 %)	3,191.12	3,629.82	4,102.22	4,610.91	5,158.66	5,748.45	6,383.46	7,067.07	7,802.91	8,594.82
Total Repayment & Interest Payment	**1,722.03**	**1,697.43**	**1,672.83**	**1,648.23**	**1,623.63**	**1,599.02**	**1,574.42**	**1,549.82**	**1,525.22**	**1,500.62**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**2,141.12**	**2,152.75**	**2,163.98**	**2,174.80**	**2,185.19**	**2,195.12**	**2,204.57**	**2,213.53**	**2,221.96**	**2,229.85**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**2,945.25**	**3,048.33**	**3,154.36**	**3,263.37**	**3,375.40**	**3,490.47**	**3,608.61**	**3,729.84**	**3,854.16**	**3,981.60**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**4,913.14**	**5,327.25**	**5,775.05**	**6,259.13**	**6,782.29**	**7,347.48**	**7,957.88**	**8,616.89**	**9,328.13**	**10,095.44**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-159.68**	**-135.07**	**-110.47**	**-85.87**	**-61.27**	**-36.67**	**-12.07**	**12.53**	**37.13**	**61.73**
Cash flow at 2% exchange rate depreciation	**-578.77**	**-590.40**	**-601.63**	**-612.45**	**-622.83**	**-632.77**	**-642.22**	**-651.18**	**-659.61**	**-667.50**
Cash flow at 5% exchange rate depreciation	**-1,382.90**	**-1,485.98**	**-1,592.01**	**-1,701.02**	**-1,813.05**	**-1,928.12**	**-2,046.26**	**-2,167.48**	**-2,291.81**	**-2,419.25**
Cash flow at 10% exchange rate depreciation	**-3,350.79**	**-3,764.90**	**-4,212.70**	**-4,696.78**	**-5,219.93**	**-5,785.12**	**-6,395.53**	**-7,054.54**	**-7,765.78**	**-8,533.09**

Year	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**
	21	22	23	24	25	26	27	28	29	30
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	11,070.17	9,840.15	8,610.13	7,380.11	6,150.10	4,920.08	3,690.06	2,460.04	1,230.02	0.00
Principle Repayment (annually on December 31)	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02	1,230.02
Interest Payment	246.00	221.40	196.80	172.20	147.60	123.00	98.40	73.80	49.20	24.60
Repayment depreciation (2 %)	761.14	792.45	823.13	853.16	882.51	911.15	939.04	966.16	992.48	1,017.95
Repayment depreciation (5 %)	2,636.12	2,794.37	2,955.70	3,120.08	3,287.49	3,457.88	3,631.18	3,807.32	3,986.22	4,167.77
Repayment depreciation (10 %)	9,446.92	10,363.56	11,349.37	12,409.29	13,548.50	14,772.52	16,087.17	17,498.56	19,013.16	20,637.74
Total Repayment & Interest Payment	**1,476.02**	**1,451.42**	**1,426.82**	**1,402.22**	**1,377.62**	**1,353.02**	**1,328.42**	**1,303.82**	**1,279.22**	**1,254.62**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**2,237.16**	**2,243.87**	**2,249.95**	**2,255.39**	**2,260.13**	**2,264.17**	**2,267.46**	**2,269.98**	**2,271.70**	**2,272.57**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**4,112.14**	**4,245.79**	**4,382.52**	**4,522.31**	**4,665.11**	**4,810.90**	**4,959.60**	**5,111.14**	**5,265.44**	**5,422.39**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**10,922.94**	**11,814.98**	**12,776.20**	**13,811.51**	**14,926.12**	**16,125.54**	**17,415.59**	**18,802.38**	**20,292.38**	**21,892.36**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**86.33**	**110.93**	**135.53**	**160.13**	**184.73**	**209.33**	**233.93**	**258.53**	**283.13**	**307.73**
Cash flow at 2% exchange rate depreciation	**-674.81**	**-681.52**	**-687.60**	**-693.03**	**-697.78**	**-701.82**	**-705.11**	**-707.63**	**-709.34**	**-710.22**
Cash flow at 5% exchange rate depreciation	**-2,549.79**	**-2,683.44**	**-2,820.17**	**-2,959.95**	**-3,102.76**	**-3,248.55**	**-3,397.25**	**-3,548.79**	**-3,703.09**	**-3,860.04**
Cash flow at 10% exchange rate depreciation	**-9,360.59**	**-10,252.63**	**-11,213.84**	**-12,249.16**	**-13,363.77**	**-14,563.19**	**-15,853.23**	**-17,240.03**	**-18,730.03**	**-20,330.01**

(Source: JICA Survey Team)

However, even with the lowest proposed interest rate of 2%, the negative cash flow after commissioning in 2021 exceeds the pre-tax profit benchmark (1,919 million BDT).

The next set of scenarios analyses the case when the repayment period is further increased to the entire project lifetime, 35 years (including 6 years grace period) and the sensitivity is assessed under different interest rates.

Table 15.2-9 Cash Flow Simulation with 35 Years Repayment Period including 6 Year Grace Period at 4% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88
Exchange Rate (JPY/BDT)	1.38									
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03
Interest Rate	4.0%									
Base Year	2014									
Year		**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
		0	1	2	3	4	5	6	7	8
Disbursement		0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03
Outstanding Loan as of December 31		0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	28,722.49	28,478.58	27,478.66
Principle Repayment (annually on December 31)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,017.95	1,017.95
Interest Payment		*0.00*	*6.00*	*221.55*	*488.70*	*865.95*	*1,014.70*	*1,148.90*	1,179.86	1,139.86
Repayment depreciation (2 %)									883.73	370.41
Repayment depreciation (5 %)									2,419.64	1,030.26
Repayment depreciation (10 %)									5,638.80	2,467.65
Total Repayment & Interest Payment									**5,943.60**	**2,157.81**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)									**6,827.33**	**2,528.22**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)									**8,363.24**	**3,188.07**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)									**11,582.40**	**4,625.46**
Project Revenue		**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**
O&M Costs		**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**
Project Income (Revenue - O&M Costs)		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**
Cash flow		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-4,368.17**	**-595.35**
Cash flow at 2% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-5,251.90**	**-965.76**
Cash flow at 5% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-6,787.81**	**-1,625.61**
Cash flow at 10% exchange rate depreciation		**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-10,006.96**	**-3,063.00**

	2023	2024						
JICA Loan (mill. JPY)	4.07	4.07						
Exchange Rate (JPY/BDT)								
JICA Loan (mill. BDT)	2.95	2.95						
Interest Rate								
Base Year								
Year	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	9	10	11	12	13	14	15	16
Disbursement	2.95	2.95	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	26,463.66	25,448.67	24,430.72	23,412.78	22,394.83	21,376.88	20,358.94	19,340.99
Principle Repayment (annually on December 31)	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95
Interest Payment	1,099.26	1,058.66	1,017.95	977.23	936.51	895.79	855.08	814.36
Repayment depreciation (2 %)	413.05	454.77	495.48	535.19	573.84	611.40	647.82	683.06
Repayment depreciation (5 %)	1,167.28	1,305.97	1,446.18	1,587.87	1,730.96	1,875.33	2,020.86	2,167.39
Repayment depreciation (10 %)	2,875.06	3,309.58	3,772.75	4,266.54	4,792.86	5,353.68	5,951.06	6,587.08
Total Repayment & Interest Payment	**2,117.21**	**2,076.61**	**2,035.89**	**1,995.18**	**1,954.46**	**1,913.74**	**1,873.02**	**1,832.30**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**2,530.26**	**2,531.38**	**2,531.38**	**2,530.37**	**2,528.30**	**2,525.14**	**2,520.84**	**2,515.36**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**3,284.49**	**3,382.58**	**3,482.07**	**3,583.05**	**3,685.42**	**3,789.07**	**3,893.88**	**3,999.69**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**4,992.27**	**5,386.20**	**5,808.64**	**6,261.72**	**6,747.32**	**7,267.42**	**7,824.08**	**8,419.39**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.79**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.41**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-554.80**	**-514.26**	**-473.54**	**-432.82**	**-392.11**	**-351.39**	**-310.67**	**-269.95**
Cash flow at 2% exchange rate depreciation	**-967.86**	**-969.03**	**-969.03**	**-968.01**	**-965.95**	**-962.79**	**-958.49**	**-953.01**
Cash flow at 5% exchange rate depreciation	**-1,722.08**	**-1,820.23**	**-1,919.72**	**-2,020.70**	**-2,123.07**	**-2,226.72**	**-2,331.53**	**-2,437.34**
Cash flow at 10% exchange rate depreciation	**-3,429.87**	**-3,823.84**	**-4,246.29**	**-4,699.36**	**-5,184.97**	**-5,705.07**	**-6,261.73**	**-6,857.04**

Year	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
	17	18	19	20	21	22	23	24	25	26
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	18,323.04	17,305.10	16,287.15	15,269.20	14,251.26	13,233.31	12,215.36	11,197.41	10,179.47	9,161.52
Principle Repayment (annually on December 31)	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95
Interest Payment	773.64	732.92	692.20	651.49	610.77	570.05	529.33	488.61	447.90	407.18
Repayment depreciation (2 %)	717.07	749.80	781.22	811.26	839.87	867.01	892.62	916.65	939.03	959.71
Repayment depreciation (5 %)	2,314.76	2,462.81	2,611.31	2,760.07	2,908.82	3,057.31	3,205.23	3,352.25	3,498.02	3,642.15
Repayment depreciation (10 %)	7,263.93	7,983.82	8,748.97	9,561.68	10,424.18	11,338.74	12,307.53	13,332.66	14,416.14	15,559.77
Total Repayment & Interest Payment	**1,791.59**	**1,750.87**	**1,710.15**	**1,669.43**	**1,628.71**	**1,588.00**	**1,547.28**	**1,506.56**	**1,465.84**	**1,425.13**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**2,508.65**	**2,500.67**	**2,491.37**	**2,480.69**	**2,468.59**	**2,455.01**	**2,439.90**	**2,423.21**	**2,404.87**	**2,384.83**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**4,106.35**	**4,213.67**	**4,321.47**	**4,429.50**	**4,537.54**	**4,645.31**	**4,752.50**	**4,858.81**	**4,963.87**	**5,067.28**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**9,055.52**	**9,734.68**	**10,459.13**	**11,231.11**	**12,052.90**	**12,926.73**	**13,854.81**	**14,839.23**	**15,881.98**	**16,984.90**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-229.23**	**-188.52**	**-147.80**	**-107.08**	**-66.36**	**-25.65**	**15.07**	**55.79**	**96.51**	**137.23**
Cash flow at 2% exchange rate depreciation	**-946.30**	**-938.32**	**-929.01**	**-918.34**	**-906.24**	**-892.66**	**-877.55**	**-860.86**	**-842.52**	**-822.48**
Cash flow at 5% exchange rate depreciation	**-2,544.00**	**-2,651.32**	**-2,759.11**	**-2,867.15**	**-2,975.19**	**-3,082.95**	**-3,190.15**	**-3,296.46**	**-3,401.51**	**-3,504.93**
Cash flow at 10% exchange rate depreciation	**-7,493.17**	**-8,172.33**	**-8,896.77**	**-9,668.76**	**-10,490.55**	**-11,364.38**	**-12,292.45**	**-13,276.87**	**-14,319.63**	**-15,422.55**

Year	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**
	27	28	29	30	31	32	33	34	35
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	8,143.57	7,125.63	6,107.68	5,089.73	4,071.79	3,053.84	2,035.89	1,017.95	0.00
Principle Repayment (annually on December 31)	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95
Interest Payment	366.46	325.74	285.03	244.31	203.59	162.87	122.15	81.44	40.72
Repayment depreciation (2 %)	978.62	995.71	1,010.90	1,024.14	1,035.36	1,044.48	1,051.44	1,056.15	1,058.55
Repayment depreciation (5 %)	3,784.22	3,923.75	4,060.24	4,193.14	4,321.84	4,445.71	4,564.04	4,676.06	4,780.95
Repayment depreciation (10 %)	16,765.17	18,033.65	19,366.19	20,763.32	22,225.05	23,750.72	25,338.91	26,987.28	28,692.39
Total Repayment & Interest Payment	**1,384.41**	**1,343.69**	**1,302.97**	**1,262.25**	**1,221.54**	**1,180.82**	**1,140.10**	**1,099.38**	**1,058.66**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**2,363.03**	**2,339.40**	**2,313.88**	**2,286.40**	**2,256.90**	**2,225.30**	**2,191.54**	**2,155.53**	**2,117.21**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**5,168.63**	**5,267.44**	**5,363.21**	**5,455.39**	**5,543.38**	**5,626.53**	**5,704.14**	**5,775.44**	**5,839.61**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**18,149.58**	**19,377.34**	**20,669.16**	**22,025.58**	**23,446.58**	**24,931.53**	**26,479.01**	**28,086.66**	**29,751.06**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**177.94**	**218.66**	**259.38**	**300.10**	**340.82**	**381.53**	**422.25**	**462.97**	**503.69**
Cash flow at 2% exchange rate depreciation	**-800.68**	**-777.04**	**-751.52**	**-724.05**	**-694.54**	**-662.95**	**-629.19**	**-593.18**	**-554.86**
Cash flow at 5% exchange rate depreciation	**-3,606.27**	**-3,705.09**	**-3,800.86**	**-3,893.04**	**-3,981.03**	**-4,064.18**	**-4,141.79**	**-4,213.09**	**-4,277.26**
Cash flow at 10% exchange rate depreciation	**-16,587.22**	**-17,814.99**	**-19,106.81**	**##########**	**-21,884.23**	**-23,369.18**	**-24,916.66**	**-26,524.31**	**-28,188.71**

(Source: JICA Survey Team)

Table 15.2-10 Cash Flow Simulation with 35 Years Repayment Period including 6 Year Grace Period at 3% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	3.0%											
Base Year	2014											

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Disbursement	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	28,722.49	28,478.58	27,478.66	26,463.66	25,448.67	24,430.72	23,412.78	22,394.83	21,376.88	20,358.94	19,340.99
Principle Repayment (annually on December 31)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95
Interest Payment	*0.00*	*4.50*	*166.16*	*366.52*	*649.46*	*761.03*	*861.67*	884.90	854.90	824.45	794.00	763.46	732.92	702.38	671.84	641.31	610.77
Repayment depreciation (2 %)								700.63	321.49	359.44	396.81	433.55	469.66	505.10	539.85	573.88	607.16
Repayment depreciation (5 %)								1,918.33	894.20	1,015.76	1,139.52	1,265.40	1,393.44	1,523.61	1,655.88	1,790.22	1,926.57
Repayment depreciation (10 %)								4,470.53	2,141.76	2,501.88	2,887.77	3,301.15	3,744.11	4,218.72	4,727.19	5,271.86	5,855.19
Total Repayment & Interest Payment								**4,712.19**	**1,872.84**	**1,842.40**	**1,811.95**	**1,781.41**	**1,750.87**	**1,720.33**	**1,689.79**	**1,659.25**	**1,628.71**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)								**5,412.82**	**2,194.34**	**2,201.83**	**2,208.75**	**2,214.96**	**2,220.52**	**2,225.43**	**2,229.64**	**2,233.14**	**2,235.88**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)								**6,630.52**	**2,767.05**	**2,858.16**	**2,951.47**	**3,046.81**	**3,144.31**	**3,243.94**	**3,345.67**	**3,449.47**	**3,555.28**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)								**9,182.72**	**4,014.61**	**4,344.27**	**4,699.72**	**5,082.56**	**5,494.98**	**5,939.05**	**6,416.98**	**6,931.11**	**7,483.90**
Project Revenue	**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-3,136.75**	**-310.38**	**-279.99**	**-249.59**	**-219.06**	**-188.52**	**-157.98**	**-127.44**	**-96.90**	**-66.36**
Cash flow at 2% exchange rate depreciation	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-3,837.39**	**-631.87**	**-639.42**	**-646.40**	**-652.60**	**-658.17**	**-663.08**	**-667.29**	**-670.78**	**-673.52**
Cash flow at 5% exchange rate depreciation	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-5,055.09**	**-1,204.58**	**-1,295.75**	**-1,389.12**	**-1,484.46**	**-1,581.96**	**-1,681.59**	**-1,783.32**	**-1,887.12**	**-1,992.93**
Cash flow at 10% exchange rate depreciation	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-7,607.29**	**-2,452.15**	**-2,781.86**	**-3,137.37**	**-3,520.21**	**-3,932.62**	**-4,376.69**	**-4,854.63**	**-5,368.76**	**-5,921.55**

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	18,323.04	17,305.10	16,287.15	15,269.20	14,251.26	13,233.31	12,215.36	11,197.41	10,179.47	9,161.52	8,143.57	7,125.63	6,107.68	5,089.73	4,071.79	3,053.84	2,035.89	1,017.95	0.00
Principle Repayment (annually on December 31)	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95
Interest Payment	580.23	549.69	519.15	488.61	458.08	427.54	397.00	366.46	335.92	305.38	274.85	244.31	213.77	183.23	152.69	122.15	91.62	61.08	30.54
Repayment depreciation (2 %)	639.66	671.34	702.16	732.11	761.14	789.21	816.28	842.33	867.30	891.15	913.86	935.36	955.62	974.59	992.22	1,008.47	1,023.27	1,036.59	1,048.37
Repayment depreciation (5 %)	2,064.87	2,205.07	2,347.07	2,490.79	2,636.12	2,782.93	2,931.09	3,080.45	3,230.81	3,382.00	3,533.79	3,685.94	3,838.19	3,990.24	4,141.77	4,292.41	4,441.79	4,589.46	4,734.98
Repayment depreciation (10 %)	6,479.76	7,148.30	7,863.66	8,628.83	9,446.92	10,321.16	11,254.91	12,251.64	13,314.91	14,448.36	15,655.71	16,940.70	18,307.10	19,758.65	21,299.00	22,931.73	24,660.19	26,487.52	28,416.50
Total Repayment & Interest Payment	**1,598.18**	**1,567.64**	**1,537.10**	**1,506.56**	**1,476.02**	**1,445.48**	**1,414.95**	**1,384.41**	**1,353.87**	**1,323.33**	**1,292.79**	**1,262.25**	**1,231.72**	**1,201.18**	**1,170.64**	**1,140.10**	**1,109.56**	**1,079.02**	**1,048.49**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**2,237.83**	**2,238.97**	**2,239.26**	**2,238.67**	**2,237.16**	**2,234.69**	**2,231.23**	**2,226.73**	**2,221.17**	**2,214.49**	**2,206.65**	**2,197.61**	**2,187.34**	**2,175.77**	**2,162.86**	**2,148.57**	**2,132.83**	**2,115.62**	**2,096.85**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**3,663.05**	**3,772.71**	**3,884.17**	**3,997.36**	**4,112.14**	**4,228.42**	**4,346.04**	**4,464.85**	**4,584.68**	**4,705.33**	**4,826.58**	**4,948.20**	**5,069.91**	**5,191.42**	**5,312.41**	**5,432.51**	**5,551.35**	**5,668.49**	**5,783.46**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**8,077.94**	**8,715.94**	**9,400.76**	**10,135.39**	**10,922.94**	**11,766.64**	**12,669.85**	**13,636.05**	**14,668.78**	**15,771.69**	**16,948.50**	**18,202.96**	**19,538.82**	**20,959.82**	**22,469.64**	**24,071.83**	**25,769.75**	**27,566.54**	**29,464.99**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**-35.82**	**-5.29**	**25.25**	**55.79**	**86.33**	**116.87**	**147.41**	**177.94**	**208.48**	**239.02**	**269.56**	**300.10**	**330.64**	**361.17**	**391.71**	**422.25**	**452.79**	**483.33**	**513.87**
Cash flow at 2% exchange rate depreciation	**-675.48**	**-676.62**	**-676.91**	**-676.32**	**-674.81**	**-672.34**	**-668.88**	**-664.38**	**-658.81**	**-652.13**	**-644.30**	**-635.26**	**-624.98**	**-613.41**	**-600.51**	**-586.21**	**-570.48**	**-553.26**	**-534.50**
Cash flow at 5% exchange rate depreciation	**-2,100.70**	**-2,210.36**	**-2,321.82**	**-2,435.00**	**-2,549.79**	**-2,666.07**	**-2,783.69**	**-2,902.50**	**-3,022.33**	**-3,142.98**	**-3,264.23**	**-3,385.85**	**-3,507.56**	**-3,629.07**	**-3,750.05**	**-3,870.16**	**-3,989.00**	**-4,106.13**	**-4,221.11**
Cash flow at 10% exchange rate depreciation	**-6,515.58**	**-7,153.59**	**-7,838.41**	**-8,573.04**	**-9,360.59**	**-10,204.29**	**-11,107.50**	**-12,073.69**	**-13,106.42**	**-14,209.34**	**-15,386.15**	**-16,640.61**	**-17,976.47**	**##########**	**-20,907.29**	**-22,509.47**	**-24,207.40**	**-26,004.19**	**-27,902.64**

(Source: JICA Survey Team)

Table 15.2-11 Cash Flow Simulation with 35 Years Repayment Period including 6 Year Grace Period at 2% Interest Rate

	Total	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
JICA Loan (mill. JPY)	40,738.23	0.00	206.87	7,436.48	9,216.78	13,015.09	5,132.08	4,629.75	1,068.17	24.88	4.07	4.07
Exchange Rate (JPY/BDT)	1.38											
JICA Loan (mill. BDT)	29,520.46	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95
Interest Rate	2.0%											
Base Year	2014											

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Disbursement	0.00	149.90	5,388.75	6,678.82	9,431.23	3,718.90	3,354.89	774.03	18.03	2.95	2.95	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	0.00	149.90	5,538.65	12,217.48	21,648.70	25,367.60	28,722.49	28,478.58	27,478.66	26,463.66	25,448.67	24,430.72	23,412.78	22,394.83	21,376.88	20,358.94	19,340.99
Principle Repayment (annually on December 31)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95
Interest Payment	*0.00*	*3.00*	*110.77*	*244.35*	*432.97*	*507.35*	*574.45*	589.93	569.93	549.63	529.33	508.97	488.61	468.26	447.90	427.54	407.18
Repayment depreciation (2 %)								517.54	272.57	305.82	338.85	371.61	404.12	436.36	468.31	499.95	531.27
Repayment depreciation (5 %)								1,417.02	758.14	864.25	973.08	1,084.63	1,199.01	1,316.25	1,436.43	1,559.57	1,685.74
Repayment depreciation (10 %)								3,302.27	1,815.88	2,128.69	2,465.96	2,829.56	3,221.67	3,644.57	4,100.69	4,592.66	5,123.29
Total Repayment & Interest Payment								**3,480.77**	**1,587.88**	**1,567.58**	**1,547.28**	**1,526.92**	**1,506.56**	**1,486.20**	**1,465.84**	**1,445.48**	**1,425.13**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)								**3,998.32**	**1,860.45**	**1,873.40**	**1,886.12**	**1,898.53**	**1,910.68**	**1,922.56**	**1,934.15**	**1,945.43**	**1,956.39**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)								**4,897.80**	**2,346.02**	**2,431.83**	**2,520.35**	**2,611.55**	**2,705.57**	**2,802.46**	**2,902.27**	**3,005.06**	**3,110.87**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)								**6,783.04**	**3,403.76**	**3,696.27**	**4,013.24**	**4,356.48**	**4,728.23**	**5,130.77**	**5,566.54**	**6,038.15**	**6,548.41**
Project Revenue	**0.00**	**0.00**	**0.00**	**248.66**	**365.26**	**495.21**	**632.18**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**0.00**	**0.00**	**0.00**	**325.67**	**602.37**	**809.83**	**1,027.49**	**1,093.77**	**1,106.73**	**1,106.79**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**1,575.43**	**1,562.46**	**1,562.41**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-1,905.34**	**-25.41**	**-5.17**	**15.07**	**35.43**	**55.79**	**76.15**	**96.51**	**116.87**	**137.23**
Cash flow at 2% exchange rate depreciation	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-2,422.88**	**-297.99**	**-310.99**	**-323.77**	**-336.18**	**-348.33**	**-360.21**	**-371.80**	**-383.08**	**-394.04**
Cash flow at 5% exchange rate depreciation	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-3,322.37**	**-783.56**	**-869.42**	**-958.00**	**-1,049.20**	**-1,143.22**	**-1,240.10**	**-1,339.92**	**-1,442.71**	**-1,548.52**
Cash flow at 10% exchange rate depreciation	**0.00**	**0.00**	**0.00**	**-77.01**	**-237.11**	**-314.63**	**-395.31**	**-5,207.61**	**-1,841.30**	**-2,133.86**	**-2,450.89**	**-2,794.13**	**-3,165.88**	**-3,568.42**	**-4,004.19**	**-4,475.80**	**-4,986.06**

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Disbursement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Outstanding Loan as of December 31	18,323.04	17,305.10	16,287.15	15,269.20	14,251.26	13,233.31	12,215.36	11,197.41	10,179.47	9,161.52	8,143.57	7,125.63	6,107.68	5,089.73	4,071.79	3,053.84	2,035.89	1,017.95	0.00
Principle Repayment (annually on December 31)	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95	1,017.95
Interest Payment	386.82	366.46	346.10	325.74	305.38	285.03	264.67	244.31	223.95	203.59	183.23	162.87	142.51	122.15	101.79	81.44	61.08	40.72	20.36
Repayment depreciation (2 %)	562.25	592.87	623.11	652.96	682.40	711.40	739.94	768.00	795.57	822.60	849.10	875.01	900.34	925.03	949.08	972.45	995.11	1,017.03	1,038.19
Repayment depreciation (5 %)	1,814.98	1,947.33	2,082.83	2,221.52	2,363.42	2,508.56	2,656.96	2,808.64	2,963.60	3,121.85	3,283.37	3,448.14	3,616.15	3,787.35	3,961.69	4,139.11	4,319.53	4,502.87	4,689.00
Repayment depreciation (10 %)	5,695.58	6,312.78	6,978.35	7,695.98	8,469.65	9,303.58	10,202.29	11,170.61	12,213.67	13,336.95	14,546.25	15,847.75	17,248.02	18,753.97	20,372.96	22,112.73	23,981.47	25,987.75	28,140.62
Total Repayment & Interest Payment	**1,404.77**	**1,384.41**	**1,364.05**	**1,343.69**	**1,323.33**	**1,302.97**	**1,282.61**	**1,262.25**	**1,241.90**	**1,221.54**	**1,201.18**	**1,180.82**	**1,160.46**	**1,140.10**	**1,119.74**	**1,099.38**	**1,079.02**	**1,058.66**	**1,038.31**
Total Repayment & Interest Payment (after exchange rate depreciation 2 %)	**1,967.01**	**1,977.28**	**1,987.16**	**1,996.65**	**2,005.73**	**2,014.37**	**2,022.55**	**2,030.26**	**2,037.46**	**2,044.14**	**2,050.27**	**2,055.83**	**2,060.80**	**2,065.13**	**2,068.82**	**2,071.83**	**2,074.13**	**2,075.70**	**2,076.50**
Total Repayment & Interest Payment (after exchange rate depreciation 5 %)	**3,219.75**	**3,331.74**	**3,446.88**	**3,565.21**	**3,686.75**	**3,811.53**	**3,939.58**	**4,070.90**	**4,205.50**	**4,343.38**	**4,484.54**	**4,628.96**	**4,776.61**	**4,927.45**	**5,081.43**	**5,238.49**	**5,398.56**	**5,561.53**	**5,727.31**
Total Repayment & Interest Payment (after exchange rate depreciation 10 %)	**7,100.35**	**7,697.19**	**8,342.40**	**9,039.67**	**9,792.98**	**10,606.55**	**11,484.90**	**12,432.86**	**13,455.57**	**14,558.48**	**15,747.43**	**17,028.57**	**18,408.47**	**19,894.07**	**21,492.70**	**23,212.12**	**25,060.49**	**27,046.42**	**29,178.92**
Project Revenue	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**	**2,669.20**
O&M Costs	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**	**1,106.85**
Project Income (Revenue - O&M Costs)	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**	**1,562.35**
Cash flow	**157.59**	**177.94**	**198.30**	**218.66**	**239.02**	**259.38**	**279.74**	**300.10**	**320.46**	**340.82**	**361.17**	**381.53**	**401.89**	**422.25**	**442.61**	**462.97**	**483.33**	**503.69**	**524.05**
Cash flow at 2% exchange rate depreciation	**-404.66**	**-414.92**	**-424.81**	**-434.30**	**-443.38**	**-452.02**	**-460.20**	**-467.90**	**-475.11**	**-481.79**	**-487.92**	**-493.48**	**-498.44**	**-502.78**	**-506.47**	**-509.48**	**-511.78**	**-513.35**	**-514.15**
Cash flow at 5% exchange rate depreciation	**-1,657.40**	**-1,769.39**	**-1,884.53**	**-2,002.86**	**-2,124.40**	**-2,249.18**	**-2,377.22**	**-2,508.54**	**-2,643.15**	**-2,781.03**	**-2,922.19**	**-3,066.61**	**-3,214.26**	**-3,365.10**	**-3,519.08**	**-3,676.14**	**-3,836.21**	**-3,999.18**	**-4,164.96**
Cash flow at 10% exchange rate depreciation	**-5,538.00**	**-6,134.84**	**-6,780.05**	**-7,477.32**	**-8,230.63**	**-9,044.20**	**-9,922.55**	**-10,870.51**	**-11,893.22**	**-12,996.13**	**-14,185.07**	**-15,466.22**	**-16,846.12**	**##########**	**-19,930.35**	**-21,649.77**	**-23,498.14**	**-25,484.06**	**-27,616.57**

(Source: JICA Survey Team)

It can be confirmed that only in the case when the interest rate is decreased to 2 %, the negative cash flow in 2021 stays under the pre-tax profit benchmark (1,919 million BDT). However, in that case, there are still two more years with a small negative cash flow, which is under 1.5 % of the pre-tax profit of PGCB. In view of the facts that the repayment period cannot be extended beyond the project lifetime and that there is a relatively small annual negative cash flow, this condition should not be of major concern.

Finally, it is noted that in all of the above scenarios, exchange rate depreciation results in a negative cash flow throughout the repayment period irrespective of its length.

Conclusion and Recommendations

The cash flow of PGCB was evaluated under different conditions in order to confirm the most favorable lending conditions for the company. The assessment was conducted against a set of predetermined criteria designed not to allow any negative cash flow from the project to result in PGCB generating losses on an annual basis, assuming that all other conditions stay the same. It is further noted that the conditions are not designed in a way that PGCB can generate profit, as with the current wheeling charges level, this is not possible. (For details see the note on financial and economic analysis.)

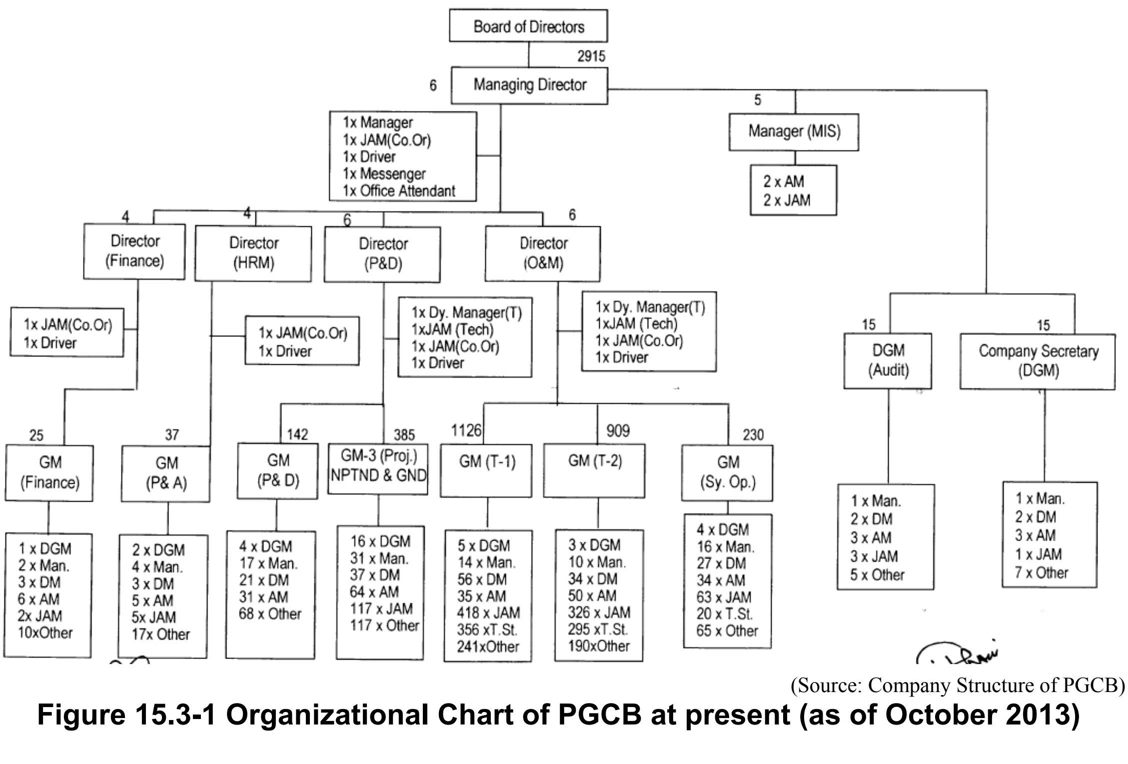
Based on the results of the simulations in the previous section and their assessment against the evaluation criteria, it is concluded that;

1) PGCB is not in the position to bear foreign exchange risk fluctuations unless it receives support from the government.
2) Decrease of the interest rate to 2% and extension of the repayment period to 35 years including 6 years of grace period will provide minimal pressure on the PGCB balance sheet.

15.3 Organizational Framework of Executing Agency

15.3.1 Present Organizational Structure

The organizational chart of the PGCB at present (as of October 2013) is shown below. The total number of employees is 2915, which includes drivers and attendants. Since there are some large-scale Transmission projects coming in, the number of employees is planned to be expanded to around 4,300 in accordance with the numbers and the progress of these projects.

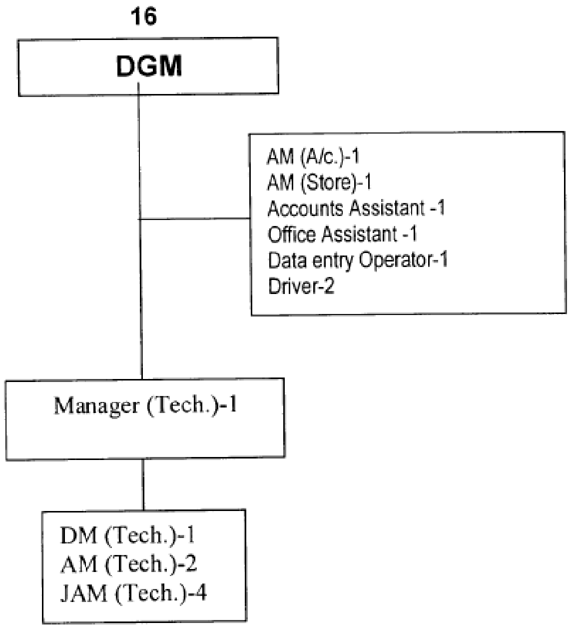


(Source: Company Structure of PGCB)

Figure 15.3-1 Organizational Chart of PGCB at present (as of October 2013)

15.3.2 Present Organizational Structure for Transmission Line Construction

The below shows the implementation framework of the Meghnaghat-Aminbazar 400kV T/L construction project. Since the scale of the Project is larger than that of existing projects, the Chief Engineer (CE) is set directly under the Planning and Designing (P&D) division; however, the structure of the on site work could yet be considered as the below project. This figure shows the structure in general, which is to set the Deputy General Manager (DGM) on top, and under the Manager, there are 2 Assistant Managers (AM) and 5 Junior Assistant Managers (JAM) per one DGM. Since most of the transmission projects adopt the below structure, the Project also will adopt it.



(Source: Company Structure of PGCB)

Figure 15.3-2 Organizational Chart of Meghnaghat-Aminbazar 400 kV T/L Project

15.3.3 Present Organizational Structure for Substation Construction

The organizational structure of the substation construction needs to have 1 AM and 2 JAM per Deputy Manager (DM) under the Manager. Since there is no difference in the classification of the voltages, it should be considered as the same organizational structure for both 230 kV and 400 kV substation construction.

15.3.4 The O&M of NLDC

Current NLDC organizations shall be maintained and an additional five engineers shall be dispatched to form a new group in charge of developing operational rules and procedures for new EMS/SCADA functions based on the revised Grid Code and Power Purchase Agreements.

15.4 Financial Status of PGCB

The tables below summarize the financial information of PGCB for the last three available fiscal years, namely 2010-11, 2011-12 and 2012-12.

Table 15.4-1 Statement of Financial Position

	30.06.2010 Taka	30.06.2011 Taka	30.06.2012 Taka	30.06.2013 Taka
Assets				
Property, plant and equipment	34,875,647,167	35,676,781,529	41,849,896,138	42,116,295,135
Capital work-in-progress	16,280,706,909	23,549,981,251	32,560,541,870	48,513,303,442
Total non-current assets	**51,156,354,076**	**59,226,762,780**	**74,410,438,008**	**90,629,598,577**
Investment in FDR	-	-	4,940,000,000	5,860,000,000
Inventories	685,483,498	1,339,656,762	1,471,182,090	1,658,585,163
Accounts and other receivables	1,352,523,069	1,379,078,119	1,577,598,855	1,607,095,693
Advances, deposits, and prepayments	948,522,654	3,981,843,413	4,037,096,904	4,958,623,141
Cash and cash equivalents	10,612,691,429	8,576,389,284	2,719,387,878	3,947,665,038
Total current assets	**13,599,220,650**	**15,276,967,578**	**14,745,265,727**	**18,031,969,035**
Total assets	**64,755,574,726**	**74,503,730,358**	**89,155,703,735**	**108,661,567,612**
Equity				
Share Capital	3,643,581,000	4,190,118,100	4,190,118,100	4,609,129,910
Deposit for shares	8,288,522,908	9,738,181,386	11,820,001,386	18,973,754,871
Retained earnings	5,533,382,436	5,853,349,465	6,121,379,532	5,774,062,389
Total equity attributable to equity holders	**17,465,486,344**	**19,781,648,951**	**22,131,499,017**	**29,356,947,170**
Liabilities				
Term loan-interest bearing	39,428,415,144	44,660,367,822	54,002,075,071	63,245,787,725
Grant from SIDA	130,551,473	125,638,246	120,725,019	115,811,792
Deferred liability-gratuity	328,218,950	513,935,448	587,934,431	674,893,948
Deferred tax liabilities	2,271,070,397	2,119,972,683	2,953,736,108	3,619,490,958
Total non-current liabilities	**42,158,255,964**	**47,419,914,199**	**57,664,470,629**	**67,655,984,423**
Term loan-interest bearing	1,790,359,767	1,808,318,493	1,991,313,004	1,966,838,264
Interest Payable	2,991,851,386	4,272,927,362	5,779,427,703	7,929,219,838
Liabilities for expenses	122,341,304	320,974,260	205,605,143	212,044,593
Liabilities for other finance	(78,928,129)	863,756,589	1,342,973,239	1,496,819,414
Provision for taxation	306,208,090	36,190,504	40,415,000	43,713,910
Total current liabilities	**5,131,832,418**	**7,302,167,208**	**9,359,734,089**	**11,648,636,019**
Total liabilities	**47,290,088,382**	**54,722,081,407**	**67,024,204,718**	**79,304,620,442**
Total equity and liabilities	**64,755,574,726**	**74,503,730,358**	**89,155,703,735**	**108,661,567,612**

(Source: PGCB Annual Reports)

Table 15.4-2 Statement of Comprehensive Income

	30.06.2010 Taka	30.06.2011 Taka	30.06.2012 Taka	30.06.2013 Taka
Revenue	5,929,637,919	6,255,121,287	7,142,208,076	7,870,432,616
Transmission expenses	(3,331,724,343)	(4,574,983,949)	(4,320,538,770)	(4,718,696,940)
Gross profit	**2,597,913,576**	**1,680,137,338**	**2,821,669,306**	**3,151,735,676**
Administrative expenses	(142,367,454)	(210,594,022)	(219,919,063)	(254,574,320)
Results from operating activities	**2,455,546,123**	**1,469,543,316**	**2,601,750,242**	**2,897,161,356**
Finance income	909,081,121	931,493,210	825,634,836	825,045,245
Other income	153,279,057	55,399,525	115,157,155	47,304,164
Finance expenses	(1,406,149,965)	(1,606,262,249)	(1,629,264,693)	(1,653,728,998)
Profit before contribution to WPPF	**2,111,756,336**	**850,173,802**	**1,913,277,541**	**2,115,781,767**
Contribution to WPPF	(100,559,826)	(40,484,467)	(91,108,454)	(100,751,513)
Profit before income tax	**2,011,196,510**	**809,689,335**	**1,822,169,086**	**2,015,030,254**
Income tax expense	721,134,461	114,912,210	(638,625,905)	(1,004,842,371)
Current Tax	5,000	36,185,504	40,415,000	43,713,910
Deferred Tax	721,129,461	(151,097,714)	598,210,905	961,128,461
Profit after tax carried forward	**1,290,062,049**	**924,601,544**	**1,183,543,181**	**1,010,187,883**
Basic Earnings Per Share (per value Tk.100) before Split	**30.79**	**22.07**		
Basic Earnings Per Share (per value Tk.10) after Split	**3.08**	**2.21**	**2.82**	**2.19**

(Source: PGCB Annual Reports)

Table 15.4-3 Statements of Cash Flow

	Particulars	2009-2010 Taka	2010-2011 Taka	2011-2012 Taka	2012-2013 Taka
A.	**Cash flows from operating activities**				
	Cash receipts from customers	5,922,353,487	6,235,045,362	6,916,887,690	7,772,581,746
	Cash paid to suppliers, contractors, employees, etc.	(1,871,141,415)	(4,204,803,283)	(1,599,722,093)	(1,719,326,111)
	Cash generated from operating activities	4,051,212,072	2,030,242,079	5,317,165,597	**6,053,255,635**
	Interest paid	(1,076,304,680)	(325,186,273)	(1,068,669,637)	(669,908,984)
	Income taxes paid	(290,797,912)	(36,185,504)	(40,415,000)	-
	Net cash from operating activities	**2,684,109,480**	**1,668,870,302**	**4,208,080,960**	**5,383,346,651**
B.	**Cash flows from investing activities**				
	Interest received	888,065,746	925,014,085	852,434,486	873,399,275
	Cash receipts from customers	148,365,830	55,399,525	115,157,155	67,304,164
	Addition to property, plant and equipments and capital work-in-progress	(6,575,928,106)	(11,322,145,296)	(17,070,678,051)	(19,605,357,885)
	Investment in fixed deposit	-	-	-	(920,000,000)
	Net cash used in investing activities	**(5,539,496,530)**	**(10,341,731,686)**	**(16,103,086,410)**	**(19,584,654,446)**
C.	**Cash flows from financing activities**				
	Share capital and deposit for share	1,169,382,271	1,751,005,935	2,081,819,999	6,629,358,848
	Long term loan	2,999,615,622	5,249,911,404	9,524,701,760	9,219,237,916
	Dividend paid	(983,766,870)	(364,358,100)	(628,517,715)	(419,011,810)
	Net cash from financing activities	**3,185,231,023**	**6,636,559,239**	**10,978,004,044**	**15,429,584,954**
D.	**Net increase in cash and cash equivalents (A+B+C)**	**329,843,972**	**(2,036,302,145)**	**(917,001,406)**	**1,228,277,160**
E.	**Opening cash and cash equivalents**	10,282,847,457	10,612,691,429	8,576,389,284	2,719,387,878
F.	**Closing cash and cash equivalents (D+E)**	**10,612,691,429**	**8,576,389,284**	**7,659,387,878**	**3,947,665,038**

(Source: PGCB Annual Reports)

Based on the information in the preceding tables, financial indicators for profitability, financial soundness and efficiency were calculated, as indicated further below. The data were also compared with the results from a similar analysis of Tata Power Company, an Indian transmission and distribution operator.

Table 15.4-4 Financial Indicators

		PGCB				Tata Power Company
		2010	2011	2012	2013	2013
1. Profitability						
	Return on assets	1.99%	1.24%	1.33%	0.93%	4.38%
	Return on equity	7.39%	4.67%	5.35%	3.44%	8.36%
	Sales cost ratio	56.19%	73.14%	60.49%	59.95%	78.85%
	Gross profit ratio	43.81%	26.86%	39.51%	40.05%	21.15%
	Operating profit ratio	41.41%	23.49%	36.43%	36.81%	17.80%
	Net profit ratio	21.76%	14.78%	16.57%	12.84%	10.71%
	Working capital ratio	20.08%	16.82%	9.34%	9.43%	-29.41%
	Operating ratio	58.59%	76.51%	63.57%	63.19%	17.21%
2. Financial Soundness						
	Current ratio	265.00%	209.21%	157.54%	154.80%	81.99%
	Quick ratio	233.16%	136.34%	45.91%	47.69%	20.80%
	Fixed assets to equity ratio	292.90%	299.40%	336.22%	308.72%	69.24%
	Fixed assets to long-term capital ratio	85.80%	88.13%	93.25%	93.42%	36.30%
	Debt ratio	270.76%	276.63%	302.85%	270.14%	238.91%
	Equity to total assets ratio	26.97%	26.55%	24.82%	27.02%	29.51%
3. Efficiency						
	Average Electricty Revenue (USD/kWh)	0.0034	0.0033	0.0029	0.0029	0.0971
	Average Electricty Expenses (USD/kWh)	0.0019	0.0024	0.0018	0.0017	0.0765
	Average Operating Profit (USD/kWh)	0.0014	0.0008	0.0011	0.0011	0.0279
	Electrical Energy per Employee (MWh/employee)	-	13,529	15,718	15,878	3,822

(Source: JICA Survey Team)

PGCB is undergoing a major expansion of its facilities and is implementing a number of new projects, mainly with international funding, which has resulted in its non-current assets almost doubling over the past four years. At the same time, the company's revenue stream has shown a 15 % increase over the same period, mainly resulting from higher volumes of electricity transmitted from newly constructed power plants. This, in addition to the fact that the wheeling fee has remained unchanged during the period of the analysis, contributed to the significant drop in the company's profitability, as shown in the falling return on assets and return on equity. Both indicators halved in the period 2010 – 2013.

The sales costs ratio remains within healthy levels, close to levels of transmission companies in neighboring countries, e.g. Tata Power in India. Most of the transmission costs come from depreciation of the assets, while maintenance costs occupy less than 10 % of the costs in 2012-13. These costs mainly cover handling of malfunctioning equipment and do not cover costs of regular maintenance of the equipment.

The current ratio remains above 150%, creating an overall impression of financial soundness, although it has been rapidly decreasing during the observation period. The quick ratio, however, has significantly dropped in the period 2011-13 and reached 47.69% in the FY 2012-2013, mainly due to the decrease in the cash and cash equivalents. Additional factor for the decrease in the current and quick ratios is the faster increase of current liabilities due to fast accumulating interest payments, compared to the increase in current assets.

In terms of efficiency, the company manages to maintain efficient operations with stable revenues per electricity transmitted and high levels of electricity transmitted per employee.

Several issues need further attention. As previously discussed, PGCB has significant exposure to foreign currency debt. The management has opted to follow the provision of the Company Law of Bangladesh, allowing it to add the foreign exchange gain or loss to Property, Plant and Equipment, thus adjusting its assets and not reflecting it in the Profit and Loss statements. In 2013 foreign exchange gain was only 2.5% of the non-current assets, making its effect seem negligible. At the same time, adding these to the Profit and Loss Statement would have increased the company profit by almost 20%. With its current policy, the company avoids the cases of reporting significant losses or significant profits due to reasons beyond its control, and does not openly expose the vulnerability of its balance sheets. Although this would have been an issue for a private commercial entity, PGCB, although listed and publicly traded, remains government owned with BPDB owning more than 80% of its shares. Its loans are also guaranteed by the Government of Bangladesh; thus, adjusting the assets against the foreign exchange rate gains or losses can be considered an optimal short-term solution. However, this practice should eventually be changed in the medium term, especially if the ownership of the company is transferred to a private owner in the future.

The company still has some unsettled payments with the BPDB and other distribution companies. As stated in the auditor's report, there is a possibility that not all of these unsettled and disputed payments are received in full. Thus, their reporting in full amount overstates the earnings per share.

Finally, in terms of inventories, PGCB is still in the process of full evaluation and registering of its inventories, as this was not completed at the time of transfer of capital from BPDB or at any other stage. Movement of inventories also seems to be not properly recorded. Therefore, this is also a Source: of uncertainty in the company's financial reporting.

The following summary can be made:

1) PGCB's financial stability is deteriorating, mainly due to low profitability.
2) Low level of wheeling fees and exposure to foreign exchange risk are a major Source: of uncertainty in the company finances in the short to mid-terms.
3) Increase in interest payments represents the major factor in the increase of current liabilities. Without any improvement on the revenue side, the company finances are

expected to be further aggravated with the start of repayment of the loans for some of the on-going projects.

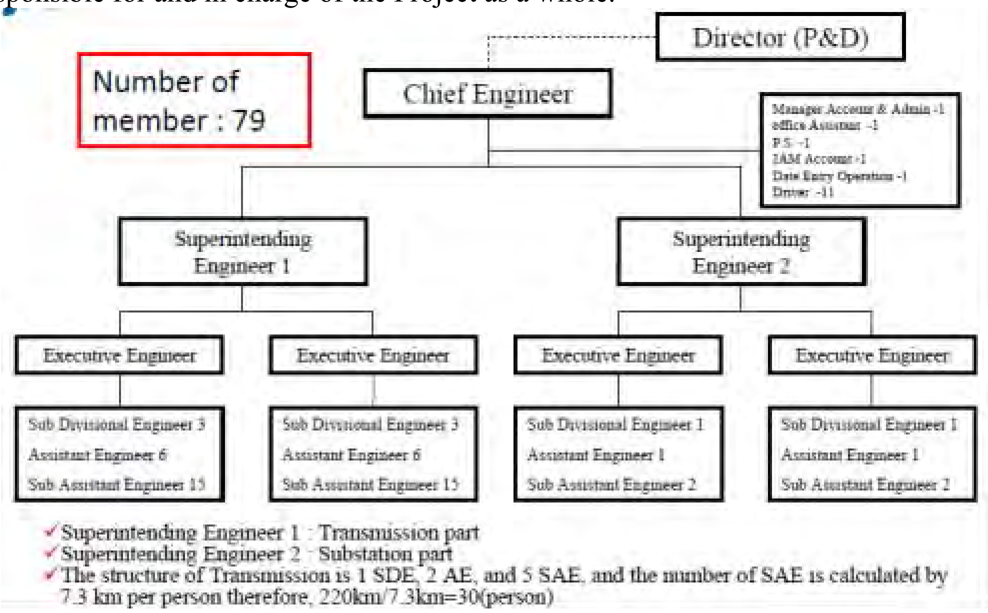
4) In the future, PGCB may need to spend more financial reSource:s on the maintenance of its operating network, especially with the aging of some of its facilities. This will increase further the downward pressure on the company profitability in the medium to long terms.

In view of the above, it is crucial that PGCB's revenue base is stabilized through an increase in the wheeling charges. Additionally, for any new loans, PGCB should not take the exchange rate risk fluctuations on its balance sheet, as it cannot control this and it will negatively affect the operation of the entire company.

15.5 Project Implementation Organization

15.5.1 Project Implementation Organizational Structure

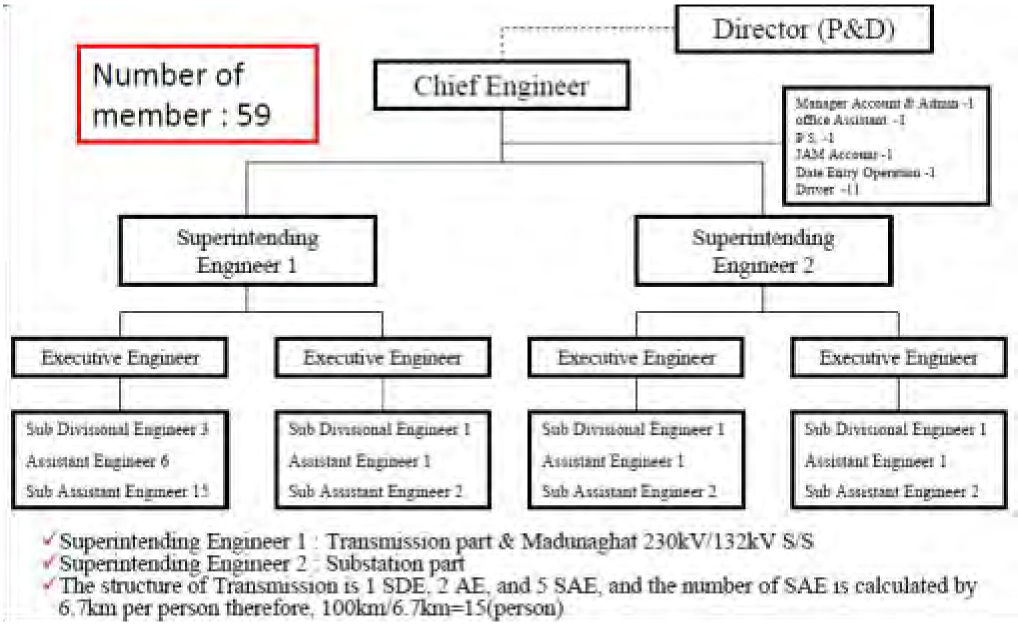
Based on the above, the project implementation organizational structure is as below. The organization is directly set under the P&D division and has the CE as its leader. This CE is responsible for and in charge of the Project as a whole.



(Source: JICA Survey Team)

Figure 15.5-1 Organization of the Project Implementation Unit (Phase 1)

Under the CE, a Super-Intending Engineer (SIE) is placed to support the CE and advise the subordinates. At Phase 1, there are two SIE, one each for the Transmission Line and the Substation. And under the SIE, an Executive Engineer (EE) is placed in order to manage the field tasks. There are 4 EE under each SIE, and for the Transmission Line department, each EE will be in charge of the transmission line for 100km in length; and for the Substation department, two EE are in charge of each substation's upgrading. Under the EE, the structures of 15.3.2 and 15.3.3 are to be considered. From the top positions, they are called: Sub Divisional Engineer (SDE), Assistant Engineer (AE), and Sub Assistant Engineer (SAE). For the Transmission Line department, 1-2-5 persons of each are placed; for the Substation department, 1-1-2 of each. In the Transmission Line department, since 1 SAE is placed for each 5 to 10 km, there are going to be 30 SAE for this project, in accordance with the length of the Project.



(Source: JICA Survey Team)

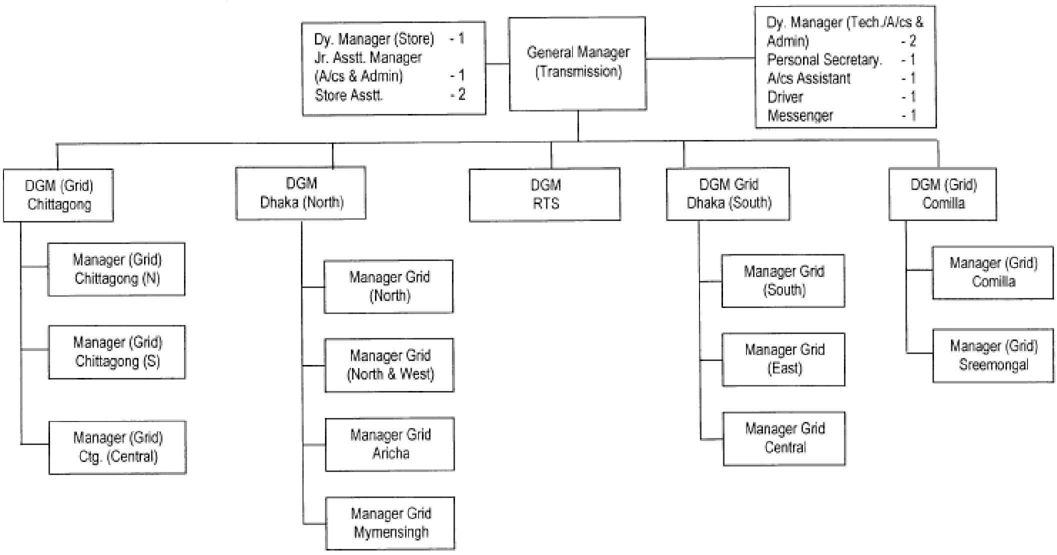
Figure 15.5-2 Organization of the Project Implementation Unit (Phase 2)

Figure 15.5-2 is the organizational structure of Phase 2 of the Project Implementation Unit. The difference between it and Phase 1 is that the SIE-1 is in charge of both Transmission Line and the Madunaghat SS; therefore, the numbers in the lower organization are different, and the numbers in the organizational structure itself are fewer than those of Phase 1.

15.6 The Organizational Structure of the O&M

15.6.1 The O&M of the PGCB

The organizational structure of the O&M is separated into East and West, and the Project lies in the Eastern District, Transmission-1.



(Source: Company Structure of PGCB)

Figure 15.6-1 Organization of Transmission 1

The figure above shows the organizational structure of the Eastern District. From Transmission 1, the area is divided into 4 districts (Chittagong, Dhaka North, Dhaka South, and Comilla) and furthermore, into 2 to 4 districts.

In consideration of the O&M areas, the O&M for the Transmission Line being constructed in the Project is assumed to have the following three districts: the Chittagong South Manager Grid Office in Madunaghat SS, the Dhaka East Manager Grid Office in the Dhaka district, and the Comilla Manager Grid Office in Comilla.

15.6.2 The O&M of the Project's Transmission Line

The Maintenance of Lines and Substation Groups in each area are operating and doing the maintenance for the transmission lines. There is one Line-man per 20 km length of the Transmission Line. Since the Project is planning to construct around 300 km in length, for Phase 1, 11 to 12 Line-men would be assumed, and for Phase 2, around 5 Line-men would be assumed.

15.6.3 The O&M of the Project's Substation

It is assumed to have the Chittagong South Manager Grid Office of Madunaghat SS and Meghnaghat SS operating and doing the maintenance for the transmission lines of the Project. If the substations are 230 kV or 132 kV in capacity, there should be only 12 to 14 persons needed; however, for the 400 kV substations, since there is no operation performed in Bangladesh, it is suggested to have around 20 operators organized in order to grasp the initial situations of operation, and for the acquisition of know-how.