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

Data Collection Survey on Computerization of Gas and Power Network Infrastructure in Bangla desh

Final Report

January 2018

Japan International Cooperation Agency (JICA)

Nippon Koei Co., Ltd.
Chiyoda U-tech Co., Ltd.

BD
CR(3)
17-003

The People's Republic of Bangladesh

Ministry of Power, Energy and Mineral Resources

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Abbreviations	Description
ADB	Asian Development Bank
AGC	Automatic Generation Control
API	American Petroleum Institute
APSCL	Ashuganj Power Station Company Limited
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
Bangladesh	the People's Republic of Bangladesh
BAPEX	Bangladesh Petroleum Exploration & Production Company Limited
BARC	Bangladesh Agricultural Research Council
BAU	Business as Usual
bbl	Barrel
BCF	Billion Cubic Feet
BDT	Bangladesh Taka
BERC	Bangladesh Energy Regulatory Commission
BGDCL	Bakhrabad Gas Distribution Company Limited
BGFCL	Bangladesh Gas Fields Company Limited
BOC	Burmah Oil Company
BOG	Boil-off-gas
BP	British Petroleum
BPC	Bangladesh Petroleum Corporation
bpd	Barrel per Day
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
C/P	Counterpart
CAPEX	Capital Expenditure
CC	Combine Cycle
CCGT	Combined Cycle Gas Turbine
CCPP	Combined Cycle Power Plant
CEGIS	Center for Environmental and Geographic Information Service
CGS	City Gate Station
CIF	Cost, Insurance and Freight
CLDO	Central Load Dispatching Office
CNG	Compressed Natural Gas
COD	Commercial Operation Date
CP	Cathodic Protection
CPGCBL	Coal Power Generation Company of Bangladesh Limited
DES	Delivered Ex-Ship
DESCO	Dhaka Electricity Supply Company Limited
DFR	Draft Final Report
DOE	Department of Environment
DOF	Department of Forest
DPDC	Dhaka Power Distribution Company Limited
DRS	District Regulating Station
DSM	Demand Side Management
EAL	Engineering Associates Limited
EAM	Enterprise Asset Management
EBA	Electricity Business Act
ECC	Environment Clearance Certificate
EDC	Economical load Dispatching Control
EEC	Energy Efficiency and Conservation
EGCB	Electricity Generation Company of Bangladesh

Abbreviations	Description
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMRD	Energy and Mineral Resources Division, Ministry of Power, Energy, and Mineral Resources
EMS	Enegry Management System
EN	European Norm (European Standards)
EQMS	EQMS Consulting Ltd.
ERD	Economic Relation Division
EU	European Union
F/S	Feasibility Study
FDI	Foreign Direct Investment
FGMO	Free Governor Mode Operation
FIRR	Financial Internal Rate of Return
FOB	Free On Board
FR	Final Report
FSRU	Floating Storage and Regasification Unit
FSU	Floating Storage Unit
FY	Fiscal Year
GDP	Gross Domestic Product
GE	General Electric Company
GHG	Greenhouse Gas
GNI	Gross National Income
GoB	Government of Bangladesh
GPS	Geographic Positioning System
GSMP	Gas Sector Master Plan
GSRR	Gas Sector Reform Roadmap
GTCC	Gas Turbine Combined Cycle
GTCL	Gas Transmission Company Limited
GUI	Graphical User Interface
ha	Hectare
HSD	High Speed Diesel
HVDC	High Voltage Direct Current transmission line
Hz	Hertz
IBRD	International Bank for Reconstruction and Development
ICI	Indonesian Coal Index
IcR	Inception Report
ICT	Information and Communication Technology
IEA	International Energy Agency
IEE	Initial Environmental Examination
IEEE	Institute of Electrical and Electronics Engineers
IGCC	Integrated Gasifier Combined Cycle
IGFC	Integrated Gasifier Fuel Cell
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contributions
IOC	International Oil Company
IPP	Independent Power Producer
IRR	Internal Rate of Return
ISO	International Organization for Standardization
ItR	Interim Report
JETRO	Japan External Trade Organization
JGTDSL	Jalalabad Gas Transmission and Distribution System Limited
JICA	Japan International Cooperation Agency
JST	JICA Survey Team
KGDCL	Karnaphuli Gas Distribution Company Limited

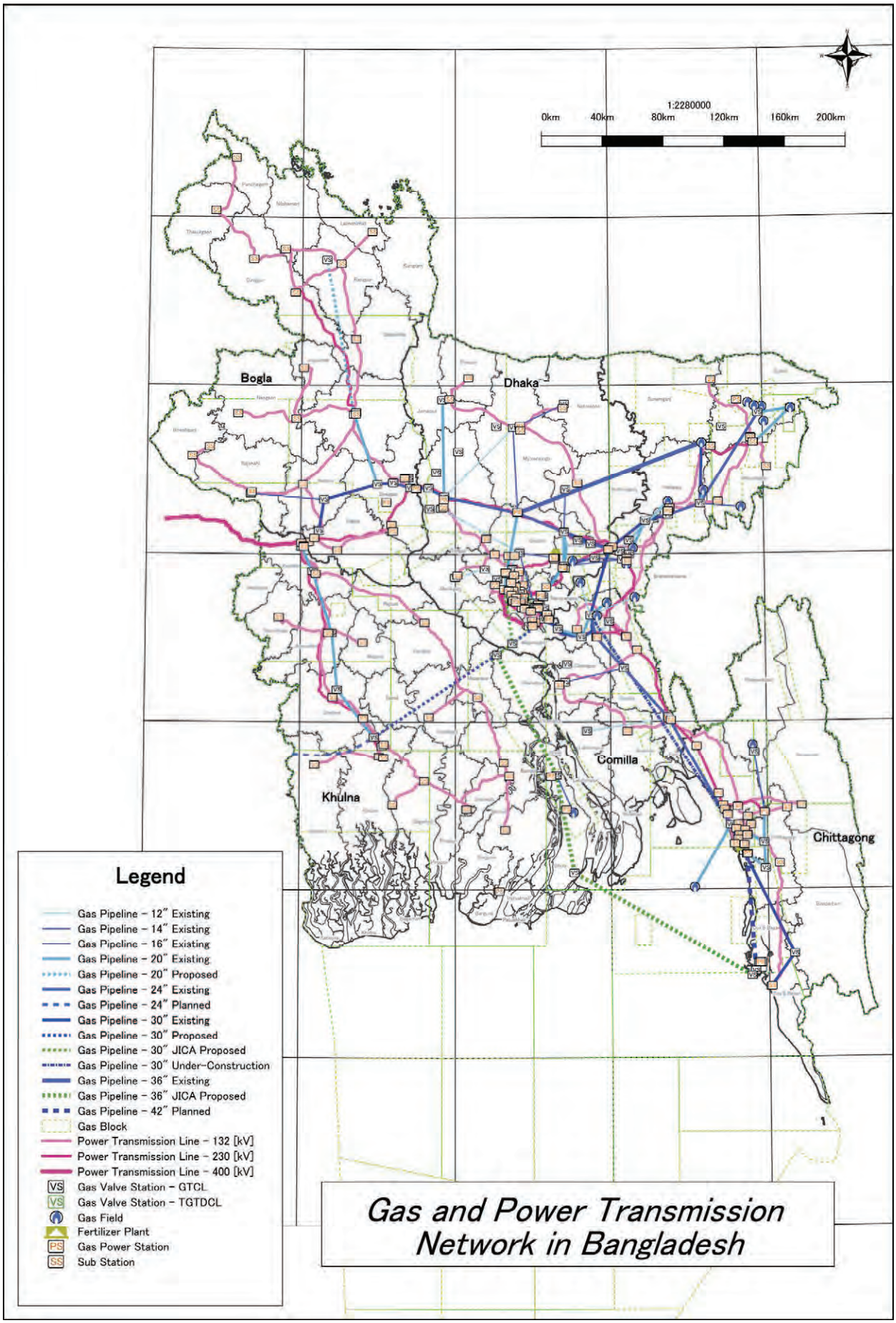
Abbreviations	Description
KPI	key performance indicators
ktoe	Kilo tonne of Oil Equivalent
KV	Kilovolt
kWh	Kilowatt Hour
LED	Light Emitting Diode
LFC	Load Frequency Control
lkm	Line kilometer
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
M/P	Master Plan
MAOP	Maximum Allowable Operating Pressure
MCF	Million Cubic Feet
MDGs	Millennium Development Goals
METI	Ministry of Economy, Trade and Industry
MF	Ministry of Finance
mm	millimeter
MMBTU	Million British Thermal Unit
mcf	Million Cubic Feet
mmscfd	Million Standard Cubic Feet per Day
MTPA	Million Metric Ton per Annam
MOI	Ministry of Industries
MoPEMR	Ministry of Power, Energy and Mineral Resources
MPL	Meghna Petroleum Limited
MPM&P	Management, Production, Maintenance & provisioning Services
MW	Megawatt
MWh	Megawatt Hour
NEXI	Nippon Export and Investment Insurance
NGO	Non Governmental Organization
NK	Nippon Koei Co., Ltd
NLDC	National Load Dispatching Center
NPV	Net Present Value
NSAPR II	National Strategy for Accelerated Poverty Reduction II
NWPGCL	North West Power Generation Company
O&M	Operation and Maintenance
O/C	Open Cut
OCR	Ordinary Capital Resources
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
OPEX	Operating Expense
P&ID	Piping and Instrument Diagram
p.a.	Per Annum
PC	Power Cell
PDP	Power Development Plan
PFD	Process Flow Diagram
PGCB	Power Grid Company of Bangladesh Limited
PGCL	Pashchimanchal Gas Company Limited
POCL	Padma Oil Company Limited
PPA	Power Purchase Agreement
PPL	Pakistan Petroleum Ltd
PPP	Public Private Partnership
PRF	Protected Public Forest
PS	Power Station
PSA	Production Sharing Agreements
PSC	Product Sharing Contract

Abbreviations	Description
PSMP	Power System Master Plan
PSOC	Pakistan Shell Oil Company
PSS/E	Power System Simulator for Engineering
PV	Photo Voltaic
Q & A	Questions & Answers
R&D	Research and Development
REB	Rural Electrification Board
RES	Renewable Energy power Source
RPGCL	Rupantarita Prakritik Gas Company Limited
SCADA	Supervisory Control And Data Acquisition
SDGs	Sustainable Development Goals
SEZ	Special Economic Zone
SGFL	Sylhet Gas Fields Limited
SIPP	Small Independent Power Producers
SME	Small and Medium Enterprise
SMYS	Specified minimum yield strength
SoB	Survey of Bangladesh
SREDA	Sustainable and Renewable Energy Development Authority
ST	Steam Turbine
STANVAC	The Standard Vacuum Oil Company
SW	Smallworld
T/D	Transmission and Distribution
TCF	Trillion Cubic Feet
TDS	Transmission and Distribution Sector (in General Electricity Utility)
TEG	Thermo-Electric Generator
TEPCO	Tokyo Electric Power Company, Inc.
TEPSCO	Tokyo Electric Power Services Co., Ltd.
TGTDCL	Titas Gas Transmission and Distribution Company Limited
Tk	Taka
TOR	Terms of Reference
U/G	Under Ground
UFR	Under Frequency Relay
USC	Ultra Super Critical
USD	United States Dollar
WB	World Bank
WZPDCL	West Zone Power Distribution Company Limited
η	Efficiency

Currency Exchange Rate (if not specified, as of End of December 2017)

1.3823 BDT/USD

113.27 JPY/USD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0km 40km 80km 120km 160km 200km
Bogla
Dhaka
Comilla
Khulna
Chittagong
Legend
Gas Pipeline – 12″ Existing
Gas Pipeline – 14″ Existing
Gas Pipeline – 16″ Existing
Gas Pipeline – 20″ Existing
Gas Pipeline – 20″ Proposed
Gas Pipeline – 24″ Existing
Gas Pipeline – 24″ Planned
Gas Pipeline – 30″ Existing
Gas Pipeline – 30″ Proposed
Gas Pipeline – 30″ JICA Proposed
Gas Pipeline – 30″ Under-Construction
Gas Pipeline – 36″ Existing
Gas Pipeline – 36″ JICA Proposed
Gas Pipeline – 42″ Planned
Gas Block
Power Transmission Line – 132 [kV]
Power Transmission Line – 230 [kV]
Power Transmission Line – 400 [kV]
VS Gas Valve Station – GTCL
VS Gas Valve Station – TGTDCL
Gas Field
Fertilizer Plant
PS Gas Power Station
SS Sub Station
Gas and Power Transmission Network in Bangladesh

EXECUTIVE SUMMARY

The major source of primary energy in Bangladesh is domestic natural gas. The demand for gas is increasing rapidly, while its production is projected to start declining. Energy sector of Bangladesh is facing challenges, such includes (i) Shift of gas operation mode from “allocation” to “demand-based”, (ii) Reliability enhancement of gas network infrastructure, (iii) Coordinated planning of gas and power investment project, and (iv) Modernization of Operation System.

Considering the above issues, Network Infrastructure Management System is the key system to overcome these challenges jointly with the development of modernized of Gas Operation System. The system should be flexible enough to accommodate all the existing systems and to support preventive maintenance, operation safety, and future development plan. SCADA (Supervisory Control And Data Acquisition) system is used to support advanced process control system primarily, and the acquired data will be shared with the Network Infrastructure Management System to support design engineering and long-term monitoring to detect gas leakage and system bottleneck.

Originally the introduction of Network Infrastructure Management System for Bangladesh was proposed in the Power Sector Master Plan 2016. In this regard, the Government of Bangladesh and JICA have agreed to conduct the Survey as a pilot project to see if the Network Infrastructure Management System is applicable to the energy sector of Bangladesh.

The purposes of the Survey are:

1) To create framework of Network Infrastructure Management System for modernized O&M (Operation and Management) and asset management of gas/power infrastructure;
2) To transfer knowledge to set up efficient gas/power infrastructure using Network Infrastructure Management System; and
3) To integrate information on power station and gas/power transmission systems, modelled in the computer system

Network Infrastructure Management System consists of high-performance GIS (Geographical Information System), and highly efficient database. Various existing data can be accommodated and integrated into the system, such include design data, O&M data, SCADA data, field survey data, topographic maps, and pipeline aliment drawings and process flow diagrams, etc. The Network Infrastructure Management System is designed to effectively manage a large-scale infrastructure network, with a network tracing capability from gas field/terminals and/or power plants to each customer.

Report Summary is provided as follows:

CHAPTER 1 INTRODUCTION summarizes the background, survey objective, scope of work, study flow, counterpart agencies, and member of the survey team.

CHAPTER 2 GAS SECTOR describes the result of data collection, current data status and issues in gas sector of Bangladesh. Gas production has continued to be increasing in Bangladesh and producing

approx..900 BCF/year in 2016. However, it is considered to be declining because of aging of existing gas fields, and no significant scale of new discovery has been made so far.

Gas business entities in Bangladesh have experienced several times of entity splits and aggregations, office moves. Numbers of important documents appears to be lost or missing in such transactions. The challenges in gas sector are: (i) Need of reproduction of missing design documents, as-build drawings, process flow diagrams, specifications, etc., (ii) Unify the design standard by reviewing all the past design specifications, and to minimize the numbers of spare parts, (iii) Secure the integrity of transmission and distribution systems to be ready for LNG introduction. (iv) Share the infrastructure information among the entities including power sectors to minimize time and cost for infrastructure investment. The recommendations are:

(i) Introduction of centralized document management system including specification, process follow diagram, and drawing,

(ii) Review of all the specifications and design standard including Maximum Allowable Operation Pressure which appears to be lower than international practice and may have lost gas transmission capacity.

(iii) Preparation of unified and common design standard, standard drawing, and standard specification, and

(iv) Establishment of system integrity from LNG import terminal, transmission pipeline, distribution piping systems up to end users.

CHAPTER 3 POWER SECTOR summarizes power infrastructure update from PSMP2016. As of June 2017, the installed capacity of the total 108 power plants including import power is 13,555 MW, and the present capacity (or de-rated capacity) is 12,771 MW. Of which, in total 61 power plants are gas power with installed capacity 8,810 MW or de-rated present capacity 8,102 MW. There are delay in commissioning power plant due to finance, lengthy approval process, and land acquisition. Power station and power grid network in 2025 and in 2035 was reviewed for future consistency with gas sector.

ICT (Information and Communications Technology) road map is being prepared. It proposes introduction of ERP (Enterprise Resource Planning) system for respective organization. For ERP, basic system with documentation management and database is necessary in the near future. In addition, database for operation data with SCADA, maintenance record, field service, and engineering design needs to be developed. In this regard, it is proposed to introduce Network Infrastructure Management System of asset management system platform.

CHAPTER 4 ENVIRONMENT refers lows and regulations, various document, maps and database which is possible to be applied for strategic environmental assessment for network infrastructure. The information includes: (i) Regulated areas by laws, regulations, act, and rules, (ii) Zoning and policies of related sectors, (iii) Baseline data of related sectors, and (iv) organizations that manage special environmental data in Bangladesh. Environmental scoping for sub-sea pipeline proposed in Chapter 6 was also conducted and major impact was summarized for pipeline corridor, pipeline construction and

operation. The preliminary route of proposed pipeline is overlapped with environmental maps and recommendation for route selection was made.

CHAPTER 5 DEMONSTRATION OF HARMONIZED GAS AND POWER STRATEGIC PLAN is the part that illustrates the prepared demonstration of gas and power network infrastructure in Bangladesh, using the Network Infrastructure Management System "Smallworld". The Network Infrastructure Management System applied "Object Model" which is suitable for large scale, high-accuracy database. The Smallworld system can be the platform of various information system such as ERP, EAM (Enterprise Asset Management), GIS, simulator, and SCADA. It manages network infrastructure facilities in real world mapping together with logical schematic diagram (such as single line diagram) and facility internal building asset data. Collected infrastructure data were incorporated and demonstrated, including data of gas transmission and distribution facilities, power transmission line, substation, and power stations in Bangladesh, together with survey maps and environment base maps. Manuals of demonstration were also prepared.

It was pointed that the drawing preparation, pipe detection survey, and GPS data collection survey is inevitable for system preparation which requires large human resources. The organization for fundamental data preparation and management needs to be set up.

CHAPTER 6 POLICY AND STRATEGY OF GAS INFRASTRUCTURE reviewed current challenges and issues of gas infrastructure. First, two fundamental design issues, MAOP (Maximum Allowable Operating Pressure) and Fish Bone Pipeline Infrastructure was discussed. Due to a lower MAOP used in Bangladesh in comparison with the international engineering practice, overall infrastructure system has been distorted to a certain extend. To provide flexibility in the operation, MAOP need to be raised. Current Fish Bone Pipeline Infrastructure had some advantage in the initial stage of the development but not suitable for current circumstances of Bangladesh. Investment should be directed to Loop construction, especially Dhaka Loop. Loop configuration has advantage of following: 1) Increase of Gas Supply Capacity, 2) Higher Reliability 3) Simple Operation and higher Operational Flexibility.

Gas supply capacity and infrastructure development plan is prepared for the year 2025 and 2035 assuming gas import of 1,750 mmscfd in 2025 and 5,000 mmscfd in 2035. It is recommended that:

By 2025, Dhaka Loop and West Loop to be constructed. Supply capacity to be increased to more than 1,750 mmscfd. Gas evacuation plan from Maheshkhali/Kutubdia to be prepared.

By 2035, Submarine Pipeline from Maheshkhali/Kutubdia to Dhaka Loop to be constructed as part of gas evacuation plan from Maheshkhali/Kutubdia. Proposed pipeline will be #900 ANSI Class, 36 inch, which is capable of transporting 1,700 mmscfd of gas. If required second pipeline can also be constructed in parallel.

This section reviews the performance of gas infrastructure by international development partners. Lessons learned are: (i) It is necessary to use unified and common design standard, (ii) Investment priority to be discussed among the development partners for consistent infrastructure development plan. (iii) Hiring internationally qualified consultant knowledgeable about the industry.

There is a large price gap between the imported gas and domestic gas. There are three LNG Pricing System in Asia, i.e., 1) traditional long-term oil linked pricing system, 2) NBP (National Balancing

Point) linked pricing system, 3) US henry Hub linked pricing system. CIF (Cost, Insurance and Freight) price or DES (Delivered Ex-Ship) price in December 2016 in Japan is USD 8.00/MMBTU, and in Europe (UK) USD 5.88/MMBTU. While Henry Hub price is USD 2.82/MMBTU. This Henry Hub Price is translated to LNG FOB (Free On Board) price of USA at USD 7.00/MMBTU. The most realistically LNG CIF price at Bangladesh will be USD 6.00-8.00/MMBTU under the international market circumstances. On the other hand, gas price for power in Bangladesh is in the range of USD 0.90-1.10/MMBTU.

It is therefore unavoidable for the Bangladesh government to raise gas price, taking into consideration of the current and future international gas price and the most appropriate long-term scenario for gas price reform. It is important to increase the natural gas price progressively to reduce the gap with the international market price of LNG so that the further increase of financial deficit in the national budget is minimized.

CHAPTER 7 SUMMARY AND RECOMMENDATIONS summarizes overall contents, challenges and recommendations. The challenges include (i) Missing system integrity and lack of common design standard, (ii) Operation mode change, (iii) Insufficient pipeline capacity for future LNG import, (iv) Absence of LNG import regulation, (v) Lack of gas and power infrastructure integrated plan, (vi) Lack of centralized data and document management system, (vii) Insufficient readiness for introduction of ERP, and (viii) Insufficient coordination of infrastructure plan among government agencies, companies, and development partners. For the necessary actions toward above challenges, JST (JICA Survey Team) listed the necessary actions as follows

- Review of overall pipeline network and introduction of Loop pipeline system
- Preparation of common design standard
- Construction of #900, 36” Off-shore pipeline
- Establishment of Capacity Right and Quality Bank structure system and accounting system
- Introduction of Network Infrastructure Management System
- Development partner coordination and elaboration of unified specification with qualified consultants

Of the above, introduction of Network Infrastructure Management System to cope with above challenges is the key recommendation in this study, and JST prepared demonstration Network Infrastructure Management System of gas and power sector in Bangladesh. The contents of T/C (Technical Cooperation) project were proposed for the establishment of Network Infrastructure Management System and capacity development in energy sector for the next phase.

CHAPTER 1 INTRODUCTION

1.1 Background of the Project

The major source of primary energy in the People's Republic of Bangladesh (hereinafter referred to as "Bangladesh") is domestic natural gas. The demand for gas is increasing rapidly, while its production is projected to start declining due to depletion around 2018. Under these circumstances, the Government of Bangladesh (hereinafter referred to as GoB) has developed the Power System Master Plan 2016 to 2041 (hereinafter referred to as PSMP2016) including not only long term power generation development target but also energy demand forecast, energy diversification plans emphasized on LNG and Coal import, and implications for energy supply and tariffs. However, Bangladesh faces challenges in energy sector.

(1) Operation Mode Shift

Gas supply system will be shifted from "allocation" to "demand-based", and introduction of advanced process control systems will be required. Mixed supply of domestic gas and LNG would require new billing system to cater the difference in pricing and heating value. Moreover, LNG might become the primary gas source and domestic gas might be the second gas source as LNG is not flexible enough to meet demand fluctuation in the load center. (Planned LNG terminal is located 400 km away from Dhaka area, and gas delivery from LNG terminal takes 10 hours. It is not possible to meet the gas demand fluctuation in Dhaka area without advanced control.)

In this regard, integrated operation system from production to final consumption need to be set up. Currently, subsidiaries of the Bangladesh Oil & Gas Corporation (hereinafter referred to as Petrobangla) operates their business independently, and so it is necessary to enhance the information sharing and coordination among all the companies in an efficient manner.

(2) Enhancement of Gas Network Infrastructure Reliability

Gas network infrastructures need to be strengthened. With the depletion of domestic gas and injection of LNG, gas flow direction will be drastically change. Currently, Gas fields and related infrastructures are concentrated in the north-eastern part of Bangladesh. Therefore, new infrastructures need to be constructed to transport LNG gas and to mitigate the gas shortage especially in the western part of the country. Minimization of Gas leakage is essential, especially during LNG injection. Rehabilitation of aged gas infrastructures is recommended together with updating process flow diagrams and route map, as well as introduction of systematic maintenance system.

(3) Gas and Power Sector Coordinated Planning

There should be more attention paid to collaboration of gas and power supply system. Power stations play an important role as the basic customer for gas pipeline development/extension; on the other hand, gas infrastructures are important for selecting construction site for power stations. Therefore, coordinated plan for both the sectors is necessary to ensure efficient development minimizing time and cost.

(4) Operation Modernizing

Last but not least, modernizing organizations including human resource development is inevitable. System integration and centralized operation/monitoring system need to be introduced in the current gas supply system to ensure proper monitoring. In addition, human resource development, especially the capacity development of the engineers, is a key success variable for Bangladesh at this stage.

For coping with the above-mentioned challenges, it was suggested that modernizing the gas operation and Network Infrastructure Management System would be a starting point in PSMP2016.

"Network Infrastructure Management System" is defined as the computer system with customised database of asset, mapping system, and document/drawings for infrastructure planning and management.

Data of infrastructures will be fed into Network Infrastructure Management System and integrated with the current systems such as SCADA. Information in the system can be utilized for realization of advanced process control, preventive maintenance, safety operation, efficient asset management, etc.

In this regard, GoB and JICA have agreed to conduct this Survey as a pilot project to introduce the Network Infrastructure Management System and investigate its applicability to Bangladesh gas and power sector.

1.2 Purpose of the Survey

The purposes of the Survey are:

1) To create framework of Network Infrastructure Management System for better O&M, and asset management of gas/power infrastructure;
2) To transfer knowledge to set up efficient gas/power infrastructure using Network Infrastructure Management System; and
3) To integrate information on power station and gas/power transmission systems, modelled in the computer system

The survey areas are as follows:

- Gas fields, gas processing plants and connecting pipeline system
- Gas Transmission Company Bangladesh Limited (hereinafter referred to as GTCL) pipelines systems and related facilities such as valve stations
- A part of Titas Gas Transmission and Distribution Company Limited (hereinafter referred to as TGTDCL) pipelines and other gas distribution companies,
- Major industrial gas users including power stations
- Power Transmission system (Lines and Sub-station)

1.3 Scope of Work

The scopes of the work of the Survey are as follows:

1) Data Collection in the Gas Sector (Production/Transmission/Distribution)
   - Gas/Condensate Component and Production, Operating Pressure
   - Process Flow Diagram (hereinafter referred to as PFD) and Piping and Instrument Diagram (hereinafter referred to as P&ID)
   - Transmission/distribution pipe route drawings, and Right-of-way (ROW [1]) information
   - As-build drawings
   - Piping Material Specification/Standard Construction Drawings
   - Construction/Operation Year and Construction Cost
   - Information on tie-in point (location, size, pressure rating, flow meters, etc.)
   - Information on Process Control, Maintenance, Emergency Transaction,
   - Information on CP (Cathodic Protection) System
   - Future expansion and rehabilitation plan (short term: up to 2025, mid term: up to 2035, long term: up to 2041)
2) Data Collection in the Power Sector (Power Station and Power Transmission system)
   - Gas based power station (numbers, location, construction year, requirement of gas, heat rate and efficiency)
   - Transmission line network route (GIS or CAD) (single line diagram, voltage level, size of conductor, number of circuit, construction year)
   - Grid Substation (location, construction year, transformer & breaker capacity, O&M information)
   - Future expansion plan of Transmission system (short term: up to 2025, mid term: up to 2035, long term: up to 2041)
3) Integration of the information of Energy and Power Sector and Proposing an integrated strategy
4) Proposal for the strategy and policy actions for gas infrastructure
5) Data Collection of relevant environment information
6) Draft the demonstration of the Network Infrastructure Management System
7) Study Tour to Japan and USA
   - 1st visit: Introduction and Basic Course (Japan)

[1] Right-of-way (ROW) is the land used for pipeline or transmission line, of which ownership belongs to land owner and right to use is given to the pipeline/transmission line owner.

- 2nd visit: Advanced Course (Japan and USA)

8) Seminars in Bangladesh
   - 1st seminar: Introduction
   - 2nd seminar: Demonstration and Technical Transfer

1.4 The Counterpart Agencies

The counterpart agencies for the Survey were both sectors of gas and power division in Ministry of Power, Energy and Mineral Resources (hereinafter referred to as MoPEMR) and its subsidized organizations, as follows.

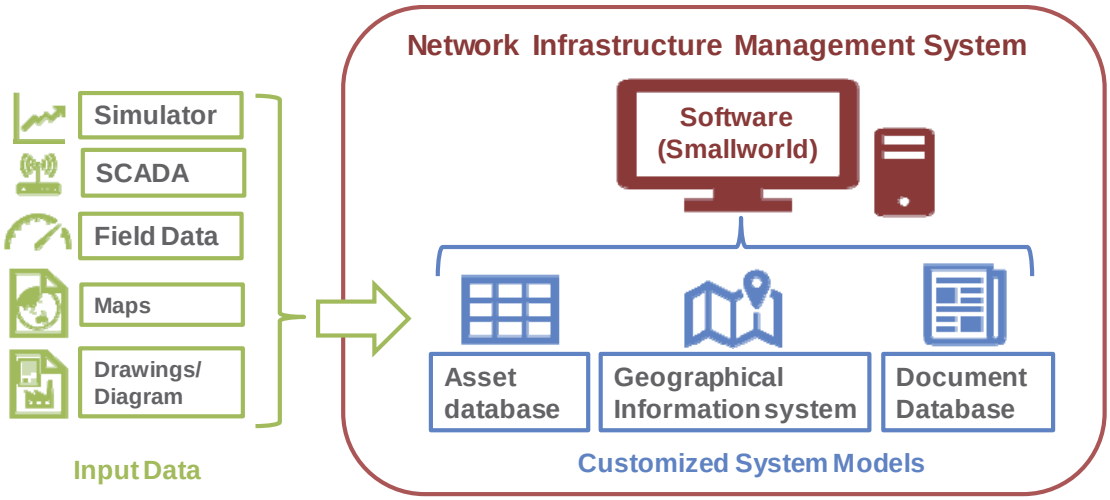
(1) The Energy and Mineral Resources Division (hereinafter referred to as EMRD) of MoPEMR is coordinating bodies for the Survey with other organizations
(2) The Power Division, MoPEMR coordinate the meetings and discussions with each energy and power related agencies and companies with EMRD of MoPEMR.
(3) Each utility agency or company cooperate to provide data and participate in the Survey. The organizations are;
   - Petrobangla and its following subsidiaries
     - Bangladesh Petroleum Exploration and Production Company (hereinafter referred to as BAPEX)
     - Bangladesh Gas Fields Company Limited (hereinafter referred to as BGFCL)
     - Sylhet Gas Field Limited (hereinafter referred to as SGFL)
     - Gas Transmission Company Limited (hereinafter referred to as GTCL)
     - Titas Gas Transmission and Distribution Company Limited (hereinafter referred to as TGTDCL)
     - Bakhrabad Gas Distribution Company Limited (hereinafter referred to as BGDCL)
     - Jalalabad Gas Transmission and Distribution System Limited (hereinafter referred to as JGTDSL)
     - Pashchimanchal Gas Company Limited (hereinafter referred to as PGCL)
     - Karnaphuli Gas Distribution Company Limited (hereinafter referred to as KGDCL)
     - Rupantarita Prakritik Gas Company Limited (hereinafter referred to as RPGCL)
   - Bangladesh Power Development Board (hereinafter referred to as BPDB) and its following subsidiaries
     - Ashugonj Power Station Company Limited (hereinafter referred to as APSCL)
     - Electricity Generation Company of Bangladesh Limited (hereinafter referred to as EGCB)

- North West Power Generation Company Limited (hereinafter referred to as NWPGCL)
- Power Grid Company of Bangladesh (hereinafter referred to as PGCB)
- West Zone Power Distribution Company Ltd. (hereinafter referred to as WZPDCL)
- North west Zone Power Distribution Company Ltd. (hereinafter referred to as NWZPDCL)
- Power Cell

1.5 Basic Concept of Network Infrastructure Management System

Network Infrastructure Management System was proposed to be introduced to tackle the challenges in energy sector in Bangladesh in PSMP2016.

Network Infrastructure Management System consists of computerized infrastructure components with customized system model. It includes asset management database, high-performance GIS (Geographical Information System), and document database. Various types of data can be input and integrated in the system such as planning data with simulator, O&M data from SCADA, field survey data, topographic maps, and drawings and diagrams. The Network Infrastructure Management System is designed to effectively manage a large-scale infrastructure network.



Source: Prepared by JST

Figure 1.5.1 Concept of Network Infrastructure Management System

Object Model has been developed for Network Infrastructure Management System. The features of Object Model are as follows:

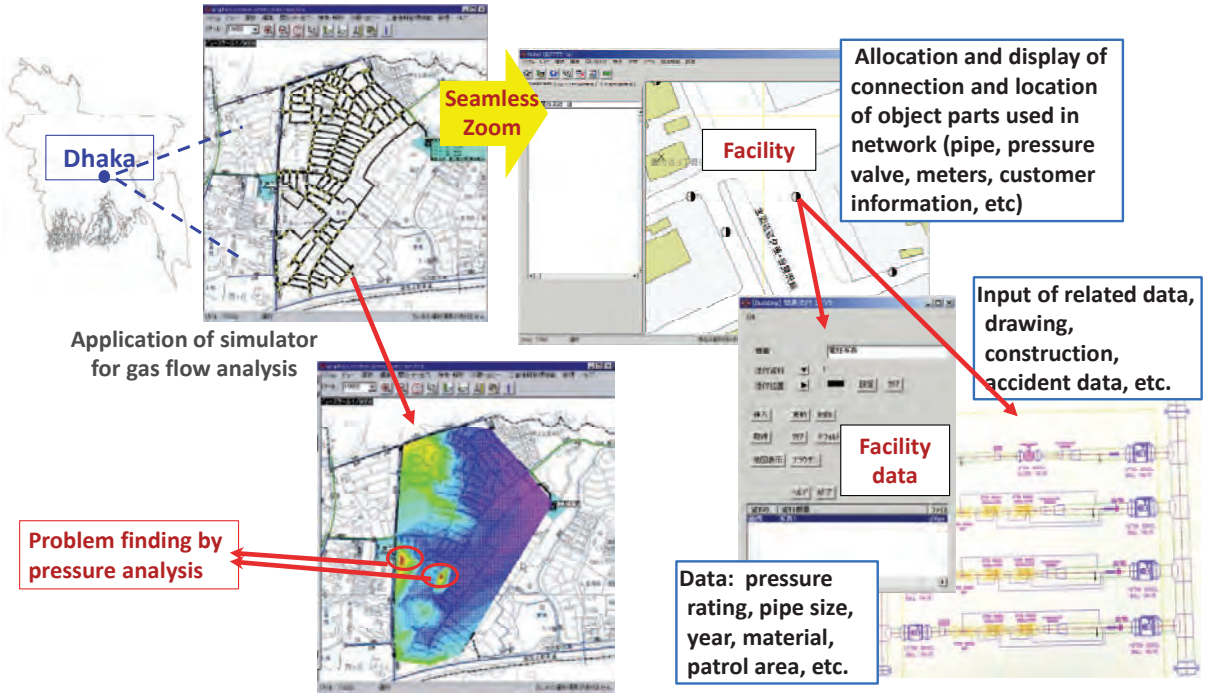
1) Accurate physical configurations of network system components (such as valves, pipes, transformers, cables, etc.) are re-created in a computer system with precise positioning on various scale of maps

2) Connection status (opened/closed, connected/disconnected, etc.) of network system component can be recognized and applied for flow analysis

3) Attribute data of huge amount of objects can be stored

4) Large amount of concurrent users are possible to operate and maintain the system

With the above features, identification of accurate location of system components becomes possible, which enables efficient asset management, optimum infrastructure planning, and operation/safety management. The Network Infrastructure Management System with Object Model has been applied to more than 1,300 utility companies such as gas, power, water, and telecommunications all over the world.



Source: Prepared by JST

Figure 1.5.2 Particular Functions of Network Infrastructure Management System

The details of Network Infrastructure Management System is as illustrated in section 5.1.1.

1.6 Survey Flow and Survey Team

The survey was conducted by a Joint-Venture Team of Nippon Koei Co., Ltd. & Chiyoda U-tech Co., Ltd. The JICA Survey Team consists (hereinafter referred to as JST) of members as shown in the table below.

Table 1.6.1 Members of JICA Survey Team(JST)

SN	Title	Name
1	Team Leader, Gas Infrastructure (Transmission Pipeline Plan)	Mr. Masaaki Ebina
2	Deputy Team Leader, Gas Infrastructure, and Network Infrastructure Management System (Power)	Ms. Yuka Nakagawa
3	Network Infrastructure Management System (Gas)	Mr. Tsunetaka Komachiya
4	Energy Economy and Policy	Mr. Kunio Hatanaka
5	Power Plant Plan	Mr. Toshiyuki Kobayashi
6	Transmission Line Plan	Mr. Keisuke Ueda
7	Gas Infrastructure (Process Design)	Mr. Takashi Sato
8	Piping Design and Standard	Mr. Takehiro Hirobe
9	Environmental and Social Consideration-1	Ms. Akiko Urago
10	Environmental and Social Consideration-2 and Gas Supply Plan	Mr. Kentaro Yamamoto
11	Study Tour Supervision	Mr. Genshiro Kano

Source: Prepared by JST

The flow of the survey is as shown in the figure on the next page.

Figure 1.6.1 Study Flow

Source: Prepared by JST

CHAPTER 2 GAS SECTOR

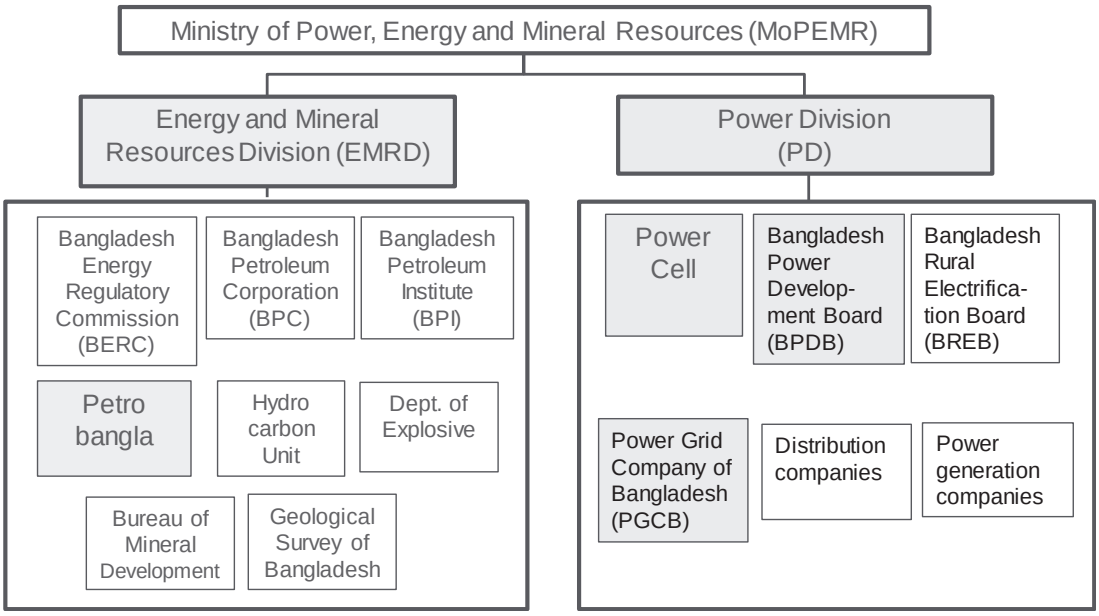
This Chapter describes about gas sector in Bangladesh. It includes organization structure of gas sector, gas production, LNG introduction, status of gas infrastructure, and result of data and document collection. Then, the chapter clarifies issues and challenges of gas sector in Bangladesh and gives recommendations.

2.1 Organization Structure of Gas Sector

2.1.1 Ministry of Power, Energy and Mineral Resources (MoPEMR)

MoPEMR is the main ministry to deal with primary energy and electrical power policy and administration in Bangladesh. As of May 2016, the Prime Minister holds the position of the minister of MoPEMR and State Minister is responsible for conducting the businesses of the Ministry/division in the parliament unless otherwise directed by the Prime Minister.

Under MoPEMR, EMRD and Power Division exist. Energy Division is responsible for all activities related to Energy and Mineral Resources. The structure of MoPEMR is as shown in the figure below.



Source: Prepared by JST with inform website of MoPEMR (https://www.mpemr.gov.bd/ as of 25 Dec. 2017)

Figure 2.1.1 Organization Structure of MoPEMR

2.1.2 Petrobangla

Petrobangla is the National Oil Company of Bangladesh founded under Energy Division in 1985. Currently there are 13 companies operating under Petrobangla dealing in oil and gas exploration, production, transmission, distribution, and marketing of coal and granite. The following is the company structure under Petrobangla.

Source: Petrobangla

Figure 2.1.2 Company Structure of Petrobangla

Under the organization, there are four major groups: Gas and Oil Exploration and Production Companies (BAPEX, BGFCL, SGFL), a Transmission Company (GTCL), a Gas Transmission and Distribution companies (TGTDCL and JGTDCL), Gas distribution Companies (BGDCL, PGCL, KGDCL, SGCL), CNG & LPG Marketing Company (RPGCL), and Coal and Granite Mining Companies (BCMCL, MGMCL). RPGCL is given responsibility to manage and operate LNG import facilities including LNG receiving Terminals.

2.1.3 Gas Companies

Gas Sector consists of three segments, i.e., Gas Exploration and Production Companies, Gas Transmission Company, and Gas Distribution Companies, as follows:

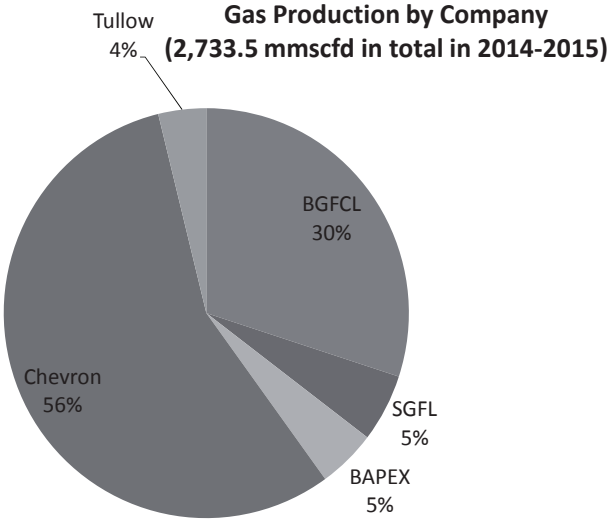
(1) Gas Exploration and Production Companies

The following are the national companies of gas exploration.

- BAPEX (Bangladesh Petroleum Exploration and Production Company Limited)
- SGFL (Sylhet Gas Field Limited)
- BGFCL (Bangladesh Gas Field Company Limited)

In addition to above three national companies, there are two international oil companies producing gas and condensate under Product Sharing Contract with Petrobangla, i.e., Chevron and Tullow.

Gas Production by above companies in FY 2014 -15 is shown in the figure below.

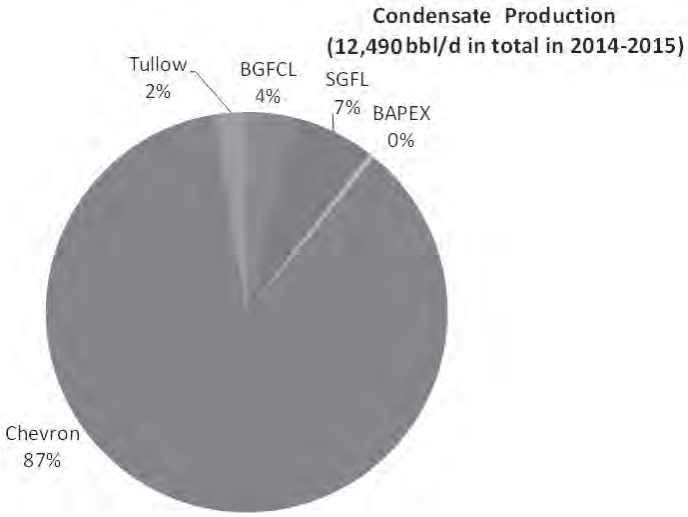


Source: Petrobangla Annual Report 2015

Figure 2.1.3 Gas Production in FY2014-15

Gas production by international oil companies (Chevron and Tullow) accounts for 60% of total gas production.

Condensate, the liquid component, is also produced as an associated product. The figure below shows the amount of production of condensate by gas companies.



Source: Petrobangla Annual Report 2015

Figure 2.1.4 Condensate Production in FY2014-15

Condensate is sold to petroleum companies in Bangladesh from the gas field companies. The total condensate production was 12,490 bbl/d in 2014-15.

(2) Gas Transmission Company

GTCL(Gas Transmission Company Limited) is the company under Petrobangla which has the responsibility to transport gas from gas field to six (6) franchise distribution companies in Bangladesh as listed in (3) below.

(3) Gas Distribution Companies

There are 6 franchise gas distribution companies to cover the country, as follows and as the following figure.

1) TGTDCL (Titas Gas Transmission and Distribution Company limited)

TGTDCL has a distribution franchise area including Dhaka. Sales volume accounts for 62% of the market share, which is the largest among others.

2) BGDCL (Bakhrabad Gas Distribution Company Limited)

BGDCL has a market franchise area in the south-east part of the country in Comilla area. Sales volume is the second largest and accounts for 14% of the market share.

3) JGTDSL (Jalalabad Gas Transmission and Distribution System Limited)

JGTDSL has a market franchise area around Sylhet. The sales volume accounts for 9% in the market.

4) KGDCL (Karnaphuli gas Distribution Company Limited)

KGDCL is splinted out from BGDCL and covers Chittagon Area. The sales volume accounts for 11% of the market.

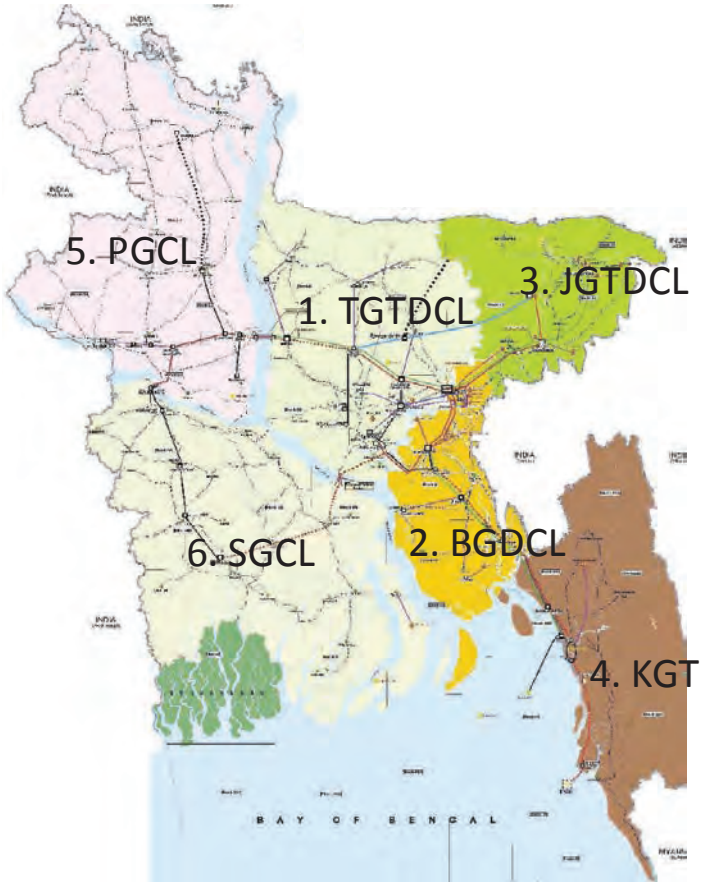
5) PGCL (Pashchimanchal Gas Company Limited)

PGCL is relatively new company with its franchise area in the north-west part of the country.

6) SGCL(Sundarban Gas Company Limited)

SGCL is new company with its franchise area in the south-west part of the country.

The locations of franchise areas of the above companies are shown in the figure below.



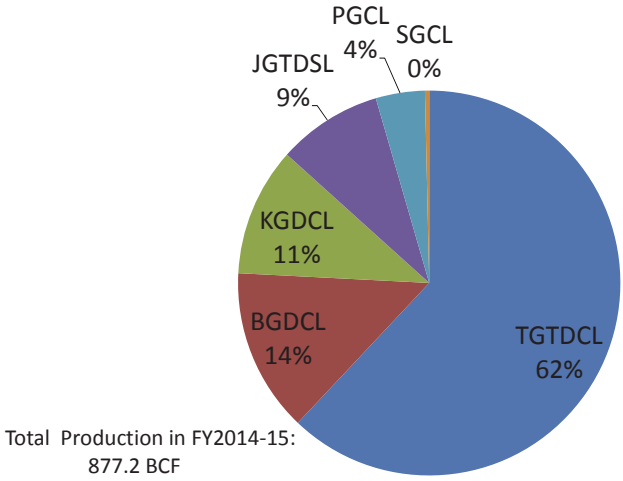
Gas Distribution Franchise Area

1. Titas Gas Transmission and Distribution Company Limited (TGTDCL)
2. Bakhrabad Gas Distribution Company Limited (BGDCL)
3. Jalalabad Gas Transmission and Distribution System Limited (JGTDSL)
4. Karnaphuli Gas Distribution Company Limited (KGDCL)
5. Pashchimanchal Gas Company Limited (PGCL)
6. Sudaban Gas Company Limited (SGCL)

Source: Prepare by JST using GTCL Map

Figure 2.1.5 Gas Distribution Franchise Area

Gas Sales share by each franchise company is as shown in the figure below.



Source: Petrobangla Annual Report 2015

Figure 2.1.6 Gas Sales Share of Gas Distribution Companies in FY2014-15

2.1.4 History of Gas Field Development and Associated Infrastructure (Pipeline and Distribution System)

After formation of Petroleum Act in 1948, The Standard Vacuum Oil Company (hereinafter referred to as STANVAC) of USA, Pakistan Petroleum Ltd. (hereinafter referred to as PPL), and Pakistan Shell Oil Company (hereinafter referred to as PSOC) started the exploration in Bangladesh. PPL was founded by Burmah Oil Company (BOC) of the United Kingdom, known as British Petroleum or BP in the present day, for exploration, prospecting, development and production of oil and natural gas resources in Indian continents.

STANVAC drilled north western part of the county, i.e., Hazipur, Bogra, and Kuchman; however no success and withdraw from the exploration race.

PPL discovered three gas fields in Haripur, Patharia, and Chhattak, and PSOC discovered 5 gas fields in Titas, Habiganj, Rashidpur, Kailashtila and Bakhrabad.

After independence of Bangladesh, 5 gas field of PSOC were bought under the state ownership in 1975, and entrusted to BGFCL. BGFCL is contributing 35% of gas production in the country. Three gas fields of PPL was entrusted to SGFL. SGFL currently operates gas fields of Haripur (Sylhet), Kailashtila, Rashidpur, and Beanibazar, a total of 13 wells produce in total 150 mmscfd of gas, which account for 5.5% of total gas production in Bangladesh in FY2014-2015.

TGTDCL was founded in 1964 as a Joint Venture (JV) between the Government of Pakistan and PSOC to commercialize the gas produced by PSCO. The company began its commercial operation with the commissioning of gas supply to Siddhirganj Thermal Power Plant in 1968 via. 14 inch 93 km gas transmission pipeline, i.e., Titas-Demra pipeline.

BGDCL was named as Bakhrabad Gas Systems Limited (BGSL) operating as gas production, transmission and distribution company. The franchise area includes Chittagon area. Bakhrabad Gas field was handed over to BGFCL and two main transmission lines: 24 inch 110 km Bakhrabad-Chittagon and 20 inch 69 km Bakhrabad Demra pipeline, were handed over to GTCL. Franchise area of BGSL was also divided into Comilla area as BGDCL and Chittagon area as KGDCL.

Gas Transmission Company Limited (GTCL) was incorporated in 1993 with the objective s of 1) centralized O&M of national gas grid, and 2) expanding national gas grid to cover all regions of the country.

In 2000, PGCL was founded to distribute the gas to North West area of the county. SGCL was also founded in 2009 to supply the gas to South West region.

2.1.5 Issues and Challenges in Maintenance

Maintenance work has not been given enough importance in Bangladesh. Physical location of the pipelines or distribution piping system is recorded only in the memory of the person in charge. Once these people retire or move, no other people can trace the exact location. Although project documents

and drawings are available, there is no centralized overall drawing/document management system at present, and important drawing/document has been dispersed or lost during personnel reshuffling.

Maintenance program and maintenance cost for gas transmission and distribution asset is not always shown in the annual report of each Petrobangla Companies. It is considered that recognition for maintenance and Asset Management needs to be enhanced.

Construction project will take a few years to complete but maintenance work will last much longer time to secure the integrity of the assets and support reliable operations.

Depreciation is based on 5% of devaluation for 20 years in average and added back to the cash flow. The idea of Depreciation is to support the renewal of the production facility in future. To justify maintenance budget, budget allocation should be reviewed and more budget should be allocated to the maintenance side to secure the integrity of the system.

Table 2.1.1 Depreciation vs. Expense for Annual Maintenance (in Bangladesh Taka)

Description	GTCL	JGTDCL	TGTDCL
Depreciation for Transmission and Distribution Asset	2,018,795,610	103,513,476	783,906,283
Expenditure for Repair and Maintenance	90,496,737	34,733,431	
Expenditure for Transmission and Distribution			330,839,046

Source: Annual report of JGTDCL and TGTDCL in 2015-16, GTCL in 2016-17

In this regard, World Bank is supporting the introduction of Enterprise Resource Planning (hereinafter referred to as ERP). GTCL has started to install ERM (Enterprise Resource Management) and EAM (Enterprise Asset Management) system for its own management information system and asset register as part of ERP, which will be the starting point to achieve the system integrity.

ERP is a concept to optimize enterprise's resource via. Information and Communication technology (ICT), not a simple software. Objective of ERP differs from industry to industry. The manufacturing industry may use the ERP to maximize the profit and minimize the cost, while utility industry may maximize the safety and minimize the cost. The difference is that lifetime of the asset is short for manufacturing industry, while that of utility industry is much longer and need to maintain as an infrastructure for long time. Each entity need to customize the system to suit by itself.

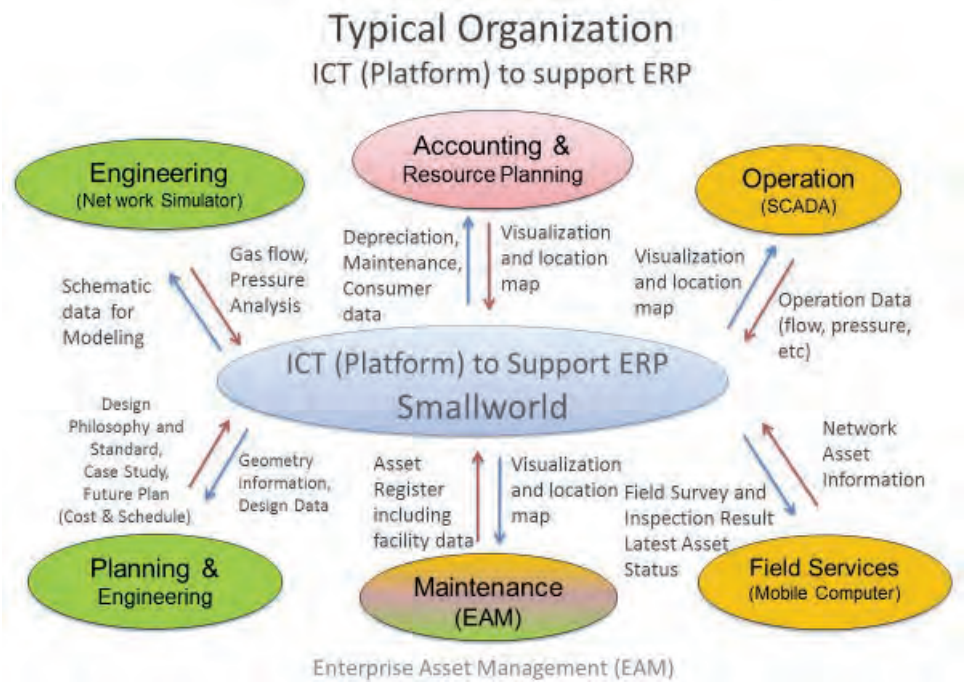
ERP is generally recognized as follows:

1) ERP is a Concept, not a System, to maximize Profit and minimize Cost introduced by Manufacturing Industry.
2) Concept of ERP differs from Industry to Industry.
3) Gas Industry has its own Concept of ERP.
4) ERP in Gas Industry has been developed since end 1970s, for 40 years.
5) ERP is continuous effort to customize and update to cope with real situation over the years

6) Standardization and sound documentation system is the key for the success of ERP

Concept of Maintenance should be developed as part of ERP and supporting budget for it should be allocated.

The following is a typical organization to support ERP through ICT. Typical organization consist of Engineering & Maintenance Department and Operation Department and Field Service Section. Field Service Section is designed to work for both O&M, and customer services for emergency transaction. Enterprise Asset Management (hereinafter referred to as EAM) is the system for the management of the physical assets of enterprise, such as design, construction, commissioning, O&M of equipment and facilities, as part of ERP. Note that integration of ERP/EAM with Network Infrastructure Management System, namely, "Smallworld" is proven by its manufacturer.



Source: Prepared by JST

Figure 2.1.7 Concept of ICT Platform for EAM

In this survey, JST recommend use of "Small World" as the data platform. Engineering, Operation, Maintenance, and ICT should work in harmony to achieve ERP.

2.1.6 Issues and Challenges in Operation

Current gas infrastructure operation system in Bangladesh is based on Gas Allocation System, managed by independent gas production, transmission, and distribution companies under Petrobangla umbrella. LNG introduction requires the system integration and the advanced control system to meet the change of operation mode. To minimize the operational and financial risk associated with LNG introduction for Petrobangla, it is worth considering the introduction of Capacity Right and Quality Bank in LNG Terminal Operation. Capacity Right is the right to use gas transmission capacity

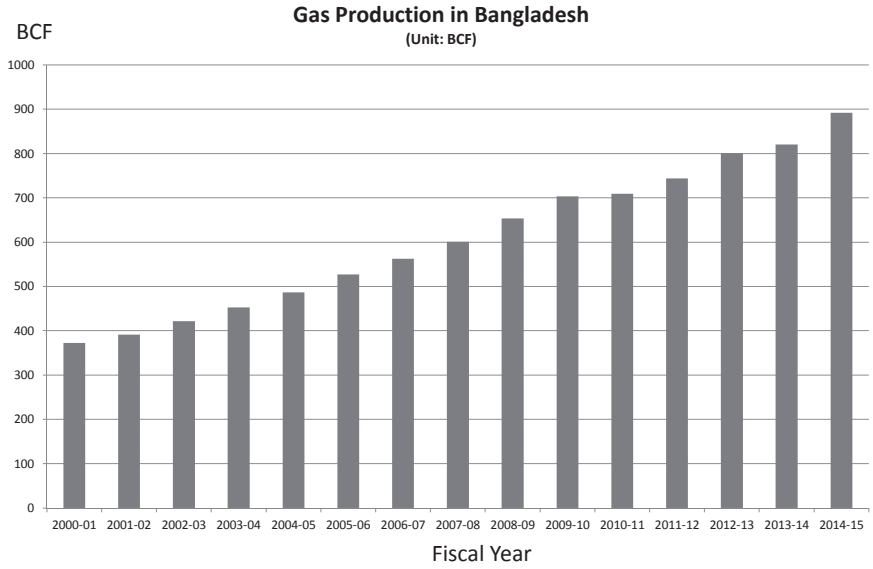
allocated to each LNG suppliers. Quality Bank works to settle the account among the supply projects with difference in gas supply capacity, heating values, pricing and contract terms.

2.2 Gas Production

2.2.1 Summary of Gas Production

Gas Production has continued to be increasing in Bangladesh until now. The following figure shows a record of gas production for the last 15 years in Bangladesh.

Gas production is increasing; however, it is considered that gas production is declining because of aging of existing gas fields, and no significant scale of new discovery has been made so far and long lead time is necessary for future new exploration.



Source: Petrobangla Annual Report 2015

Figure 2.2.1 Gas Production Trend in Bangladesh

Although Petrobangla regards the enhancement of exploration and exploitation of natural gas in Bangladesh is one of their mission, it is necessary to prepare the case when gas exploration is not successful as expected.

2.2.2 Summary of Gas Exploration

(1) Onshore Exploration Activities

BAPEX as the only state-owned petroleum exploration company, is given responsibility of exploration. Most of the fund comes from Gas Development Fund (hereinafter referred to as GDF), financed by part of gas sales revenue. BGFCL is trying to solve the issues of gas seepage in the Titas gas field associated with gas exploration and production activities, supported by Azia Development Bank (hereinafter referred to as ADB). SGFL is also actively drilling the gas field in Sylhet, Kailashtilla, and Rashidpur fields. It is supported by GDF.

1) BAPEX

BAPEX has set plan to accelerate the development activity and to trim down the dependence on IOCs in 2015. To materialize the objective, BAPEX has undertaken the following work-plan to reach the goal of Vision 2021:

- BAPEX will conduct 3,000-line km 2D seismic survey under proposed project named "Block 8 and 11 Regional 2D Seismic Survey Program" from July 2016 to June 2019;
- Drilling of 53 exploratory wells, 35 development wells and workover/remedial of 20 wells (a total of 108 wells) from July 2015 to June 2021; and
- To strengthening BAPEX and to implement the above work plan, employment of consultants and experts of different relevant fields on contractual basis is under active consideration.

2) Summary of Onshore Exploration Investment Project

The following is a list of project and budget scale under implementation; it summarizes the activities.

Table 2.2.1 List of Exploration Project under Implementation

Unit: Taka in Million

	Project Name	Project Period	Fund	Executing Agency	Estimated Cost
1	Mobarakpur Oil/Gas Exploration Well Drilling Project	Jan 06-Dec 15	GoB	BAPEX	892.6
2	Gas Fields Development Project of BAPEX (Saldanadi Well no. 3,4 and Fenchuganj Well no. 4, 5)	Jan 10-Jun 16	GoB	BAPEX	3056.4
3	Augmentation of Gas Production under Fast Track Program (Drilling of 4 wells under BGFCL and 1 well under SGFL) (Titas Well no. 19, 20, 21, 22 and Rashidpur Well no. 8)	Jul 10-March 16	GoB	BGFCL, SGFL	13005
4	Gas Seepage Control and Appraisal and Development of Titas Gas Field (Titas Well no. 23, 24, 25 and 26)	Jan 10- Jun 17	ADB	BGFCL	
6	Procurement of Standby Gas Process Plant for Shahbazpur Field	June'17	GDF	BAPEX	953.4
7	Workover of Wells at Titas Gas Field Seepage Area	Jul 13-Dec 16	GDF	BGFCL	2350
8	Drilling of 1 Appraisal Oil Well/ Development Gas Well (Kailashtilla no. 7) at Kailashtilla Structure	Sep 12-Dec 16	GDF	SGFL	2181.9
9	3D Seismic Project of BAPEX	Dec 12 -Nov 17	GDF	BAPEX	1825
10	2D Seismic Project of BAPEX	Dec 12- Jun 17	GDF	BAPEX	711.3
11	Drilling of Well no. Kailashtilla-9 (Appraisal/ Development Well)	Nov 13- Dec 17	GDF	SGFL	1400.7
12	Drilling of Well no. Sylhet-9 (Appraisal/ Development Well)	Dec 13-Jun 18	GDF	SGFL	1602.7
13	Drilling of Well no. Rashidpur-9 (Appraisal/ Development Well)	Feb 15- Jun 17	GDF	SGFL	1980.7
14	Drilling of Well nos. Rashidpur-10 and 12 (Exploratory Wells)	Jul 14- Dec 17	GDF	SGFL	4098.1
15	Installation of Gas Compressors at Bakhrabad Field	Jqn 14- Jun 17	GDF	BGFCL	1197.5
16	Procurement of Gas Process Plant for Srikail Gas Field	Jul 14- Dec 16	GDF	BAPEX	754.5
17	Shahjadpur-Sundalpur (Sundalpur-2) Appraisal/ Development Well Drilling Project	Oct 14- Jun 16	GDF	BAPEX	754.5
18	Rehabilitation of Engine, Mud Tanks & Electrical Power System of IDECO-Rig Project	Nov 14- Jun 16	GDF	BAPEX	389

Note:
GoB: Government of Bangladesh
GDF: Gas Development Fund
ADB: Asia Development Bank

Source: Petrobangla Annual Report 2016

(2) International Oil Company (IOC) and Product Sharing Contract (PSC)

According to Annual Report of Betrobangla 2016, 4 gas fields are currently being operated by IOCs under PSC. Of them, 3 fields (namely Bibiyana, Jalalabad and Moulvibazar Gas Fields) are being operated by Chevron and Bangora Gas Field by Tullow/KrisEnergy.

Bibiyana: Bibiyana field is now the largest supplier of gas to the national grid, delivering around 1,200 mmscfd gas and 9,500 bbl/day condensate from 26 wells. The design capacity of the process plant is 1,350 mmscfd.

Jalalabad: Jalalabad Gas Field has 7 wells including 3 additional new wells drilled at 2015. Currently, total production from this field is around 270 mmscfd gas and 2,000 bbl/day condensate.

Moulvibazar: Moulvibazar is producing 40 mmscfd (down from 110 mmscfd) from 6 wells while the installed process plant capacity is 125 mmscfd. As production is now declining, the operator is investigating ways to enhance or at least sustain present rate of production.

Bangora: Bangora field started its production in 2006, peaking at 120 mmscfd in 2010 and thereafter declining to 100 mmscfd from 4 wells. 2 development wells have been planned to drill to sustain the current rate of production. In December 2016, one well has been drilled successfully.

(3) Preparation for future Offshore Bidding Round:

High investments and technologies are required for deep sea exploration and production.

To attract the IOCs who are capable of developing the offshore field, model PSC need to recognize, address and accommodate this issue in their model PSC offerings. Current offshore exploration status is as follows:

1) Block SS-04 and 09 by ONGC Videsh Ltd. (OVL)

In the 1st phase ONGC Videsh Ltd.(OVL) has completed 3,008 lkm[2] of 2D marine seismic survey data acquisition. In the 2nd phase OVL will carry out 2542 lkm 2D OBC survey. As of December 2016 OVL completed about 500 lkm survey. By January 2019 OVL will drill 1 exploratory well in block SS-04 and 2 exploratory wells in block SS-09.

2) Block SS-11 by Santos

Santos conducted 3,050 line kilometers of 2D seismic survey in 2015 Interpretation and integration of the data sets have been completed and submitted the report to Petrobangla in the first quarter of 2016. They are going to conduct 300 sq. kilo meters of 3D seismic survey in the 3rd quarter 2017. By February 2019 Santos will drill 1 exploratory well in block SS-11.

3) 2D Seismic Survey by Petrobangla

Petrobangla has planned to undertake 2D Non-Exclusive Multi-Client Seismic Survey in the offshore area of Bangladesh. The objective of the survey is to provide oil and gas industry

[2] Line kilometer

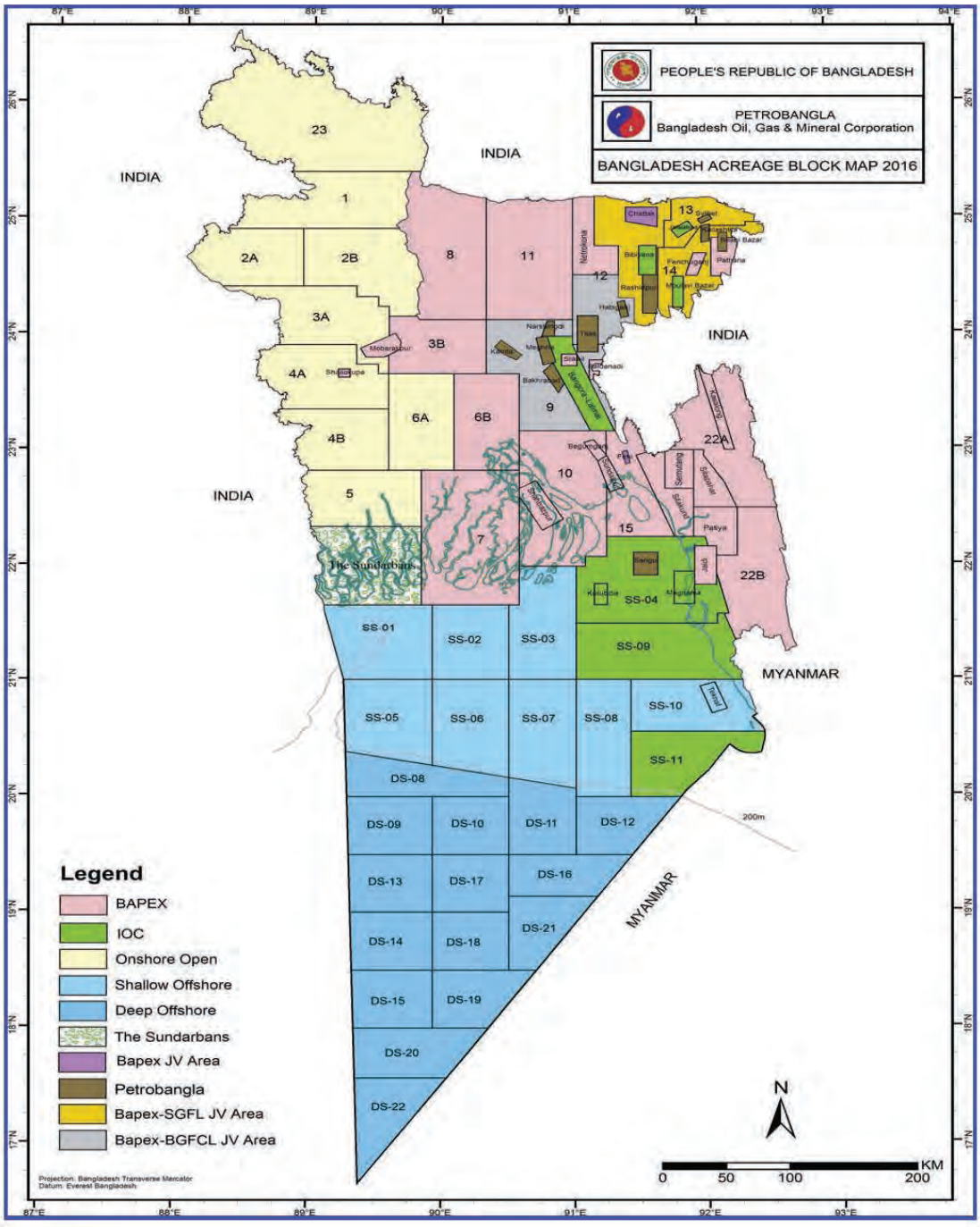
with 2D Non-Exclusive Multi-Client Seismic data of the offshore areas in order to help with basin evaluation, prospect generation and robust bid round participation. Bids have been invited, received and evaluated. Government approval is now awaiting for signing the contract with successful bidder.

4) Block DS-12 by POSCO DAEWOO Corporation

Under the Special Act for speedy gas supply, PSC for deep sea block DS-12 is going to be signed with POSCO DAEWOO Corporation. Initially they will carry out 1800 lkm 2D seismic survey. Depending upon the outcome of the survey Daewoo will conduct 1000 Sq.km. 3D seismic survey and drill one exploratory well.

5) BAPEX Farm-in to Block 16

BAPEX has taken over 49% of rights of Santos Bangladesh Ltd's block 16 Magnama stake under PSC. BAPEX and Santos have started to drill Magnama-2 exploratory well.



Source: Petrobangra Annual Report 2016

Figure 2.2.2 Gas Block Map in 2016

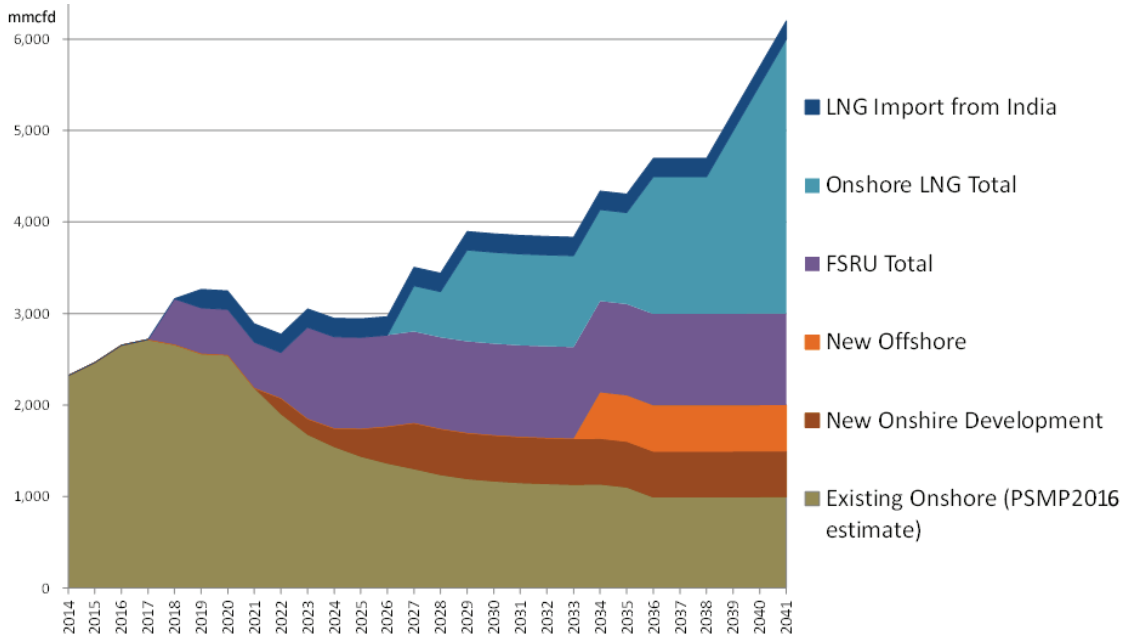
As stated above, there are large expectation of new gas field development including offshore field. Financial resources should be injected for the enhancement of capacity of BAPEX for gas exploration including 2D/3D seismic survey.

Meanwhile, new gas field exploration takes long time. It should prepare for the cases if the new gas exploration does not be developed as expected.

2.3 LNG Introduction Project Summary

In accordance with PSMP 2016, LNG requirement by 2041 will be increased to 4000 mmscfd, assuming that 1000 mmscfd of gas is produced from new onshore/offshore gas fields in future.

However, there are risks in future discoveries in onshore and offshore gas fields, what if it is not happening as expected, and what if depleting profile of existing gas field is faster than expected. To avoid such risk exposure, LNG import plan should be prepared and facility should be constructed soonest and to be ready for any conceivable risks in supply.



Source: PSMP 2016

Figure 2.3.1 Gas Supply Scenario by PSMP 2016

According to Draft Final Report of Gas Sector Master Plan (GSMP) as of July 2017, Forecast gas requirement is much higher than that of PSMP 2016. Even in the moderate case, 12,000 mmscfd of gas will need to be imported in 2041, while PSMP forecast 4,000 to 5,000 mmscfd, if no new discovery is made by 2041.

The following table shows LNG import projects statuses known at this stage.

Table 2.3.1 LNG Import Projects

(as of Nov 2017)

	Type	Terminal Operator	Location	Flow Rate (mmscfd)	Commissioning Schedule	Project Type	Status
1	FSRU	Excelerate Energy	Moheskhali	500	Apr-18	BOOT	Contract Signed
2	FSRU	Summit Corp.	Moheskhali	500	Oct-18	BOOT	Contract Signed
3	Land Terminal	China Huanqiu Contracting & Engineering (HQC)	Moheskhali	1,000	Dec-21		MoU Signed
4	FSU	Hongkong Shanghai Manjala Power Ltd. (HSMPL)	Moheskhali	500	26 months after Agreement		Term Sheet Signed
5	Land Terminal	Petronet	Kutubdia	1,000	Under confirmation		Head of Understanding Signed
6	FSU	Relience	Kutubdia	500	Dec-19		MoU signed
7	Land Terminal	Sembcorp	Moheskhali	1,000	Dec-22		MoU signed

Source: RPGCL

So far, seven projects are listed and under development stage. Some developer proposes to use Floating Storage Re-Gasification Unit (FSRU), some propose land terminal, and some proposes Floating Storage Unit (FSU). Proposed site is also different project by project.

RPGCL, one of the state-owned companies under Petrobangla, has been given responsibility to manage gas import and LNG Terminal Operation. RPGCL will need to set up the system to manage mixture of several different aspect of gases as follows:

(1) Different pricing
(2) Different Quantity/Profile/Contract Term
(3) Different Heating Value

2.4 Status of Gas Production/Transmission and Distribution Infrastructure

2.4.1 Data Collection Summary

Data are collected from Petrobangla and its 10 subsidiary companies. These include the following:

- Gas Transmission/ Distribution: Target Organization is GTCL, TGTDCL, BGDCL, JGTDCL, PGCL, SGCL, and KGTDCL
- Gas Field and Processing Facilities: Target Organization is Petrobangla, SGFL, BGTCL, BAPEX
- LNG Terminal: RPGCL

(1) Data for Gas Transmission and Distribution

The following data was collected from gas transmission and distribution companies

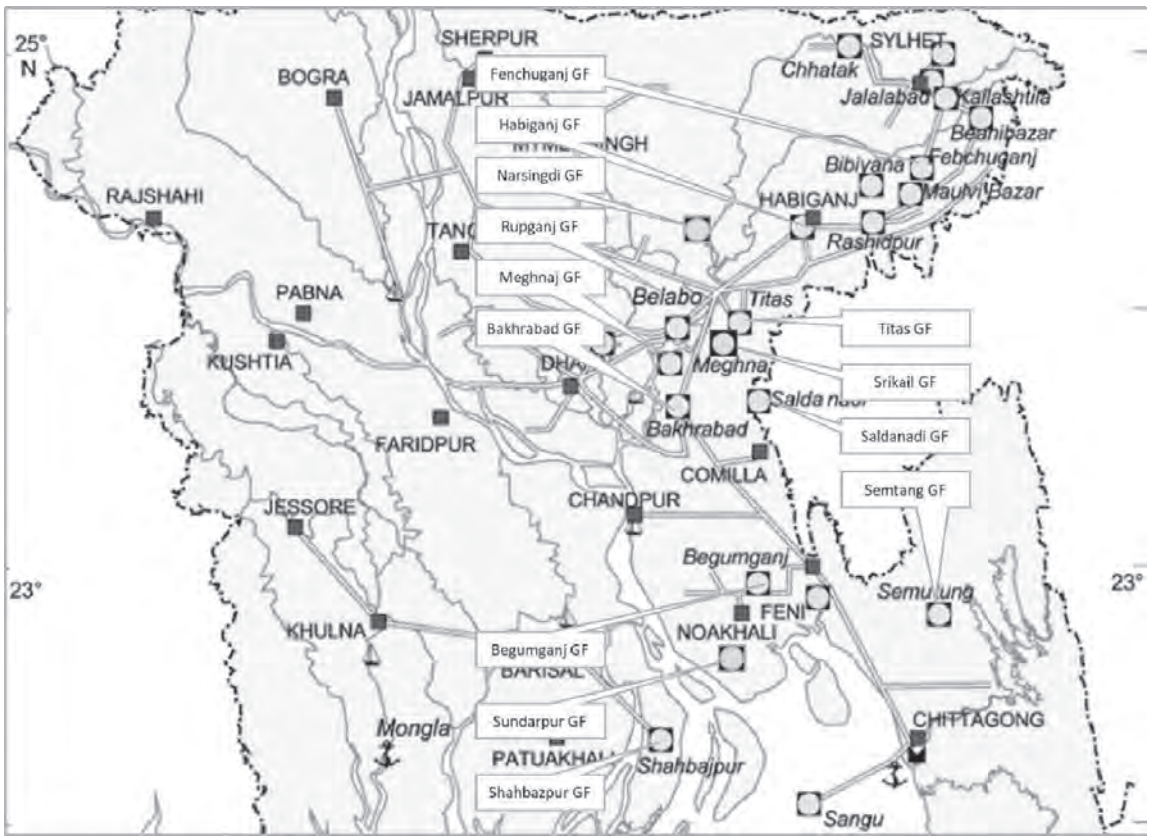
- Gas transmission pipeline alignment drawings and Right-of-way[3] (ROW)
- Distribution pipe drawings
- PFD (Process Flow Diagram), P&ID (Piping and Instrument Diagram) for transmission and distribution systems
- PFD, P&ID for Valve Stations
- Data/design information:
    - Design standard and specifications
    - Material specifications
    - Standard drawings
- Information on cathodic protection systems

There is no centralized drawing/document management system in the organizations for long term storage, and most of the old paper drawings are degraded and some are already not visible. Data collection therefore can be done only by personal relations and finding of the person who supposed to own. Physical location of the pipeline or distribution piping systems relies on the memory of the person in charge. Once these people retire or move, no other people can trace the exact location.

(2) Data Collection for Gas Fields

Process flow diagram of gas treatment facilities and associated operation/process data are collected from BAPEX for 8 gas fields and BGFCL for 5 gas fields. The locations of those 13 gas fields are shownbelow.

[3] Right-of-way (ROW) is the land used for pipeline or transmission line, of which ownership belongs to land owner and right to use is given to the pipeline/transmission line owner.



Source : PSMP2016, modified by JST

Figure 2.4.1 Data Collection from Gas Fields

2.4.2 General Observation on Collected Data and Issues

Collected drawings and data are a mixture of as-build stage and planning stage, and difficult to identify. Some drawings are old and available in a form of blue print. Some drawings are not readable due to deterioration.

In view of data consistency, gas flow tracing from gas fields to transmission system and to each franchise distribution companies are not possible since no updated flow diagram exist.

The following are general observations and situation of the collected data.

- Lack of information on interfaces and/or connection point to related facilities:
  - Between gas field facilities and transmission pipeline
  - Between Transmission pipeline and related valve stations (construction drawings)
  - Process conditions of connection points (design pressure/temperature, operation pressure/temperature, design/operation flow rate)
- Lack of process flow diagram (PFD):
  - Process flow sheet is a basis for designing pipeline and related facilities, and identify limit of operational performance together with flow rate, direction of flow, variable range of operating pressure, and temperature. However, no such PFDs exists.

- So-called PFD for valve stations are more like assembly drawing, and different from the one expected to be used for process flow tracing/control
- Preparation of appropriate PFDs are essential to assess the impact of process change including gas flow direction, flow rate, and pressure.
- PFDs from BGFCL are satisfactory and collected data includes operating temperature, pressure, flow rate, design pressure and temperature.

From the collected drawings, tie-in or battery limit among the gas field/transmission/distribution companies were not clear. Many drawings were lost and dispersed, and drawings indicating demarcation of responsible facilities of each company have not been prepared during the gas company separation and reformation process. The preparation of such drawings will require time for investigation and verification, which need to be implemented in the next stage of the technical cooperation projects, and most importantly require human resources.

2.4.3 Gas Field Data

Data on gas field facilities and operational information are collected from 2 companies. Table 2.4.1 summarizes data from BAPEX where chemical analysis data of Gas/Condensate together with Gas Pressure/Temperature were taken on the time as shown, e.g. July 2017, November 2015, etc. BGFCL provided information shown in Table 2.4.2 where Gas/Condensate data were given without data date and chronological records of monthly production for the period from January 2012 through June 2017.

Production rates of those two companies correspond to 1/3 of total daily production of Bangladesh. Information on the largest gas field, Bybiana, that produce 56% of Bangladesh under Production Sharing Agreements (PSA) by international oil company (IOC) is not available.

Table 2.4.1 BAPEX Gas Facilities

BAPEX **Gas Fields**	**PRODUCTION CAPACITY (MMSCFD)**	DATA DATE OF CHEMICAL ANALYSIS FOR GAS /CONDENSATE	GAS PPRESSURE, TEMPERATURE, ETC.	PRODUCTION REPORT (8 July 2017)	PFD / P&ID	GP LOCATION & TIE-IN INFORMATION	NUMBER AND COMPLETION YEAR OF GAS PROCESS PLANTS
SALDANADI GF	20	Jul-17	✔	4		✔ (*)	1 1998
FENCHUGANJ GF	60	Jul-17	✔	20	✔	✔ (*)	1 2005
SHAHBAZPUR GF	70	Jul-17	✔	40	✔	✔ (*)	1 2015
SEMTANG GF	30	Jul-17	✔	1	✔	✔ (*)	1 2010
SUNDALPUR GF	10	Nov-15	✔	0		✔ (*)	1 2011
SRIKAL GF	60	Jul-17	✔	36	✔	✔ (*)	1 2016
BEGUMGANJ GF	20	Aug-15	✔	0	✔	✔ (*)	1 2015
RUPGANJ GF	30	Jul-17	✔	2	✔	✔ (*)	1 2017

LEGENDS: ✔ Received (*) With coordinates
" " (blank) Not received

Source: Compiled by JST from BAPEX data

Table 2.4.2 BGFCL Gas Field Facilities

BGFCL **Gas Fields**	**PRODUCTION CAPACITY (MMSCFD)**	GAS /CONDENSATE DATA	GAS PPRESSURE/TEMPERATURE, ETC.	PRODUCTION REPORT (Monthly Reports)	PFD/P&ID	GP LOCATION & TIE-IN INFORMATION
TITAS GF	557	✔	✔	Jan-12 thru Jun-17	✔	✔ (*)
HABIGANJ GF	222	✔	✔	Jan-12 thru Jun-17		✔ (*)
BAKHRABAD GF	1	✔	✔	Jan-12 thru Jun-17	✔	✔ (*)
NARSINGDI GF	28	✔	✔	Jan-12 thru Jun-17		✔ (*)
MEGHNA GF	13	✔	✔	Jan-12 thru Jun-17		✔ (*)

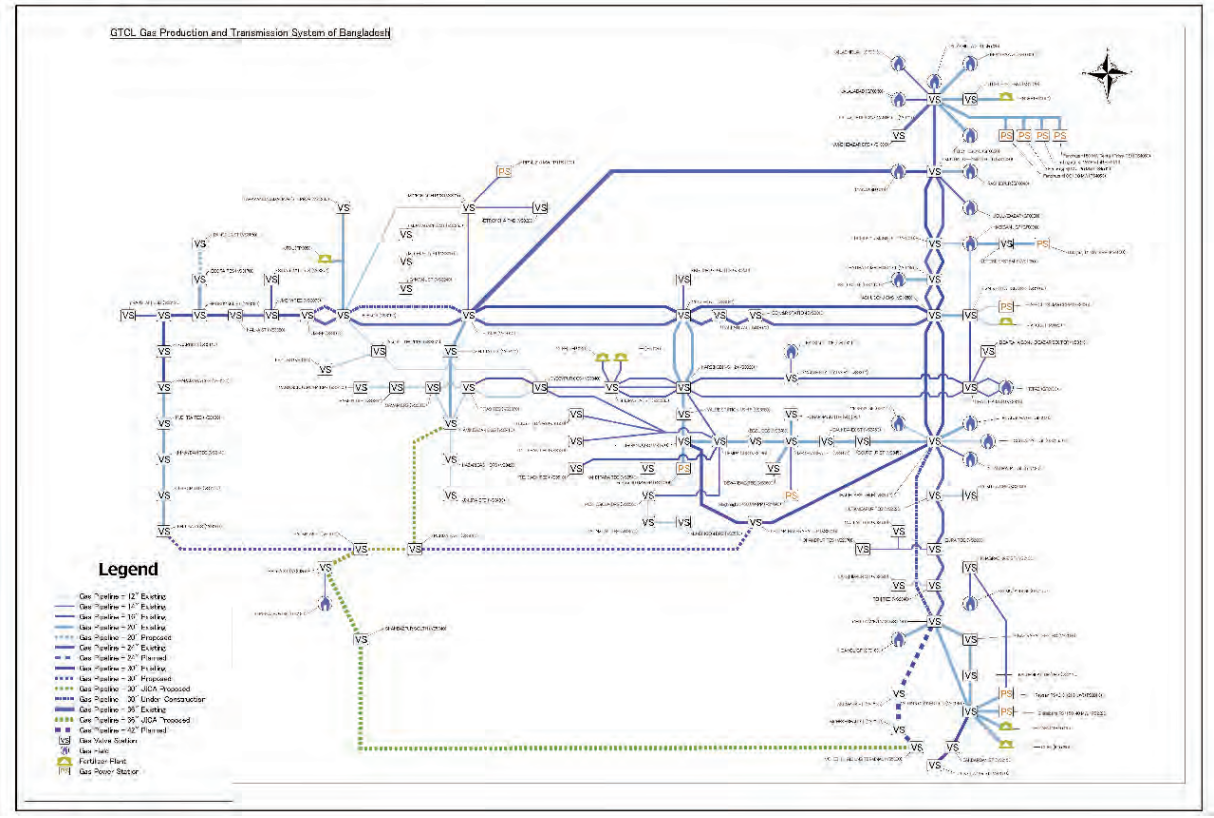
(*) With coordinate

Source: Compiled by JST from BGFCL data

BAPEX owns 8 gas processing plants at 8 sites, and 32 processing plants owned by BGFCL at 6 sites. All of processing plants of BAPEX were constructed within these 20 years. BGFCL plants are aging where a half of the processing plants exceed service life of 30 years or more.

2.4.4 Gas Transmission Facilities

The following schematic diagram is only available transmission system drawing provided by GTCL, however, there are many flaws in the drawing and it needs to be corrected and updated to reflect actual situation.



Source: Prepared by JST referring to GTCL information.

Figure 2.4.2 GTCL Pipeline Schematic Diagram

Above GTCL Schematic Diagram is also included in Appendix B-2.

Pipeline route alignment drawings are collected from GTCL, TGTDCL, JDTDCL, and BGFCL. 29 pipeline drawings have been collected out of 49. Majority of the drawings are collected from GTCL. Main GTCL pipelines from north to south and east to west includes coordinate data (location data with longitude and latitude, collected by GPS), and can be physically identified.

The following table summarize the data acquisition status of each transmission system.

Table 2.4.3 Transmission Line List-GPS Information (Coordinate data) and ROW

Company		Name of The Line and Route	Data Received *1	Pipe Diameter *2	Alignment Drawing *3	ROW *4	Alignment (Coordinate)	Alignment (Bending)	Valve Station in between	Data Clearness *5
TGTDCL	1	TITAS-DHAKA	No	14						
	2	TITAS-NARSHINGDI	No	16						
	3	NARSHINGDI-JOYDEVPUR	Yes	14	Mouza	No	Yes	Yes	0	BA
	4	NARSHINGDI-GHORASAL (Third Parallel)	Yes	14	Mouza	Yes	No	No	1	BA
	5	HABIGANJ-ASHUGANJ	Yes	12	Yes	Yes	Yes	No	0	
	6.1	MONOHARDI-NARSHINGDI	Yes	20	Route Map	Yes	Yes	Yes	0	AA
	6.2	MONOHARDI-NARSHINGDI	Yes	20	Yes	No	Yes	Yes	1	AA
	7	MONOHARDI-KISHORGDI	No	4						
	8	ASHUGANJ V.S. #3-ZFCL	No	10						
	9	ELENGA-TARAKANDI	No	12						
	10	DHONUA-MYMENSINGH	No	12						
	11	TARAKANDI-JAMALPUR	No	8/6						
	12	MYMENSHINGH-NETROKONA	Yes	8/6	Yes	Yes	Yes	Yes	1	AA
GTCL	13	NORTH SOUTH	Yes	24	As Built	No	Yes	Yes	6	AB
	14	ASHUGANJ-BAKHRABAD 1	Yes	30	As Built	Yes	Yes	No	0	AA
	15	BANGABANDU BRIDGE(DN)	Yes	30	As Built	Yes	Yes	No	0	AA
	16	ELENGA-NALKA(DN)	Yes	24	As Built	Yes	Yes	No	0	BA
	17	NALKA-BAGHABARI(DN)	Yes	20	As Built	Yes	Yes	No	0	AA
	18	BEANIBAZAR-KAILASHTILA	No	20						
	19	ASHUGANJ-HABIGANJ	Yes	30	Mouza	No	Yes	Yes	3	AB
	20	RASIDPUR-HABIGANJ	Yes	30	As Built	No	No	Yes	2	AA
	21	NALKA-HATIKUMRUL	Yes	30	As Built	As Built	Yes		0	
	22	HATIKUMRUL-BOGRA	Yes	20	As Built	Yes	Yes	Yes	0	BB
	23	MONOHARDI-DHANUA ELENGA PIPELINE (1ST PHASE)	Yes	30	As Built	Yes	Yes	-	0	AA
	24	BAKHRABAD-DEMRA	Yes	20	As Built	No	Yes	No	1	
	25	BAKHRABAD-CHITTAGONG	Yes	24	Yes	No	Yes			
	26	ASHUGANJ-ELENGA(B-B)	Yes	24						
	27	ASHUGANJ-MONOHARDI	Yes	30	Mouza Map	No	Yes	Yes	0	AA
	28	DHAKA CLEAN FUEL (GTCL PART)	Yes	20	As Built	No	No	Yes	0	AB
	29	BONPARA RAJSHAHI	No	12						
	30	HATIKUMRUL-BHERAMARA	Yes	30	As Built	Yes	Yes	Yes	0	AB
	31	24" DIA 8 KM FROM TITAS GAS FIELD-AB PIPELINE	Yes	24	As Built	No	No	No	0	AA
	32	SRIKAIL GAS FIELD (LOCATION 2)-AB PIPELINE PROJECT	No	20						
	33	BIBIYANA-DHANUA	No	36						
	34	BAKHRABAD-SIDDHIRGANJ(BS)	Yes	30	As Built	No	Yes	Yes	2	AA
	35	SRIKAIL GAS FIELD (LOCATION 2)-AB PIPELINE PROJECT INTAKE POINT OF TITAS AB PIPELINE AT CHAYABARIA	No	10						
KGDCL	36	ASHUGANJ-BAKHRABAD 2	No	30						
	37	CHITTAGONG RING MAIN	No	24/20/16						
	38	KPM SPAUR	No	8						
	39	CHITTAGONG-RAUZAN	No	20						
JGTDSL	40	SEMUTANG-CHITTAGONG	No	10						
	41	HARIPUR-NGFF	No	-						
	42	KAILASHTILA-KUCHAI	No	8						
	43	KUCHAI-CHATAK	No	6						
	44	DEVPUR-KUMARGAON	No	6						
	45	HABIGANJ-SHAHJI BAZAR	No	8						
	46	SHAHAJI BAZAR-SHAMSHER NAGAR	No	6						
	47	SRIMONGAL-MOULOVI BAZAR	No	6						
	48	CHATAK-TENGRATILA	No	4						
	49	TENGRATILA-SUNAMGANJ	No	4						

Yes: Existence
Document Acuracy
Document data sufficiency;
*1. Although data might exist in related companies,
Yes ; JST could collect, No; JST could not collect And there are some missing data (Row' Bending data and Coordinate data) in received drawings..
*2. Unit : inch
*3. Mouza Map and Route Map had been prepared for Land acquisition. Some project used Mouza Map and project used Route Map.
*4. ; Row ; Right of Way.
Yes ; Row is mentioned in drawing.
No ; Row is not mentioned.
*5. : Data Clearness.

X	Y

X : Data Accuracy : A; Initial Pont & End Point are clear, B; Insufficient Initial Point and End point and/or Data lack in between
Y : Document data Sufficiency. : A; Coordinate data, Angle data, ROM which are attached, B; Illegible due to Data fade, and lack of information

Source: Prepared by JST

Table 2.4.4 Transmission Pipeline List-Design Information

Company		Name of The Line and Route	Data Received	Diameter	Length	MAOP *1	Operating Pressure	Max. Flow Capacity	Date of Original Drawing *2	Design Data (Note1) *2					
										Design Data Exist	Material	Design Class	Wall Thickness	Drawing Status	
				(Inch)	(Km)	(Psig)	(Psig)	(MMSCFD)	Year			API	mm	Electronic or Paper (E/P)	Angle Point (Yes/No)
TGTDCL	1	TITAS-DHAKA	No	14	81.8		1000	175							
TGTDCL	2	TITAS-NARSHINGDI	No	16	46.31		1000	265							
TGTDCL	3	NARSHINGDI-JOYDEVPUR	Yes	14	37.51		1000	220	Jul-82						
TGTDCL	4	NARSHINGDI-GHORASAL	Yes	14	10.3		1000	220	Apr-83						
TGTDCL	5	HABIGANJ-ASHUGANJ	Yes	12	57.75		1000	85							
TGTDCL	6-1	MONOHARDI-NARSHINGDI	Yes	20	24.5		1000	300	Jul-95						
	6-2	MONOHARDI-NARSHINGDI	Yes	20											
TGTDCL	7	MONOHARDI-KISHORGANJ	No	4	35		1000	6							
TGTDCL	8	ASHUGANJ V.S. # 3-ZFCL	No	10	4		1000	95							
TGTDCL	9	ELENGA-TARAKANDI	No	12	42.41		1000	80							
TGTDCL	10	DHONUA-MYMENSINGH	No	12	56.7		1000	55							
TGTDCL	11	TARAKANDI-JAMALPUR	No	8/6	21		1000	25							
TGTDCL	12	MYMENSINGH-NETROKONA	Yes	8/6	40		1000	60	Mar-95						
GTCL	13	NORTH SOUTH	Yes	24	175		1050	330							
GTCL	14	ASHUGANJ-BAKHRABAD 1	Yes	30	58		1000	425							
GTCL	15	BANGABANDU BRIDGE(DN)	Yes	30	9		1000	300	May-16						
GTCL	16	ELENGA-NALKA(DN)	Yes	24	28.5		1000	250	May-16						
GTCL	17	NALKA-BAGHABARI	Yes	20	35.5		1000	250	May-16						
GTCL	18	BEANIBAZAR-KAILASHTILA	No	20	18		1050	250							
GTCL	19	ASHUGANJ-HABIGANJ	Yes	30	54		1050	500		Yes			14.3		
GTCL	20	RASIDPUR-HABIGANJ	Yes	30	28		1050	500							
GTCL	21	NALKA-HATIKUMRUL	Yes	30	6		1000	425							
GTCL	22	HATIKUMRUL-BOGRA	Yes	20	54		1000	225							
GTCL	23	MONOHARDI-DHANUA ELENGA PIPELINE (1ST PHASE)	Yes	30	51		1000	750							
GTCL	24	BAKHRABAD-DEMRA	Yes	20	68.72		1000	250	Jul-85	Yes			0.375″		
GTCL	25	BAKHRABAD-CHITTAGONG	Yes	24	174.65		1000	300							
GTCL	26	ASHUGANJ-ELENGA	Yes	24	124		960	330							
GTCL	27	ASHUGANJ-MONOHARDI	Yes	30	37		1000	425							
GTCL	28	DHAKA CLEAN FUEL (GTCL PART) Dhonua-Aminbazar	Yes	20	60		1000	425	Jul-97						
GTCL	29	BONPARA-RAJSHAHI	No	12	53		1000	450							
GTCL	30	HATIKUMRUL-BHERAMARA	Yes	30	78		1000	400							
GTCL	31	24" DIA 8 KM FROM TITAS GAS FIELD-AB PIPELINE PROJECT	Yes	24	8		1050	330							
GTCL	32	SRIKAIL GAS FIELD (LOCATION 2)-AB PIPELINE PROJECT	No	20	1.5		1000	250							
GTCL	33	BIBIYANA-DHANUA	No	36	137		1000	640							
GTCL	34	BAKHRABAD-SIDDHIRGANJ(BS)	Yes	30	60		1000	450	Sep-16	Yes	API5L CRx' PSL-2	Class 3	14.3		
GTCL	35	SRIKAIL GAS FIELD (LOCATION 2)-AB PIPELINE PROJECT INTAKE POINT OF TITAS AB PIPELINE AT CHAYABARIA	No	10	7.7		1000	250							
KGDCL	36	ASHUGANJ-BAKHRABAD 2	No	30	61		1000	450							
KGDCL	37	CHITTAGONG RING MAIN	No	24/20/16	59.48		350	451							
KGDCL	38	KPM SPAUR	No	8	36.15		350	18							
KGDCL	39	CHITTAGONG-RAUZAN	No	20	18		350	150							
KGDCL	40	SEMUTANG-CHITTAGONG	No	10	56		960	70							
JGTDSL	41	HARIPUR-NGFF	No	-	43		1000	62							
JGTDSL	42	KAILASHTILA-KUCHAI	No	8	13		1000	62							
JGTDSL	43	KUCHAI-CHATAK	No	6	39		1000	36							
JGTDSL	44	DEVPUR-KUMARGAON	No	6	11		1000	36							
JGTDSL	45	HABIGANJ-SHAHJI BAZAR	No	8	2		1000	53							
JGTDSL	46	SHAHAJI BAZAR-SHAMSHER NAGAR	No	6	65		1000	11							
JGTDSL	47	SRIMONGAL-MOULOVI BAZAR	No	6	26		1000	11							
JGTDSL	48	CHATAK-TENGRATILA	No	4	19		1000	10							
JGTDSL	49	TENGRATILA-SUNAMGANJ	No	4	13		1000	10							

*1. To study maximum allowable flow rate from the relation of MAOP, Operating Pressure and Design Pressure.
*2 Data from Drawings

Source: Prepared by JST

The oldest as-built drawings (or design document) date back to late 1980's. Numbers of important information, including design pressure, design flow rate or materials of construction are missing and quality of data image is degraded.

It is not easy to retrieve correct information since long time after construction. There are also several cases of inconsistency between data summary sheet and as-built drawing, material specification, and design pressure or Maximum Allowable Operating Pressure (MAOP).

In view of weakness, it is difficult to assess overall integrity of the system.

In addition to the review of material specification, MAOP needs to be reviewed. Pressure system for fittings are specified by American Society of Mechanical Engineers (ASME) Code to follow. ASME code regulates the design and construction standard of pipe and pressure vessels. These include Hydrostatic Test Pressure and Rated Design Pressure. MAOP and System Design Pressure and Normal Operating Pressure are decided by project owners.

In general, MAOP for long distance pipeline is set closer to Rated Design Pressure to maximize the transmission capacity. It is noted that the higher the compression ratio is, the higher the transportation capacity will be.

#600 Class is used for transmission line in Bangladesh. MAOP of #600 Class can go up to 1,480 psig, however, 960-1,135 psig has been used in Bangladesh, and pipe wall thickness has been designed to 960-1,135 psig. This has been limited the gas transportation capacity and results in increasing numbers of compressor stations.

Table 2.4.5 Pressure Reference Table

	ASME Class			
	#600 World STD		#600 Bangladesh	
	psig	kg/cm2g	psig	kg/cm2g
Rated HydrostaticTest Pressure	2225	156	2225	156
Rated Design Pressure	1480	104	1480	104
MAOP (Design Pressure)	1440	101	960-1135	80
Operating Pressure	1000	70	1000	70

#600 means ASME pressure rating class of the pipeline is 600 lb.
Rated Hydrostatic Test Pressure is a pressure in which pipeline fittings can be tested for ensuring mechanical strength.
Rated Design Pressure is the maximum pressure for fittings that can be allowed to expose. MAOP is the Maximum Allowable Operating Pressure, and equivalent of design pressure by which wall thickness of the pipe is calculated.
Operating Pressure is the normal operating pressure of a pipeline.
Source: prepared by JST referring to ASME 31.8

For information management purposes, the following data items should be included in design/as-built alignment drawings:

- Project Name
- Pipeline Name
- Date of Taking-over of the Facility from Contractor
- Start Point (Name of Valve Station with ID No) with Coordinates
- End Point (Name of Valve Station with ID No) with Coordinates
- Total Distance
- Notes for ROW (Reference information for Land Acquisition/Requisition and use of ROW of existing Pipeline)

- Nominal Diameter of Pipe
- Design Code
- Pipe Material
- Wall Thickness of Pipe
- Design Pressure (with Temperature)
- Maximum Allowable Operating Pressure (MAOP) for each pressure level
- Normal Operating Pressure (for each pressure level)
- Hydrostatic Test Pressure
- Hydrostatic Test Records
- Rated Flow
- Flow Rate at Normal Operating Conditions
- No of Valve Stations en route
- No of Tie-ins and/or Off-takes en route
- No. of Cathodic Protection Station en route
- No of Cathodic Protection Test Points en route
- No of Insulating Joints en route
- Name of Contractor (with Date of Design Approval for Construction)
- Name of Owners Engineer
- Name of Surveyor for As-built Certificate (with Date of As-built Certificate)

2.4.5 Valve Stations

Process flow of valve stations are the key information for assessing the operational change and preparing expansion or modification plan. However, available data at present is more like assembly drawing and not suitable for these purposes. All of the valve stations need to be reviewed and re-drawn. Identification numbers also need to be given to each valve station to identify exact location of the station. The following table is the list of valve station for transmission line.

Table 2.4.6 Valve Station List of GTCL and Other Gas Companies

Valve Station ID	Valve Station Name	District	Operation Status
VS1010	KAILASTHTILA 2&3 MANIFOLD	Sylhet	Existing
VS1020	MUCHAI CS-2 MANIFOLD	Habiganj	Existing
VS1030	HOBIGONJ MONIFOLD	Habiganj	Existing
VS1040	KHATIHATA METERING ST	Brahamanbaria	Existing
VS1050	ASHUGONJ GMS	Brahamanbaria	Existing
VS1060	VALVE STATION VS-3	Brahamanbaria	Existing
VS1070	JDTDSL SYSTEM A	Sylhet	Existing
VS1080	JDTDSL SYSTEM B	Brahamanbaria	Existing
VS1090	MUNSHIBAZAR DRS	Sylhet	Existing
VS2010	BAKHRABAD HUB	Comilla	Existing

Valve Station ID	Valve Station Name	District	Operation Status
VS2020	KUTAMBAPUR TBS	Comilla	Existing
VS2030	BIJRA TBS	Comilla	Existing
VS2040	FENI TBS	Feni	Existing
VS2050	CHITTAGONJ CGS	Chittagong	Existing
VS2060	COMILLA DRS	Comilla	Existing
VS2070	CHANDPUR TBS	Chandpur	Existing
VS2080	MATLAB TBS	Chandpur	Existing
VS2090	LAKSHIMPUR ST	Lakshmipur	Existing
VS2100	NASIRABAD HP/DRS	Chittagong	Existing
VS2110	KALURGHAT HP/DRS	Chittagong	Existing
VS2120	MOHESHKHALI ST	Cox'S Bazar	Planned
VS2130	KHAGRACHARI ST	Khagrachhari	Existing
VS2140	VS RING CONNECTION	Bandarban	Existing
VS2150	BANDARBAN ST	Bandarban	Existing
VS2160	COXS BAZAR ST	Cox'S Bazar	Existing
VS3010	BB M&R STATION	Narsingdi	Existing
VS3020	DAULATKANDI	Narsingdi	Existing
VS3030	MONOHORDI	Narsingdi	Existing
VS3040	DHONUA	Gazipur	Existing
VS3050	ELENGA	Tangail	Existing
VS3060	JMB-E	Tangail	Existing
VS3070	JMB-W TBS	Sirajganj	Existing
VS3080	NALKA ST	Sirajganj	Existing
VS3090	HATIKUMRUL ST	Sirajganj	Existing
VS3100	BONPARA NATORE ST	Natore	Existing
VS3110	ISWARDI ST	Pabna	Existing
VS3120	BHARAMARA CGS	Kushtia	Existing
VS3130	KUSHTIA TBS	Kushtia	Existing
VS3140	JHINAYDAH TBS	Jhenaidah	Existing
VS3150	JESSOR TBS	Jessore	Existing
VS3160	KHULNA CGS	Khulna	Existing
VS3170	BOGRA TBS	Bogra	Existing
VS3180	RANGPUR ST	Rangpur	Existing
VS3190	RAJSHAHI CGS	Rajshahi	Existing
VS3200	KISHOREGONJ TBS	Kishoreganj	Existing
VS3210	MIMENSINGH RMS	Mymensingh	Existing
VS3220	NETROKONA RMS	Netrakona	Existing
VS3230	TARAKANDI/JAMALPUR/SHERPUR	Jamalpur	Existing
VS3240	GHATAIL ST	Tangail	Existing
VS3250	MODHUPUR ST	Tangail	Existing
VS3260	MUKTAGACHA ST	Mymensingh	Existing
VS3270	SIRAJGONJ DRS	Sirajganj	Existing
VS3300	GHATURA M&R	Brahamanbaria	Existing
VS3310	VALVE STATION VS-11	Narsingdi	Existing
VS3320	NARSINGDI VS-12	Narsingdi	Existing
VS3330	GHORASHAL ST	Narsingdi	Existing
VS3340	JOYDEVPUR CGS	Gazipur	Existing
VS3350	TANGAIL TBS/DRS	Tangail	Existing
VS3360	EPZ DRS	Tangail	Existing
VS3370	TITAS TBS	Dhaka	Existing
VS3380	SAVAR DRS	Dhaka	Existing
VS3390	DHAMRAI DRS	Dhaka	Existing
VS3400	MANIKGONJ ARICHA DRS	Manikganj	Existing
VS3410	AMINBAZAR CGS	Dhaka	Existing

Valve Station ID	Valve Station Name	District	Operation Status
VS3420	HAZARIBAGH DRS	Dhaka	Existing
VS3430	JINJIRA DRS	Dhaka	Existing
VS3440	ASHULIA CGS	Dhaka	Existing
VS3450	GOURIPUR ST	Comilla	Existing
VS3460	DAUNDANDI ST	Munshiganj	Existing
VS3470	MEGHNAGHAT ST	Narayanganj	Existing
VS3480	BGSL CGS	Narayanganj	Existing
VS3490	DEMRA CGS	Dhaka	Existing
VS3500	SIDDHIRGANJ CGS	Narayanganj	Existing
VS3510	TEJGAON TBS	Dhaka	Existing
VS3520	GULSHAN TBS	Dhaka	Existing
VS3530	TONGI TBS/DRS	Gazipur	Existing
VS3540	NANDIPARA TBS	Dhaka	Existing
VS3550	MUNSHIGON DRS	Narayanganj	Existing
VS3560	POSTOGOLA DRS	Dhaka	Existing
VS3570	KADAMTALI TBS	Dhaka	Existing
VS3580	VALVE STATION VS-15	Narayanganj	Existing
VS3590	SONARGAON TBS	Narayanganj	Existing
VS3600	DEWANBAG TBS	Narayanganj	Existing
VS3610	B.BARIA, A'GONJ, B'BAZAR SECTOR	Brahamanbaria	Existing
VS3620	BHOLA ST	Bhola	Existing
VS3700	KHULNA BAKHRABAD JP	Narayanganj	Existing
VS5010	PADMA EAST	Munshiganj	Proposed
VS5030	MOHESHKHALI LNG TERMINAL	Cox'S Bazar	Planned
VS2125	ANOWARA ST	Chittagong	Proposed
VST0010	Gulshan DRS	Dhaka	Existing
VST0020	Tejgoan TBS	Dhaka	Existing
VST0030	City Center DRS, Gulistan	Dhaka	Existing
VST0040	Postogola DRS	Dhaka	Existing
VST0050	Dhania, Chittagong Road	Dhaka	Existing
VST0060	Demra CGS	Dhaka	Existing
VST0070	Nondipara DRS	Dhaka	Existing
VST0080	Shiddhirganj RMS	Narayanganj	Existing
VST0090	NEPC RMS	Narayanganj	Existing
VST0100	Horipur RMS	Narayanganj	Existing

"Planned" means the line is included in GTCL plan and budgeting is underway. "Proposed" means proposed but budget plan is not arranged.

Source: Prepared from JST, based on Schematic Diagram of GTCL

Drawings of limited numbers of above valve stations were available. The Table below summarizes design information availble from collected drawings. A check mark (✓) represents availability of data while a blank indicates that required information is not shown in the drawings. A letter "P" signifies that the information does not cover all interface points but is partial.

Table 2.4.7 Available Information on Collected Drawings

VALVE STATION	INLET					OUTLET					INSUL. JOINT (*2)
	FROM	PIPE SIZE	RATING (*1)	PRESS -URE	FLOW RATE	TO	PIPE SIZE	RATING (*1)	PRESS -URE	FLOW RATE	
AGMS PLANT	✔	P		P	P	✔	P		P	P	P
ASHULIA CGS	✔	✔		✔	✔	✔	✔		✔	✔	
BKB GAS FIELD END	✔	✔				✔					
DEMRA CGS	✔	✔				✔	✔				
KHATIHATA GTCL GMS	✔	✔			✔	✔					
KTL-2 SCRAPPER STATION	✔	✔				✔	✔				
MUCHAI COMPRESSOR STATION	✔	✔				✔					
MUCHAI SCRAPER STATION	✔	✔		✔		✔					
VS-3	✔	✔			✔	✔	P			✔	
SHAHJALAL FERTILIZER CMS	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
BAGHABARI DRS	✔	✔	✔				✔	✔			✔
BOGRA		✔	✔	✔			✔	✔	✔		✔
HATIKUMRUL		✔	✔				✔				✔
ISHWARDI DRS		✔	✔	✔		✔	✔		✔		✔
RAJSHAHI		✔		✔		✔	✔		✔		✔
SADANANDAPUR TBS (*3)											
ULLAPARA DRS		✔									✔

✔	Data availble
P	Data partially available
blank	Data not shown
(*1)	Pressure rating of connecting flange with outsiside facilities
(*2)	Insulating joints
(*3)	Information is limited to those within the facility. No data on interfacing with outside facilities.

Source: Prepared by JST

The valve station diagram currently used is more like assembly drawing rather than PFD. Process flow and interface with other system needs to be indicated and basic instrumentation and control system or SCADA system is also necessary to be shown.

PDF is available in some gas distribution companies. However, in many drawings, images are fading and degraded. To protect important information, reproduction of drawings by engineering software is essential to preserve available information, as well as updating the design data to reflect changes or modifications of facilities.

The following is a list of information to be included in PFD drawings.

- Project Name (If applicable)
- Station Name (with ID No and Coordinates)
- Date of commissioning
- Gas Inlet Pipes; Name of Connected Pipeline, (Size, Pressure Rating) and Process Design Conditions (Design/Operating Pressure, Temperature and Flow Rates)
- Gas Outlet Pipes; Name of Connected Pipeline or Destination of Connected Local Distribution Network together with Process Design Conditions (Design/Operating Pressure, Temperature and Flow Rates)

- Class Break Points of Pressure Rating within the Station
- Design Pressure for Each Class Break
- Test Pressure for Each Class Break
- Protection Device and Specifications for Overpressure
- Location of Insulating Joints with Size and Pressure Rating
- Flow Meter (Make, Type, Size and Operating Range)
- Maximum Allowable Operating Pressure (for each pressure level)
- Emergency Shutdown Valves with Operation Schematics
- Information Interface with SCADA system (if applicable)
- Date of Updating "As-built" Information
- Odorizer (Expected Monthly Consumption of Odorant, and Minimum Stock Level)

2.4.6 Material Specifications and Design Specifications

"Technical Specification for Gas Distribution Pipe Line and Gas Connection Materials" was published in 2004 by Petrobangla for low pressure pipe system. This appears to be used by TGTDCL and other companies primarily. The following specifications are included in the above Technical Specification:

- Technical Specification of Line Pipe for Gas Distribution Network up to 150 psig
- Technical Specifications for Miscellaneous Fittings
- Technical Specifications for Hot Formed Beds
- Technical Specifications for Domestic Regulator and Others
- Technical Specifications for meters
- Technical Specifications for Commercial and Industrial Gas Pressure and Regulator
- Technical Specifications for Ball Valves
- Technical Specifications for Relief Valves
- Technical Specifications for Cathodic Protection Materials
- Technical Specifications for Other Materials (covering Odorizer, Tetrahydrothiophene, Gas Pressure and Temperature Recorder, Single Basket Type Strainer, Y-Type Strainer, Pressure Gauge, Master Pressure Gauge, Single Channel Flow Data Logger, and Valve Tee & Flanged Tee)

Review of Technical Specification is continued effort and reviewed regularly to refract updated experiences and failure cases. One of the important discoveries in this survey is about the use of ERW (Electrical Resistance Weld) Steel Pipe in some of the pipeline system in Bangladesh. Due to a number of pipeline rupture cases reported in the world, industrial practice restricts the use of ERW pipe, if not treated by heat properly and inspected, only to non-critical services.

ERW pipes in general, if they are not treated by heat, have higher residual stress due to its production process, i.e., welding by high electric current along the limited areas of longitudinal seam in a short time.

A technical report[4] states that laboratory test indicate fracture risk of ERW pipe. It is pointed out that Impressued Current Cathodic Protection (CP) system tends to cause producing hydrogen along higher stress area, leading into hydrogen stress corrosion and embrittlement of the pipe.

Pipelines using ERW are as follows:

- Bibiyana Gas Field to to Aushkadi DRS (6”x 5 km at 1000 psig, Completed in 2012)
- Sreemongal TBS to Bhairabgonj Bazar DRS (6”x 2.5 km at 500 psig, Completed in 2016)
- Debpur to Kumargaon (8”x 10 km at 1000 psig, Completed in 2014)
- Patibag DRS to Jalalpur Valve Station (6” x 18 km at 500 psig, Completed in 2016)

These pipeline systems need to be monitored and investigated carefully and need to be replaced with appropriate materials to avoid potential rupture case.

As mentioned earlier, design standard differs from project by project. A set of specifications used by ”Dhanua-Elenga and West Bank of Bangabandhu Bridge-Nalka Gas Transmission Pipeline Project” of GTCL provides complete set of specifications and can be a base for future common standard in Bangladesh.

2.4.7 Design Standard and Standard Drawings

(1) Design Standard

Design Standard is the technical standard that all projects in the same organization have to be referred and applied in design.

However, two recent projects were constructed with slight difference in design philosophy and standard. The difference is summarized as follows:

[4] Study on applicability of HF-ERW pipes for the high-pressure gas pipelines (JFE Technical Report Vol.2-2011)

Table 2.4.8 Design Parameters for Pipelines

Project	Bakhrabad -Siddihirganj Pipeline Project		Dhanua-Elenga and West Bank of Banghabandhu Bridge-Nalka Gas Transmission Pipeline Project	
Pipeline	30"*60 km		30"*52 km (Along with existing 24" Pipepline)	
Owner's Engineer	Dorsch International Consultants GmbH		Penspen Ltd.	
Contractor	Fernas Construction Co., INC.		<Not shown>	
Drawing Issued	October 2016		July 2016	
Design Code	Not shown in Drawings		ASME B31.8	
Location Class	Class-3 (Location Factor F=0.5)		Class-2 (Location Factor F=0.6)	
	Class-4 (Location Factor F=0.4)			
Depth of Cover (min)	1.2 m (2.5 m for crossing portion)		1.0 m (1.8m for crossing portion)	
			(Along with existing 24" pipeline)	
			Casing Pipe: 34" NPS	
Size*Thickness	762mm OD*14.3mm WT, 3LPE	for Class-3 Zone	762mm OD*14.27 mm WT, 3LPE	for Class-2 Zone
	762mm OD*17.5mm WT, 3LPE	for Class-4 Zone	762mm OD*15.88 mm WT, 3LPE	for HDD Portion
Pipe Material	API 5L X70		API 5L X60	
Design Pressure	Not shown		1135 psig	

Note: Location Class in the above table is the safety factor for steel pipe in the design code of ANSI B31.8, the derating factor dependent upon the location class unit, which is an area that extends 220 yards on either side of the centerline of any continuous 1-mile length of pipeline. Each separate dwelling unit in a multiple-dwelling-unit building is counted as a separate building intended for human occupancy.

Source: Compiled by JST from GTCL drawings

In addition to the above, construction practice of CP system installation may be different and corrosion allowance may also be different. The design class is the rating factor dependent upon the location class determined mainly according to population and building density.

Systematic and global spacious approach, not project by project approach, is required to determine the design factors including the following:

Design Classification: Design classification is related to thickness of pipe, specified according to population. Current population and future development plan need to be considered prior to decide classification, and determined during Environmental Impact Assessment (EIA).

Soil Resistivity: CP system may differ to the soil resistivity and condition. Data should be prepared and verified as part of EIA.

(2) Standard Drawings

Standard Drawings are the drawings designed to minimize construction and maintenance cost and avoid risk in unique design. Standard drawings are the platform of accumulating knowledge and lessons learnt through past experience, and outcome of systematic gathering and compilation will serve as a knowledge base.

Standard drawings will contribute to uphold the integrity of overall systems and to minimize the numbers of spare parts by making those interchangeable among the companies. By its nature, however, standard drawings require continued updating by reflecting own experience from day-to-day work, and collecting information about new developments of technologies. For this, Structured approach (i.e., centralized organization) to register and maintain the documents would be essential and centralized information and technology management system need to be in place.

The following are a list of standard drawings classified according to each discipline category:

(1) Civil

- Typical Crossing Details:
  - Road, Railway, Cable/Pipeline, Water Course, River, River Crossing with HDD (Horizontal Directional Drilling)
- Site Construction:
  - Road, Pavement, Boundary Wall and Gate, Fence, Trench, Drainage, Concrete Foundations, Valve Pit, Valve Pit Cover, Pig Trap Foundation

(2) Piping

- Pipe Support Standard, Welding Details, Scraper Trap, Pig Launcher and Receiver, Scraper Signaler, Vent and Drain Piping at Valve Station

(3) Instrument

Instrument Hook-up for:

- Direct Mounted Pressure Gauge
- Direct Mounted Gas Operated Valve
- Remote Mounted Pressure Transmitter
- Thermo-Electric Generator (TEG)

(4) Electrical

- Earthing System, Electrical Load List, Hazardous Area Classification Electric

(5) CP System

- Anode Grounding (Horizontal/Vertical),
- Test Station Installation (Various Types)
- Test point Installation (Various Types)

Standardization should include drawings such as PFD, P & ID and alignment drawings that differ from project to project.

(3) Criteria for Contractor Selection

Currently, contractors for construction of pipeline facilities are selected based on proposals submitted by bidders. Accordingly, the design philosophy is depending on contractors, which is different from project to project, and it causes design inconsistency of overall system.

In a general practice, list of venders including material suppliers, contractors, and service providers should be prepared prior to the commencement of the project. In the process of the formulating the list, each business entity need to submit its experiences and track record of financial statement in addition to the quality assurance/control systems, and pricing indications. The listed vendors should be knowledgeable about the design philosophy/specification of the facility owner before commencement of the project.

2.4.8 Cathodic Protection System

There are the following items in cathodic protection (CP) system. Each distribution company applies different CP system according to site condition.

(1) Installed Facilities

Cathodic protection of buried pipeline with insulating type of external coating is a mandatory requirement except for use in a limited service life. As corrosion attributes difference in electric potential between contacting materials, protection of buried pipe depends on control of electric current between pipe and environments (i.e., soil). When materials susceptible to corrosion (e.g., magnesium) is buried along with pipeline, it will corrode instead of steel pipe and pipe is protected. This is called as Sacrificial Anode System. Electric current charged from outside sources to mitigate generated current between pipe and soil will also protect pipe from corrosion, and it is called as Impressed Current System.

(2) Sacrificial Anode System

Sacrificial Anode system is used for isolated installations in general. The system does not require supply of electricity and installation is rather easy. However, a change of surface conditions of sacrificial anode in contact with soil may cause failure of protection mechanism to corrode underground structure instead of anode itself. Therefore, it can be used when direct monitoring is practicable and replacement of anode in short service period is acceptable.

(3) Impressed Current System

Beside a need of external electric supply, Impressed Current system is widely used for pipelines as the effective performance of the protection system is attainable for long service period. The system has flexibility to adjust itself for changes of soil conditions or influence from foreign installations such as nearby pipelines, railways, buildings, etc.

Electricity for the system is supplied by either transformer/rectifier or by TEG (Thermo-Electric Generator), while recent market information introduces hybrid type of TEG consolidated with solar panel to eliminate needs of external power supply.

(4) Summary of Installed CP Facilities

Data were collected from four operating gas distribution companies. All companies use Impressed Current system while method of electricity supply varies. The Table below summarizes those facilities of CP Stations and Test Posts.

Table 2.4.9 Summary of CP Facilities

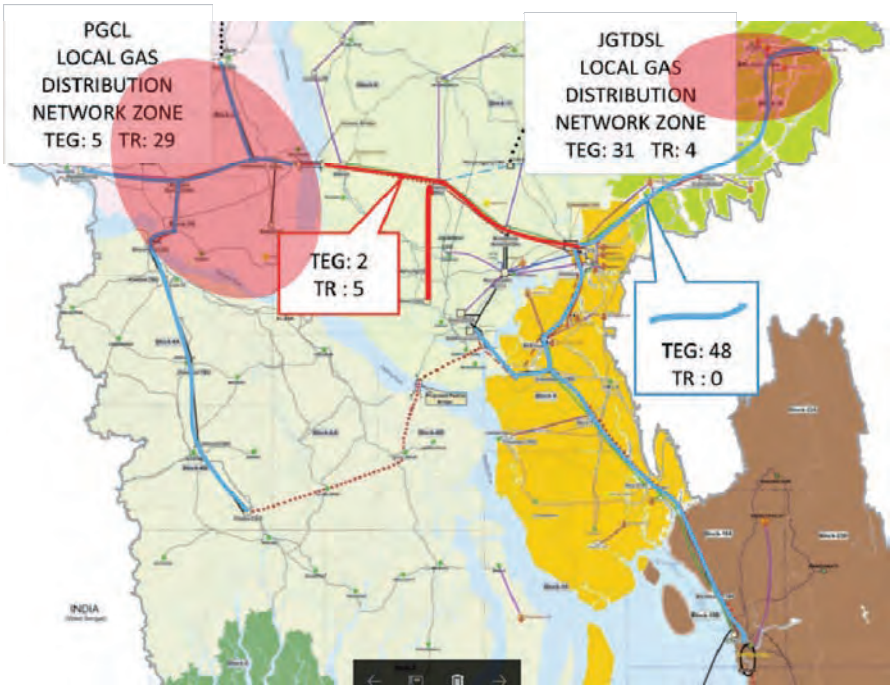
COMPANY	No. OF CP STATIONS		No. OF TEST POINTS
	USING TEG	USING TR	
GTCL	50	5	1618 (*1)
JGTDSL	31	4	100 (*2)
BGDCL	10	0	NO DATA (*3)
PGCL	5	29	743 (*2)

TEG: Thermo-Electric Generator, TR: Transformer/Rectifier
(*1) Aggregate sum of pipeline length with cathodic protection: 1425 km
(*2) Local town distribution network
(*3) Collected from "Site Visit Report" for inspection of facilities
Source: Compiled by JST from data of GTCL, JGTDSL, BGDCL and PGCL

General practice in Bangladesh is to use transformer/rectifier where external electric supply is available and TEG for remote/isolated locations, however, actual installation for town distribution in JGTDCL areas uses TEG, and transformer/rectifier is used for pipelines from Ashuganj to Elenga in GTCL. It is understood that such design options are depending on local availability of electricity at the time of pipeline construction.

Recent development promotes the use of hybrid type of TEG with solar panel, and study/investigation of new technology is to be implemented for maintenance/replacement of existing facilities.

Locations of stations installed along with transmission/distribution pipelines are plotted in the figure below where type of electric sources is identified.



Source: Prepared by JST using map of GTCL

Figure 2.4.3 CP Station Type (TEG/TR) and Locations Along Gas Pipelines

(5) Maintenance of Cathodic Protection System

Among those collected data, no information is available as to items for test/monitoring or its intervals and acceptance criteria. However, a site inspection by CP Equipment supplier recorded 8 days to complete tests of 10 test points, and 6 locations are reported as "maintenance/repair is needed". Thus, it is understood that CP maintenance is an issue.

Most important requirements for maintenance of Cathodic Protection System is known as "record-keeping" while the collected data by JST did not include such record, except for one report shown in the above.

Number of CP facilities are spread all over the country which includes remote locations, and it makes such proper maintenance difficult. Structured organizational set-up is needed including education and training involving engineers/technicians as they are required to discharge duties at remote locations without additional supervision. Thus maintenance is fully dependent on discipline and capability of each individual.

There are numbers of training programs which are provided by NACE (National Association of Corrosion Engineers)[5] or by equipment suppliers and consultants.

The material requisition/specification of GTCL specifies requirements for materials, together with a suppliers' proposal for training course.

Environments for installed pipelines are changing and operation parameters (such as soil resistivity, distance, etc) are needed to be properly adjusted. Accordingly, involvements of well qualified engineer/technicians are essential.

GTCL sublets the measurement of pipe to soil potential (PSP) to third party and the monthly repors are submitted to GTCL. The ability and quality of the third party reports of PSP need to be investigated.

(6) Maintenance Pprogram for CP System

It is recommended to establish Maintenance Program including the following:

- Procedure for planning test and maintenance of entire CP system
- Written procedure or guideline for test/evaluation/adjustments/repair of CP system
- To avail necessary tools /equipment and calibration tools
- Implementation of test/inspections according to established procedures, and record-taking
- Set-up of adequate organization and assignment of qualified personnel, including education and training
- Collection of operational data alongside the existing pipeline network and compile comprehensive data base covering whole areas of pipeline installation. As a result, consistency

[5] National Association of Corrosion Engineers (NACE) International, is a professional organization for the corrosion control industry of which headquarter is located in Houston, USA. It is a society for protection of people, assets, and the environment from the adverse effects of corrosion.

and integrity of CP system is maintained by sharing information among operating companies to cover entire area of pipeline installation.

2.4.9 Operation & Maintenance Records

Data as to O&M Record were not available except some CP data. As noted in the Para 850.2 "Basic Requirements" of ASME B 31.8 for Gas Transmission and Distribution Piping Systems, the gas operating company needs to:

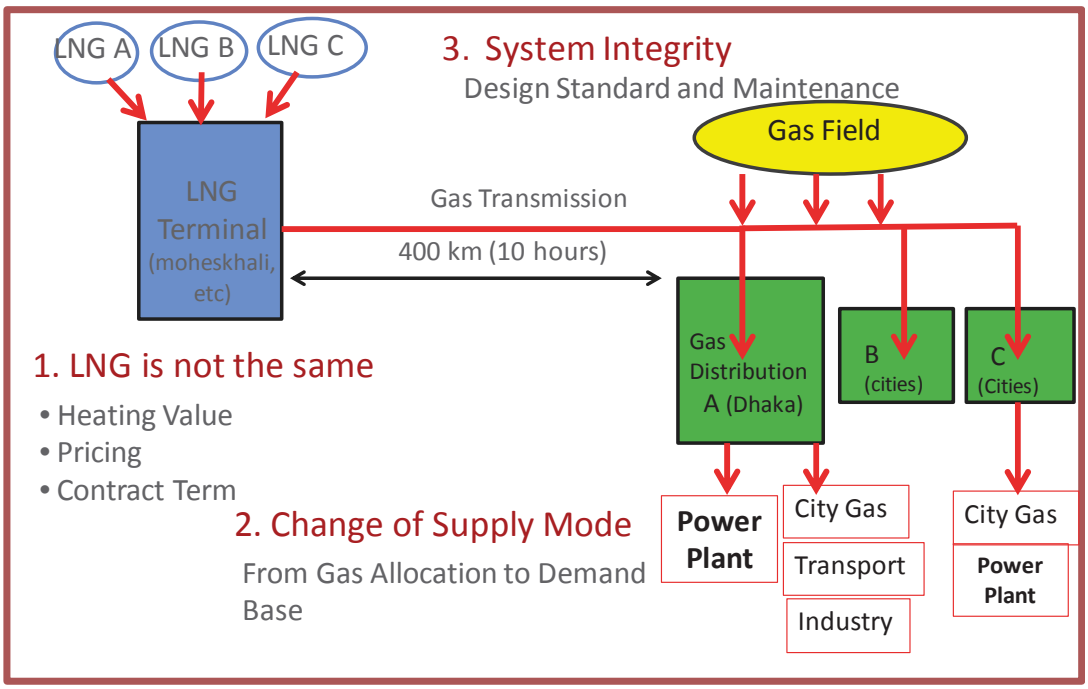
- have a written plan covering O&M
- have a written emergency plan covering facility failure and other emergencies
- operate and maintain its facilities in conformance with these plans
- modify the plans periodically
- provide training for employees
- keep records to administer plans and training properly

These must be implemented as part of Enterprise Resource Planning (ERP). ERP is the system to manage human resource, asset, and financial data. It integrates and covers necessary information for enterprise such as production, sales, procurement, asset, O&M, accounting system. The system needs to be customized for necessary aspects of each company.

2.5 Issues and Challenges in Gas Sector

2.5.1 Gas Operation Mode Change

Gas demand in Bangladesh will be increasing while domestic gas production is considered declining. Significant amount of gas will be imported to fill in the demand and supply gap. Operation mode will also be changing from Gas Allocation Base to Gas Demand Base, as shown in the figure below. Gas system integrity considering such operation mode change has not been reviewed in the past. There is no standard design philosophy and standard, and applied standards differ from project to project. Systematic maintenance system need to be in place.



Source: Prepared by JST

Figure 2.5.1 Gas Operation Mode Change to Demand Base

2.5.2 Integrated Operation and Information Sharing System

Advanced Operation and Information Sharing System is necessary in Bangladesh considering the following.

(1) LNG introduction

LNG will be introduced by several different entities. Nature of LNG may also differ from sources to sources. These gases are also mixed with domestic gases in gas transmission system. Gas flow speed is slow, different from electricity transmission which can be sent instantaneously. Accordingly, if electricity demand and gas demand for power is suddenly increased, amount of gas flow cannot respond to cope with power demand increase. Time gap will be created between gas demand and gas supply.

Due to a gas delivery time lags created by pipeline transmission system, proportion of gas mixture may change with the supply profile. Supply profile is designed to fill out the demand curve predicted based on historical data, similar to power supply profile, i.e., base load and peak shaving supply.

LNG terminal and FSRU should have high utilization factor in terms of economic efficiency, and gasification rate should be kept at rated capacity as possible. Accordingly, amount of gas from LNG is preferred be stable. Meanwhile, the gas production in domestic gas field can be adjusted. Considering this aspect, LNG may be used to supply to a base load profile, while domestic gas may be used to fill out a middle/peak shaving profile portion. To accommodate these issues, central monitoring and control system should be introduced. As the minimum requirement, The following system should be introduced, as described in section 2.1.5.

To minimize the operational and financial risk associated with LNG introduction for Petrobangla, it is worth to consider introduction of "Capacity Right allocation" and "Quality Bank" in LNG Terminal Operation.

- Capacity Right is the right to use gas transmission capacity allocated to each LNG suppliers.
- Quality Bank works to settle the account among the supply projects with difference in gas supply capacity, heating values, pricing and contract terms.

(2) Operation mode

Operation mode will change from the current "Gas Allocation System" to "Demand Base System". Operators in gas supply side need to know gas demand profile beforehand and send the gas to meet the actual demand profile. Advanced operation system must be designed to integrate the system from gas fields/LNG terminals to downstream customers.

(3) System Integrity

Integrity of gas transmission and distribution system has not been reviewed in the past. There is no design philosophy and standard commonly applied in all organizations in Bangladesh. Applicable standard and design philosophy are differently selected from project to project.

There is no centralized information management system, and no asset register is maintained. No process of physical asset verification is also in place, and therefore, system integrity is not known. GTCL has started to install ERM and EAM system for management of information system and asset register, which will be the starting point to achieve system integrity.

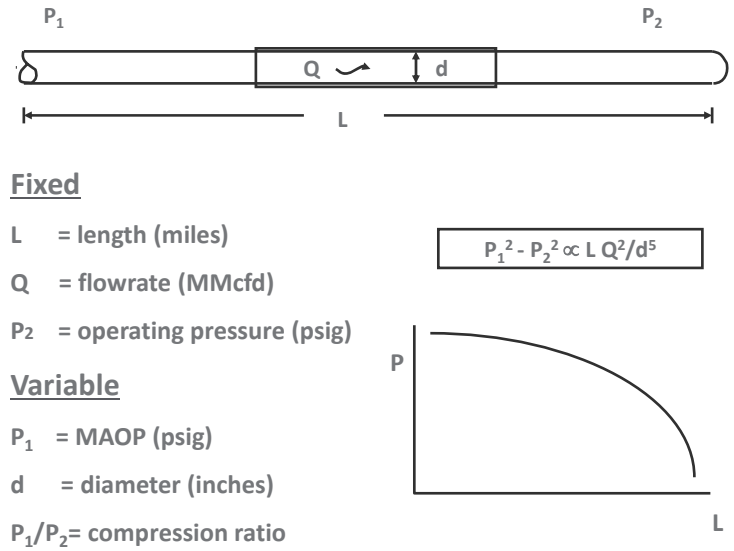
2.5.3 Reliable Gas Network Infrastructure

(1) Design Philosophy

Before discussion about Reliability of Gas Network Infrastructure, Design Basics should be shared among the engineers:

In general, gas flow rate and pipe length are the given parameter in design. In addition, sometimes operation pressure is also set as target. In case of compressor design, Maximum Allowable Operating Pressure (MAOP) is also set as a compressor inlet design pressure. Pressure will decline according to the distance. The higher the inlet pressure is, the longer the travel distance will be.

Basic calculation method of gas flow is as shown in the figure below.

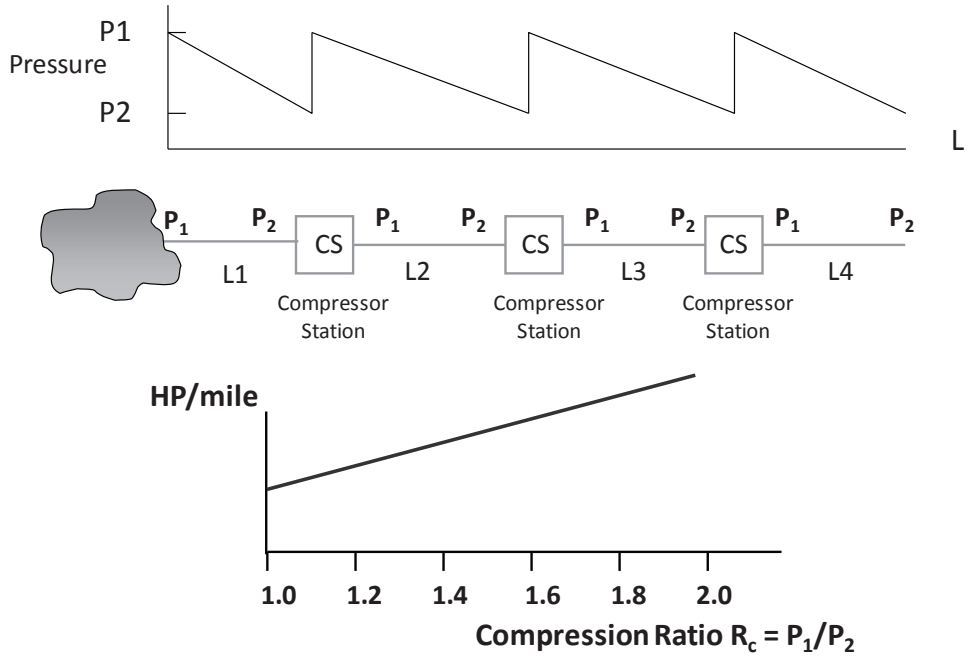


Source: Prepared by JST

Figure 2.5.2 Flow Equation Basics

Compressor station is installed to deliver the gas for longer distance. Compression ratio is pressure at pipe outlet divided by pressure at pipe inlet. Theoretically, the higher the compression ratio is, the longer the compressor station spacing will be, which can save the numbers of compressor stations. It is noted that construction of compressor station is costly. Currently MAOP of Bangladesh for Class #600 is set to be 1,135 psig and operating pressure is set to be 1,000 psig. Compression ratio is 1.135, which is considered to be too low. International practice for Class #600 system allows raising the MAOP to 1,440 psig. This need to be considered in the review of design philosophy.

The concept of compression ratio of compressor station is as illustrated below.



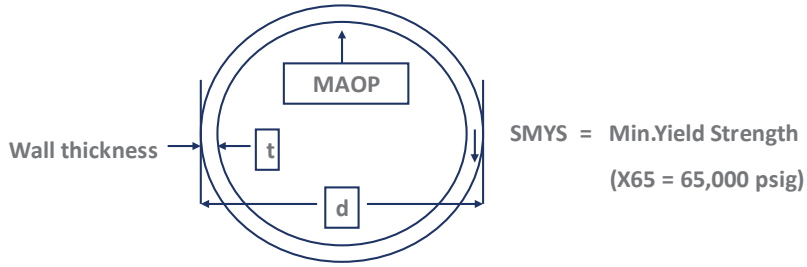
CS: Compressor Station, P1: pressure at gas field or CS, P2: pressure at CS inlet,
L1, L2, L3, L4: length between CS's, HP : Horse Power
Source: Prepared by JST

Figure 2.5.3 Compressor Station Basics

MAOP is basically comes from pressure limitation of valves and fittings. Specified minimum yield strength (SMYS) is dependent on steel material. SMYS is a common term used in the steel pipes for oil and in accordance with a listed standard specification in USA. It is recommended to use American Petroleum Institute standard (API) X60[6] or X65 as a standard steel pipe material in a view point of the welding quality.

Welding of higher yield strength material require more skills and quality control. In terms of cost and benefit, cost impact is larger if diameter is increased in comparison with raising MAOP. The following figure illustrates Cost and Benefit of MAOP and Diameter.

[6] X60 indicates that Specified Minimum Yield Strength of material is 60,000 psi.



(MAOP) (d) = (2t) (SMYS)

Tonnes of steel ∝ d * t, therefore:

Increase MAOP

Tonnes of steel ∝ MAOP

Increase diameter

Tonnes of steel ∝ d^2

t: thickness, d:diameter, MAOP: maximum allowable operating pressure, SMYS: Minimum Yield Strength
Source: Prepared by JST

Figure 2.5.4 Cost and Benefit of MAOP and Diameter

$$P_1^2 - P_2^2 \propto LQ^2/d^5 \qquad Rc = P_1/P_2 = \text{Fixed}, \quad L = \text{Fixed}$$

Hence:

$$P_1^2 \propto Q^2/d^5$$

$$Q \propto P_1 * d^{2.5}$$

Therefore :

Flowrate ∝ MAOP ∝ Tonnes of Steel

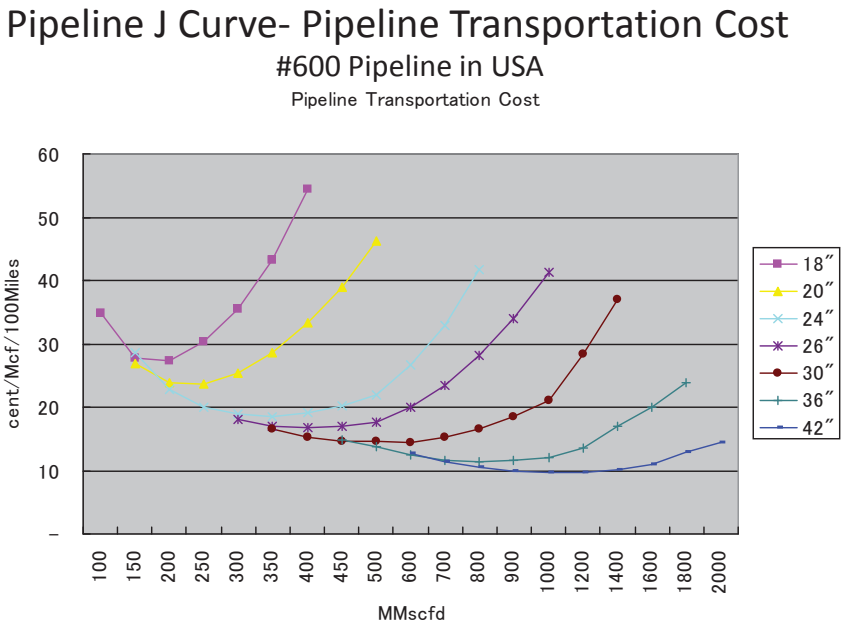
Flowrate ∝ $d^{2.5}$ ∝ Tonnes of Steel * $d^{0.5}$

P_1: outlet pressure, P_2: inlet pressure, d: diameter, Q: Flow rate, L: pipe length, Rc: Compression rate
Source: Prepared by JST

Figure 2.5.5 Benefit from MAOP and Diameter

In case flow rate is needed to be maximized, it is more advantageous to use larger pipe rather than to use higher MAOP.

J-Curve is produced taking all the design elements and economic elements into consideration, which provides optimum operation range.



Source: Prepared by JST

Figure 2.5.6 Pipeline Transportation Cost by Diameter

The following is a comparison table showing the typical MAOP and what used in Bangladesh:

Table 2.5.1 Design Standard and Valves and Fittings (Typical MOAP and Bangladesh)

ASME Class	MAOP	Comment
400 #	960 psig	Not commonly used
600 #	1440 psig	Popular
	1135 psig	Bangladesh
	1000 psig	Bangladesh
	960 psig	Bangladesh
900#	2160 psig	Offshore/Long Distance

Source: Prepared by JST

Current MAOP in Bangladesh is in the range of 960-1,135 psig. MAOP can be raised to 1,440 psig, if pipe wall thickness is also designed to1,440 psig to maximize the system performance. Pipe material grade is specified by Specified Minimum Yield Strength (SMYS) in ASME standard. Considering the welder qualification and education system in Bangladesh, it is safer to use Grade X60 (SMYS is 60,000 psi) or X65 (SMYS is 65,000 psi). Welding of X70 and higher grade material require higher skill and knowledge and systematic quality control, and contractors also need to be qualified.

2) Design Standard

There is no unified design standard in Bangladesh. Design standard differs from project to project in Bangladesh. The following is an example of the design difference, each has its own standard and design philosophy and meets international standard. However, it is not preferred way in view of overall integrity of the system and spare parts management. When applied material standard is different, different range of spare parts are required.

Table 2.5.2 Applied Material and Standard by Project

Pipeline	Material	General Section		Road Crossing		Corrosion Allowance (mm)	Soil Cover Depth (m)
		Class/ Zone	Safety Factor	Class/ Zone	Safety factor		
Bakhrabad-Siddhrirgonji	API 5L X70	3	0.5	4	0.4	1.27	1.2
Dhonua-Elenga (D-N)	API 5L X60	2	0.6	Casing Pipe		1.5	1

Source: Prepared by JST, according to information form GTCL

Design Class and safety factor, specified in ANSI B31.8 Pipeline design Code, must be decided as part of EIA. Future area development plan must also be incorporated to decide the pipe Classification. Organized and standardized approach must be discussed and introduced. When classifying locations for the purpose of determining the design class for the pipeline construction and testing that should be prescribed, due consideration shall be given to the possibility of future development of the concerning area. At the time of planning a new pipeline, if the future development is likely to change each piping classification in each location, this should be taken into consideration in the design and testing of the proposed pipeline.

3) Asset Management

It appears that more focus has been given to new construction projects; however, asset management including maintenance plan should significantly be improved. There are needs to update process flows and pipeline alignment drawings;, also, available complete valve station and manifold information is quite insufficient so far.

Introduction of Enterprise Asset Management (EAM) and Enterprise Resource Planning (ERP) is discussed among the government entities. In order to introduce the systems successfully, The following are the basics things to be prepared:

- Drawings/Documents Management System
- Unified Design Standard, including Unified Material Specification

Centralized information management system need to be established, and asset register should be maintained and process of physical asset verification is also necessary in be in place, and only after that, system integrity will be known.

2.6 Control/Monitoring Target

Control and Monitoring Target for Transmission and distribution in Bangladesh will be as follows:

(1) Transmission System

Real time monitoring of flow and pressure will be conducted via SCADA system, however, long term monitoring to find out abnormalities is necessary, including:

- Detect System bottlenecks
- Detect System loss
- CP Monitoring and Maintenance

  Monitoring of these should be carried out as part of asset management.

All the information, including updated process flow diagram, alignment drawings and material specifications update need to be properly managed and kept in the system.

(2) Distribution System

Major control and monitoring target for Distribution System is necessary to:

- Minimize system loss
- Minimize accident.
- Prevent pilferage of gas i.e., gas theft

These are monitored and detected.

(3) Accident and Alternative Supply Routing

In case one of the gas field system is shut down, the system needs to indicate alternative routing to back up operational transaction.

- In case part of transmission line is shut down, the system allows to detect alternative route to minimize the affected area.

Any accident areas need to be spotted and alternatives supply routing should be calculated.

2.7 Recommendation on Asset Management in Gas Sector

2.7.1 Recommendation on Network Infrastructure Management System

As was stated in Chapter 2.4, it is necessary to establish asset management system with document and drawing management for long term operation.

For that, Network Infrastructure Management System, capable of creating virtual database by communicating with various data systems and sources owned by each company, is proposed. Using the virtual database, spare parts can be shared in common and minimize the material redundancy. Reality of the current situation is that there are no useful drawings and documents to support introduction of computer systems.

In the Network Infrastructure Management System for asset management of gas pipeline facility, necessary data field is studied and compiled. The following table is the list of minimum requirements of data field items for (i) gas transmission line, (ii) valve stations, and (iii) gas fields.

Detailed items for the gas network infrastructure and data fields are explained in detail in section 5.3.

Table 2.7.1 Recommended Data Items in Asset Management

Transmission Line	Valve Stations (Manifold)	Gas Field
Pipeline ID	Valve Station ID	Gas Field ID
Company Name	Station Name	Gas Field name
Pipeline Name	Process Flow Diagram	Gas Production (mmscfd)
From (VS ID)	P & ID	Processing Plant Outlet Pressure (psig)
To (VS ID)	Piping Layout	Processing Plant Inlet Pressure (psig)
OD (inch)	Piping Drawing	Condensate Production (bpd)
Length (km)	Bill of Material	Processing Plant PFD
Pipe Material	SCADA ID Flow Meter	Processing Plant P&ID
Design Class	SCADA ID Pressure Gauge	Latitude
Wall Thickness (mm)	Utlity	Longitude
Corrosion Allowance (mm)	Latitude	Elevation
Design Pressure (psig)	Longitude	Temporary latitude, longitude
Maximum Allowable Operating Pressure (psig)	Elevation	Longitude temp
Normal Operating Pressure (psig)	Temporary latitude, longitude	
Normal Flow Rate (mmscfd)		
Operation Status		
Year of Commissioning (YYYY/MM)		
CP System		
Crossing (River, Road, Pipeline, etc.)		
Angle Point (Latitude, longitude, elevation)		

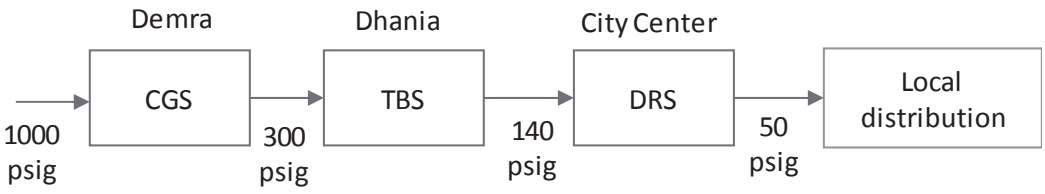
Source: Prepared by JST

The asset management system should also have document management system with searching function for reference serial number, date, document type, department, responsible staff, related information (such as ongoing/incoming, project name, etc.), and soft copy should be saved in a central server and shared by responsible person in charge as necessary.

2.7.2 Data Group Configuration in Network Infrastructure Management System

Data Group consist of three pressure levels (i.e., High Pressure, Mid Pressure and Low Pressure. High Pressure system) is used by transmission system. Mid pressure and Low Pressure is used by local distribution companies. Gas is sourced from onshore gas fields and LNG terminal in near future. These gasses are transmitted by high pressure pipeline (1000 psig) to each areal franchise companies,

through City Gate Station (CGS) stations, or manifold stations. Local Franchise company receives gas from high pressure gas transmission company via Town Bordering Station (TBS) where gas pressure level is further reduced to the level of 300 psig or 140 psig to supply each District Regulating Station (DRS) stations. Gas pressure is further reduced at DRS to 50 psig (Low pressure system) to deliver the gas to each customer. The typical system is as illustrated below.



CGS: City Gate Station, TBS: Town Bordering Station, DRS: District Regulating Station
Source: Prepared by JST

Figure 2.7.1 Valve Station Group by Pressure

CHAPTER 3 POWER SECTOR

This chapter describes about power sector in Bangladesh. It summarizes organizational structure, development planning, O&M status, and asset management status. The Chapter clarifies the space for improvements in O&M in power sector especially with SCADA.

3.1 Power Sector Organization

3.1.1 Ministry of Power, Energy and Mineral Resources (MoPEMR)-Power

Ministry of Power, Energy and Mineral Resources (MoPEMR) is the main ministry to deal with primary energy and electrical power policy and administration in Bangladesh. As of May 2016, the Prime Minister holds the position of the minister of MoPEMR and State Minister is responsible for conducting the businesses of the Ministry/division in the parliament unless otherwise directed by the Prime Minister.

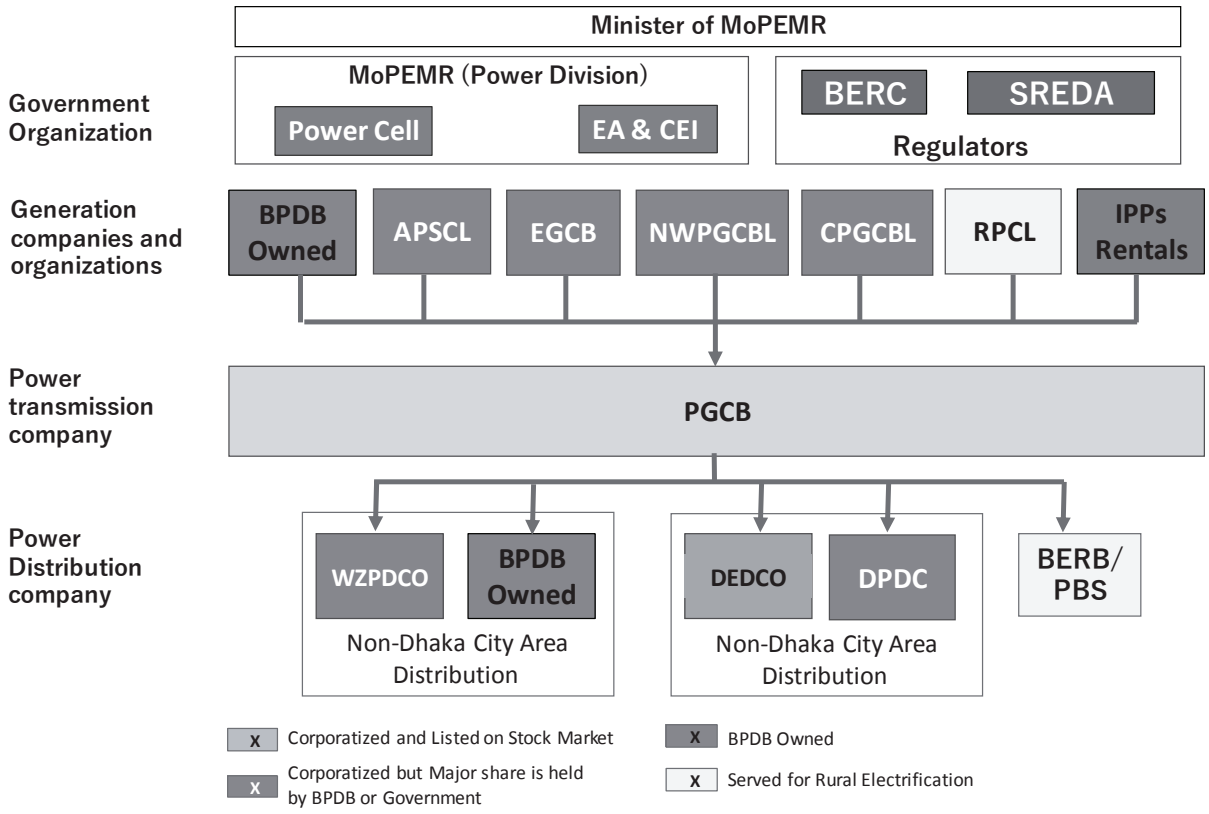
The organization diagram of MoPEMR is shown in Figure Figure 2.1.1. Under MoPEMR, Energy Division (Energy and Mineral Resources Division) and Power Division exist.

All prices of main energy sources, natural gas, oil and electrical power are subject to approval or consent by either government or regulatory body.

Power generation entities are partly public corporations and some private companies, however, natural gas entities are all state-owned, and substantial oil import/refinery entities are also state-owned.

3.1.2 Power Division

In Bangladesh power sector (mainly on-grid related) entities exist under the supervision and administration of Power Division, as shown below.



Source: PSMP2016, modified by JST

Figure 3.1.1 **Overview of Bangladesh Power Sector**

From early 1990s, Power Sector Reform made substantial progress and led to the corporatization of then vertically integrated power giant Bangladesh Power Development Board (BPDB). These public corporations have in general improved operational performance.

3.1.3 Power Sub-Division Organization

Power Division is responsible for all activities related to power generation, transmission and distribution. Its scope also covers the coordination with other divisions and ministries to promote public-private partnership, private investment, rural electrification and renewable energy, and energy efficiency and conservation. Power Division also monitors the performance of public-owned power utilities with key performance indicators (KPIs). If a utility performs below the pre-determined/agreed KPI, then the utility needs to pay a penalty.

Power Division has below sub-division organizations:

(1) Power Cell

Power Cell was established in 1995 as a promoter of the power sector reform. They played a central role of the sector reform in the late 1990 to the early 2000s and contributed to the establishment of public generation companies and distribution companies. Recently Power Cell provides strategic advices on business planning and human resource development for those public power utilities. In

addition to those rolls, Power Cell takes a counterpart role in land-based LNG terminal project to ensure stable primary energy supply for power sector[7].

(2) Office of the Electrical Advisor & Chief Electric Inspector and Energy Monitoring Unit:

Electrical Advisor and Chief Electrical Inspector (EA & CEI): This office was established to ensure the safety of those who work for power generation, transmission and distribution, by not only licensing for high voltage and medium voltage consumers, electrical contractors, engineers and electricians, but also inspecting installations, substations and lines. The subdivision office of Energy Monitoring Unit (a subdivision of EA & CEI) ensures that industries are using energy efficiently and energy is being conserved were possible[8].

(3) Bangladesh Power Development Board (BPDB)

BPBD was initially established as Water and Power Development Board under East Pakistan administration. After the independence, it became Power Development Board in 1972, with the installed capacity just 200 MW. Until 1990s, when the power sector reform made a substantial progress, BPDB was a vertically integrated power entity. Even now BPDB owns 30 to 40% of installed capacity and distribution lines (however, BPDB-owned thermal power plants in general suffer poor maintenance and low efficiency, which results in the BPDB-own power plants contribute less than 30% of electricity generation). BPDB Board consists of chairperson and other 6 members.

BPDB plays a vital role as a single buyer of power sector. As a result of non-cost recovery tariff, BPDB has accumulated operation deficit, and it once reached 64 billion BDT in FY2012. Currently Bangladesh has strived for continuous power tariff raise, and also benefited from the oil price decline (this reduces the BPDB's expense for fuel subsidy to the rental power plants). These factors contributed to the reduction of the accumulated deficit to 52 billion in FY2015.

BPDB's distribution networks were unbundled and made into public distribution companies in the 1990s to the early 2000s. Two distribution companies were established in Dhaka area, and another one in the western area.

(4) Power Grid Company of Bangladesh (PGCB)

PGCB was formed under the restructuring process of Power Sector in Bangladesh with the objective of bringing about commercial environment including increase in efficiency, establishment of accountability and dynamism in accomplishing its objectives. PGCB was incorporated in November 1996 with an authorized capital of Tk.10 billion. It was entrusted with the responsibility to own the national power grid to operate and expand the same with efficiency. Pursuant to Government decision to transfer transmission assets to PGCB from Bangladesh Power Development Board (BPDB) and Dhaka Electric Supply Authority (DESA), PGCB completed taking over of all the transmission assets on 31.12.2002. PGCB expanded its network and capacity manyfold and operating those efficiently and effectively. PGCB is a public limited company, where 23.75% of its issued shares are listed in a stock market and the rest 76.25% is owned by the Government. PGCB has a long list of development

[7] Source: www.powercell.gov.bd.
[8] Source: www.eacei.gov.bd

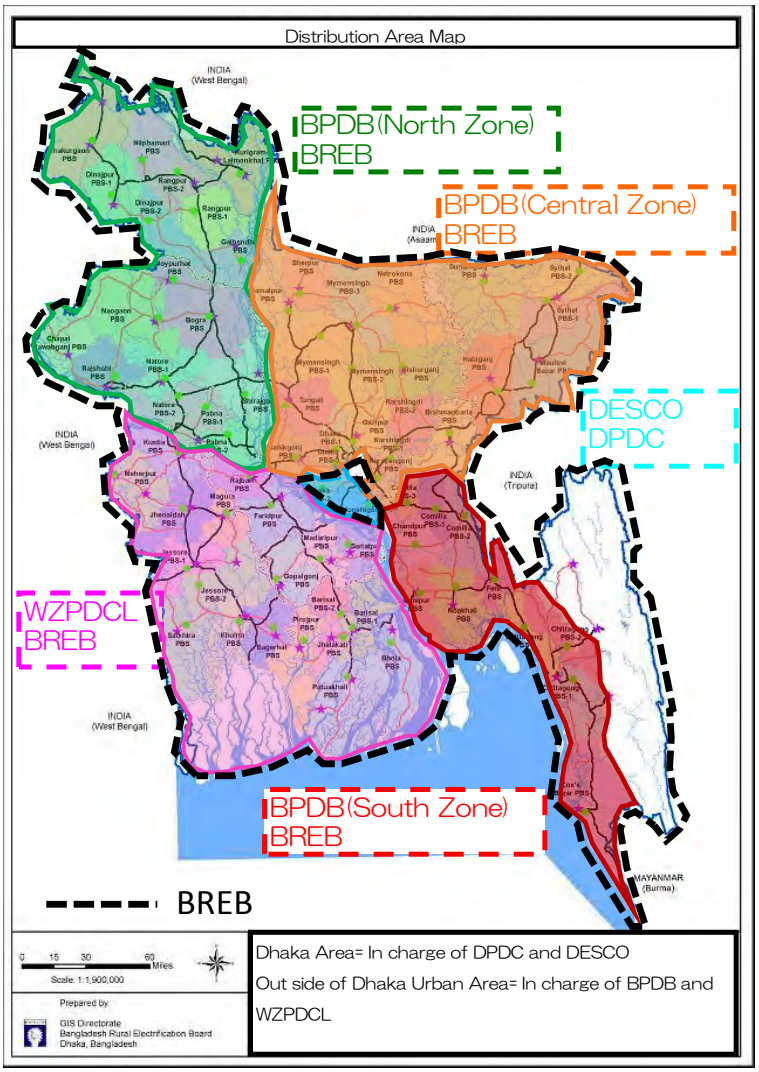
partner's funded projects, including JICA, World Bank, ADB and KfW.

(5) Distribution Entities and Rural Electrification

There are urban distribution companies in Bangladesh. Dhaka Electric Supply Company Limited (DESCO) and Dhaka Power Distribution Company Limited (DPDC) are in charge of Dhaka area, and West Zone Power Distribution Company Limited (WZPDCL) is in charge of the western municipalities including Khulna and Barisal areas. The rest municipal power distribution is still under BPDB's operation.

DESCO and DPDC have made significant operational improvement sometime after its corporatization. DESCO outsourced its meter-readers and introduced performance-based compensation and reduced the meter-reader's frauds. DESCO and DPDC introduced prepayment billing system on a trial basis. As a result of the assessment and also associated operational efforts, both companies achieved system loss less than 9%, and improved billing collection ratio by more than 98% at DESCO and 90% at DPDC, which is higher than other distribution entities.

Bangladesh Rural Electrification Board (BREB) was established in 1977, with reference to the US's rural electrification cooperatives. BREB supervise and manages 72 PBS (Palli Bidyut Samity, or electrification cooperatives) all over in Bangladesh, and monitor the electrification projects in PBSs. BREB also promotes use of electricity to facilitate socio-economic development and improve agriculture in rural areas. The number of BREB's customer (the total contracts of all sectors including industry, commercial and domestic) is more than 14 million, as of February 2016.



Source: prepared by JICA Survey Team using BREB map

Figure 3.1.2 Distribution Companies and Areas

(6) Power Generation Entities[9]

There are several power generation companies and entities as shown in Figure 3.1.1. Followings are the main power generation companies are summarized as follows:

1) Ashganji Power Station Company Limited (APSCL): Established in 2000. The APSCL started based on the transferred asset from BPDB. As of 2016 its generation capacity reaches 960 MW and contributes to the 9% of the county's power generation. APSCL has also a good track record of development partner's funded projects, such as ADB.

2) Electricity Generation Company of Bangladesh (EGCB): Established in 2004. As of 2016, it has 622 MW installed capacity, and contributes to the 7% of the Bangladesh's power

[9] The installed capacity varies depending on the source. Therefore in this section, the installed capacity is solely based on the BPDB web site as of February 2015, and BPDB Annual report FY2014-2015. http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=193&Itemid=120

generation. EGCB also has attracted development partner's funding, including JICA, World Bank and ADB.

3) North West Power Generation Company Limited (NWPGCL): Established in 2007. As of 2016, it has 368 MW mainly in western part of Bangladesh, and contributes to the 5% of the Bangladesh's power generation. NWPGCL also has attracted development partner's funding, including JICA. Recently, NWPGCL has launched a project of LNG import from West Bengal, India, to ensure fuel supply for its gas-fired power plants.
4) Coal Power Generation Company of Bangladesh Limited (CPGCBL): Established in 2011. CPGCBL is an executing agency of JICA-supported Matarbari Ultra-Super Critical (USC) coal fired power plant. It has yet any working power generation plant.
5) Rural Power Company Limited (RPCL): Established in 1993. BREB (described later) owns 30% of equity and 12 PBS own the rest (no capital ties with BPDB). Its installed capacity is 77 MW and impact to the grid network is limited.
6) Independent Power Producers (IPPs) and Quick Rentals: There are in total 16 IPPs in Bangladesh with total installed capacity 2,627 MW. In order to accelerate the introduction of power urgently in 2010 and after, so called "Crash Program" was introduced. The program was to install about 40 numbers of "rental" and "quick rental" power plants. Most of them were oil-based in a period of 3 years. The total power generation from IPP and these rental and quick rental power plants can be up to 50% of entire power generation in Bangladesh. This rapid expansion of rental and quick rental power plants greatly contributed to the reduction of power outage; however, the expensive power purchase price also expands the deficit of BPDB.
7) Ministry of Science and Technology: Ministry of Science and Technology and Bangladesh Atomic Energy Commission are the main body to implement Bangladesh's first nuclear power plant.

(7) Bangladesh Energy Regulatory Commission (BERC)

BERC was established in 2003, under BERC Act. BERC has set rules and regulations to ensure transparency of operation and tariffs in electricity, domestic natural gas, and oil subsectors. Commission protects the benefit of consumer and industry, and promotes competitive market. Commission consists of one chairperson and four members.

In respect of the electricity, BERC Act defines the Commissions major responsibilities are taking regulatory measures for efficient generation of electricity, transmission and distribution of quality electricity, creating enabling environment for private sector investment, management of the sector through fixing reasonable tariff with transparency and creating competitive market.

Specifically the energy prices, BERC only exercises its authority on natural gas and electricity prices, while the BERC Act (2003) stipulates the following:

> *Notwithstanding anything contained in any other law for the time being in force, the price of power generation in wholesale, bulk and retail, and the supply of energy at the level of end-user,*

shall be determined in accordance with the policy and methodology made by the Commission in consultation with the Government

Currently oil prices except LPG are determined by Energy and Mineral Resources Division (to be described in the following section), based on the discussion with Bangladesh Petroleum Corporation (BPC). LPG price is currently determined in the market base, but some regulation will be introduced shortly for the sake of customer protection.

Furthermore, it should be noted that the Commission has responsibilities of two critical areas namely i) to set codes and standards for quality electricity supply, and ii) to facilitate energy efficiency, energy audit and setting standards for the power plants. These areas have been undermined in power sector operation; however, the strengthening BERC's capability and related regulations are indispensable for the further development of the Bangladesh's power sector[10].

(8) Sustainable and Renewable Energy Development Authority (SREDA)

SREDA[11] was established in 2012 based on the SREDA Act. The main mission of SREDA is to ensure the Bangladesh's energy security through promoting renewable energy, and energy efficiency and conservation (EEC). SREDA is responsible for promoting and approval of renewable energy projects, and sets an ambitious target, additional renewable energy capacity approximately 3,200MW by 2021. SREDA is also responsible to develop an energy audit/ energy management system and administrate related activities to promote energy efficiency and conservation.
Regarding the EEC promotion, SREDA is considered to be responsible for demand side, while BERC is responsible for supply side (e.g. power generation plants), although such demarcation is not in a publically opened written document. As of May 2016, SREDA is designing various EEC systems, based on the JICA-supported Energy Efficiency and Conservation Master Plan (2015).

3.2 Development Planning

3.2.1 Generation

(1) Existing facility

As of June 2017, there are 44 power plants having installed capacity of 7,582 MW under Public sector and 64 Power Plants having capacity of 5,373 MW under Private sector in Bangladesh. Apart from the power plants, Bangladesh is also importing power of 600 MW from India. The installed capacity of the total 108 power plants including import power is 13,555 MW. However, due to an aging of the facility, performance is degraded, which is called de-rated capacity. Present capacity (or de-rated capacity) of the above power plants is discounted to 12,771 MW. A summary of power plants is given in the following Table.

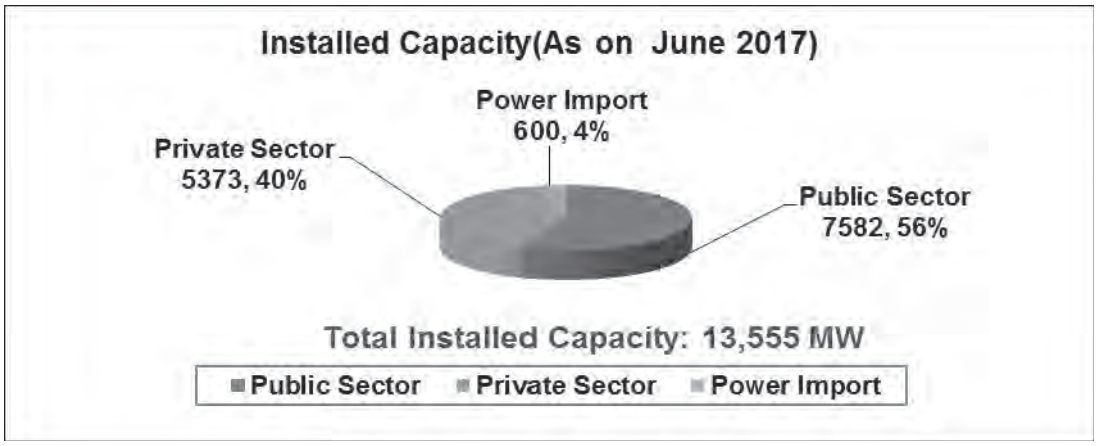
[10] Source：www.berc.org.bd, and interview with Energy Division

[11] http://www.sreda.gov.bd/oldsreda/index.php/about-sreda/function

Table 3.2.1 Summary of Power Plants

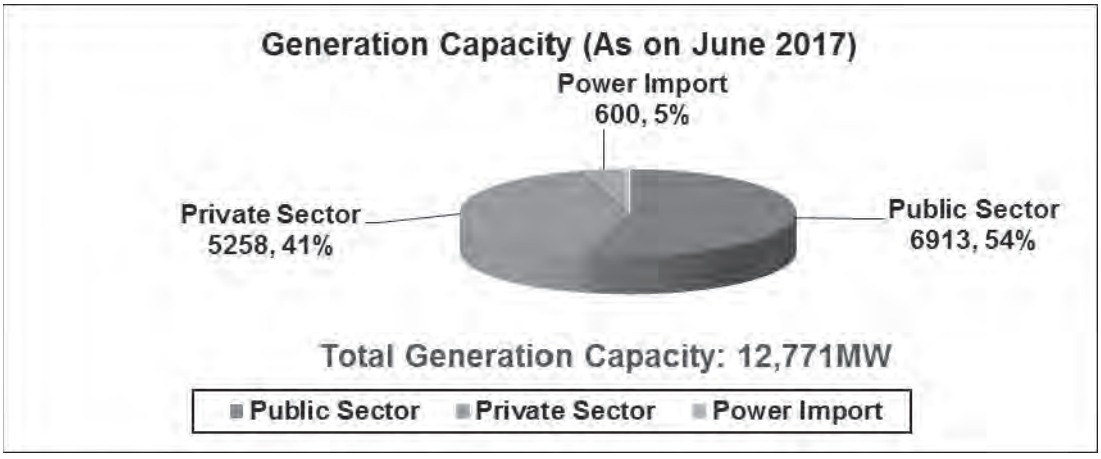
Owner	No. of Power Plants	Installed Capacity (MW)	Present Generation Capacity (MW)
Public Sector	44	7,582	6,913
Private Sector	64	5,373	5,258
Power Import	0	600	600
TOTAL	108	13,555	12,771

Source: System Planning, BPDB



Source: System Planning, BPDB

Figure 3.2.1 Installed Capacity (MW) of Power Plants (As on June 2017)



Source: System Planning, BPDB

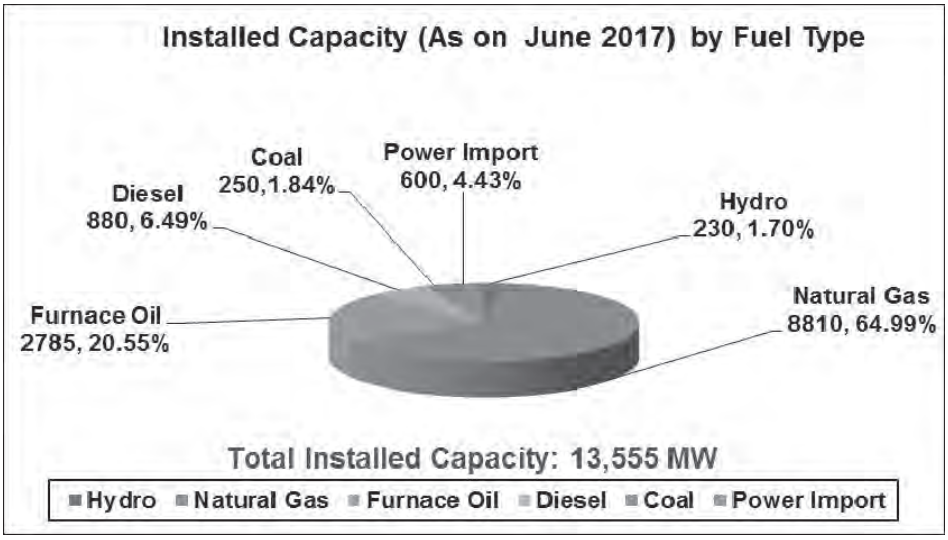
Figure 3.2.2 Present Generation Capacity (MW) of Power Plants (As on June 2017)

The fuel type of power plants is given in Table 3.2.2. The fuel mix of installed capacity shown in chart is given in Figure 3.2.3 and present capacity in Figure 3.2.4.

Table 3.2.2 Fuel Mix of Power Plants

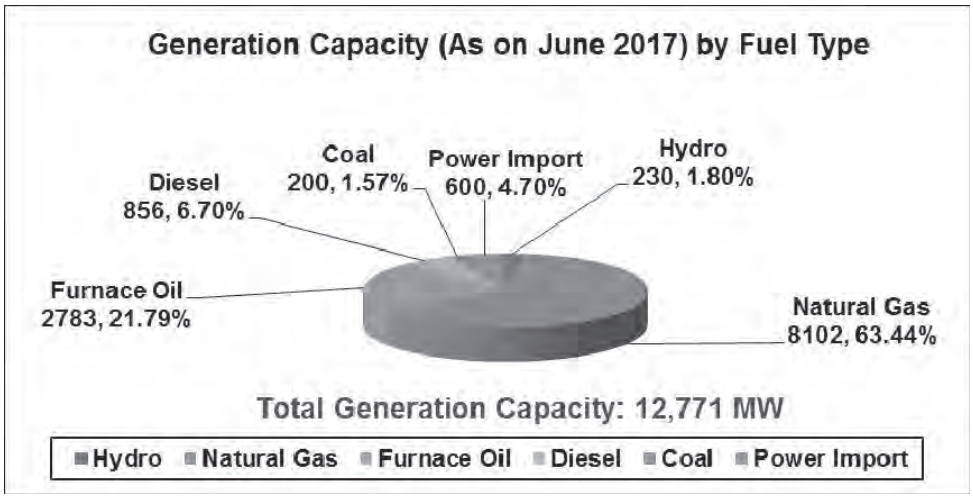
Fuel Type	No of PP	Installed Capacity (MW)	Present Generation Capacity (MW)
Hydro	1	230	230
Natural Gas	61	8,810	8,102
Furnace Oil	36	2,785	2,783
Diesel	9	880	856
Coal	1	250	200
Power Import		600	600
Total	**108**	**13,555**	**12,771**

Source: System Planning, BPDB



Source: System Planning, BPDB

Figure 3.2.3 Fuel Mix of Installed Capacity of Power Plants



Source: System Planning, BPDB

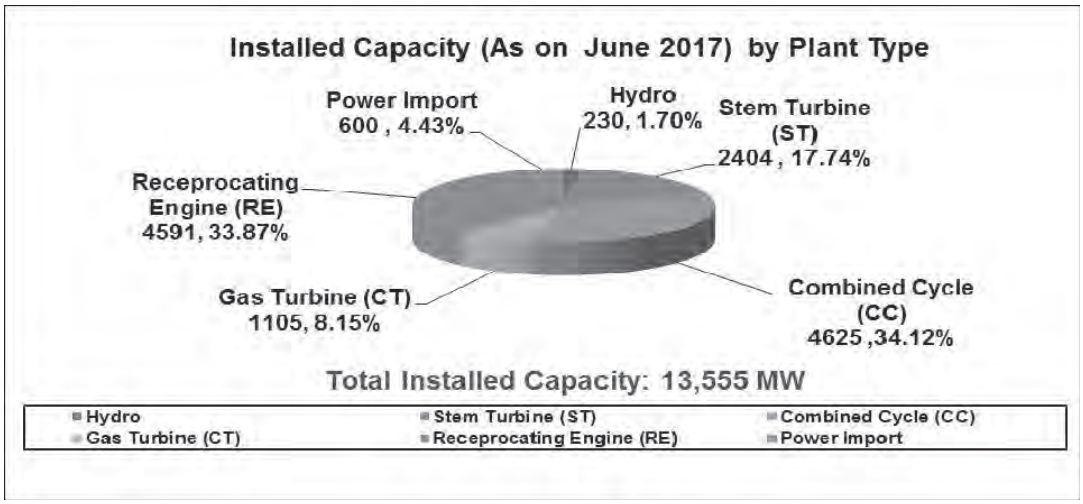
Figure 3.2.4 Fuel Mix of Present Capacity of Power Plants

The Plant type of power plants is given in Table 3.2.3. The plant type wise installed capacity of the power plants shown in chart is given in Figure 3.2.5 and present capacity in Figure 3.2.6.

Table 3.2.3 Plant Type of Power Plants

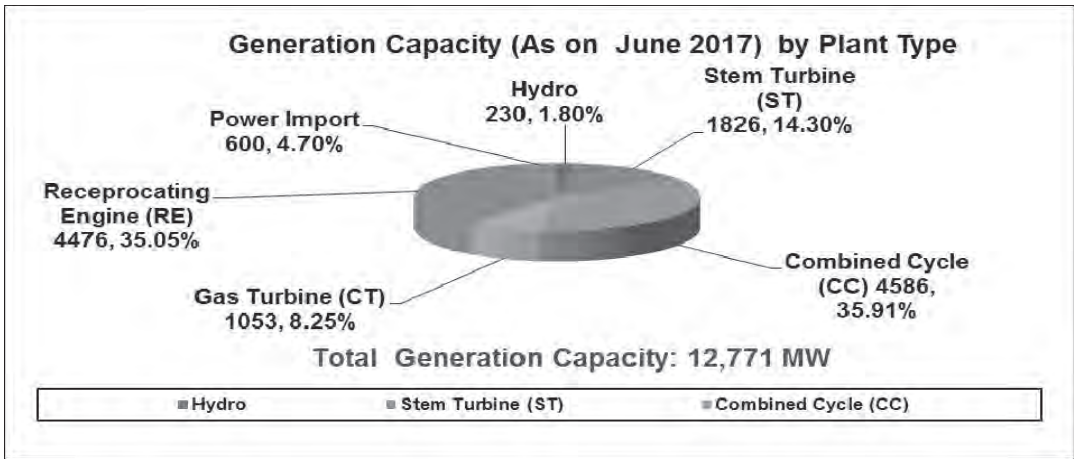
Fuel Type	Installed Capacity (MW)	Present Generation Capacity (MW)
Hydro	230	230
Steam Turbine (ST)	2,404	1,826
Combined Cycle (CC)	4,625	4,586
Gas Turbine (CT)	1,105	1,053
Receprocating Engine (RE)	4,591	4,476
Power Import	600	600
Total	**13,555**	**12,771**

Source: System Planning, BPDB



Source: System Planning, BPDB

Figure 3.2.5 Plant wise Installed Capacity of Power Plants



Source: System Planning, BPDB

Figure 3.2.6 Plant wise Present Generation Capacity of Power Plants

(2) Power Development Plan (PDP)

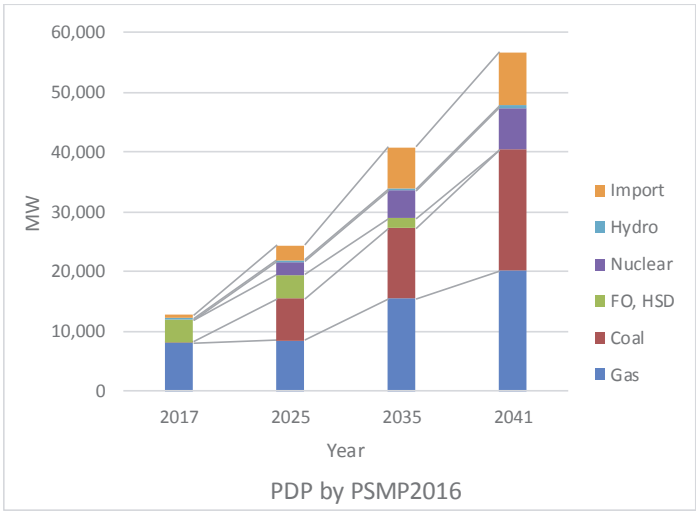
Based on Power Development Plan (PDP) prepared in PSMP2016. The total generation capacity in PSMP2016 was counted to be 24,459 MW in 2025 and 40,858 MW in 2035.

The following tables and figures shows the total generation capacity of PDP in PSMP 2016 by fuel type. The generation capacity of power plants planned to be retired deducted in each year.

Table 3.2.4 PDP in PSMP2016

Year	Gas	Coal	FO, HSD	Nuclear	Hydro	Import	TOTAL
2017	8,102	200	3,639	0	230	600	12,771
2025	8,515	6,977	4,005	2,232	230	2,500	24,459
2035	15,446	11,777	1,673	4,632	330	7,000	40,858
2041	20,177	20,195	0	7,032	330	9,000	56,734

Source: Prepared by JST, referring to PSMP2016



Source: Prepared by JST, referring to PSMP2016

Figure 3.2.7 PDP in PSMP2016 and PDP

In addition to the above, BPDB is planning additional generation plans considering rapid demand increase considering IPP and other generation plans.

(3) Investment planning

The list of Power Development Plan (PDP) as of August 2017 is as shown in the table below. As per PSMP 2016, Power Development Plan (PDP) was prepared with expected Commissioning Date (COD) of the planned power plants to meet the power requirement in future. System Planning of BPDB has updated the status of the planned power plants in 2017. Comparing the status of the planned power plants in 2017 with the status given in the PSMP2016, it was found that COD of some power plants were delayed. The main reasons for the delay in commissioning of the power plants are as follows:

1) Finance Problem:

After initiation of the projects, finance is to be arranged from the financing organizations: development partner agencies, banks etc. Sometimes, it takes long time to arrange the fund, which causes the delay in project implementation for both public and private sector.

2) Lengthy Project Approval:

During implementation of the project, sometimes deviation occurs with the planning. These deviations need to be approved by the approving authority. This approval process takes lot of time causing delay in implementation.

3) Land Availability

The difficulty in implementation of land acquisition caused the delay of schedule. Especially, solar and coal based power plants in private sector are facing land crisis.

Gap analysis of the status of the planned power plants in 2017 with the status given in the PSMP2016 is given in Table 3.2.5

Table 3.2.5 Gap analysis for Power Development Plan (PDP) as of August 2017

Sl. No	Name of the Power Plant	Gross Capacity (MW)	Owner-ship	Type of Fuel	Expected Commissioning Date		progress	PSMP2016		Gap analysis		Remarks
								Net Capacity (MW)	Expected Commissio-ning Date	in capacity	in COD	
Projects Completion by Year 2017												
Public Sector												
1	Siddirganj 335 MW CCPP	335	EGCB	Gas	SC:June, 2017 ST: Dec.,2017	2018	•Achieved: 92 %	328	2016	-7	-2	Finance Problem and Lengthy project approval
2	Shikalbaha 225 MW CCPP	225	BPDB	Gas/ HSD	SC:Jun, 2017 ST: Dec.,2017	2018	•Achieved: 71 % • GT Under Test Run	218	2017	-7	-1	Finance Problem and Lengthy project approval
3	Bheramara 360 MW CCPP	410	NWPGCL	Gas	SC:May, 2017 ST: Dec.,2017	2018	•Achieved: 86 % •Under Test Run	402	2018	-8	0	
4	Ashugonj (North) CCPP	381	APSCL	Gas	June, 2017	2017	•Achieved: 59 % •Under Test Run	370	2017	-11	0	
5	Chapai Nababganj 104 MW PP	104	BPDB	FO	June, 2017	2017	•Achieved: 94 % •Under Test Run	102	2017	-2	0	
6	Ghorasal 365 MW CCPP	365	BPDB	Gas	SC:July, 2017 ST: Dec, 2017	2017	•Achieved: 56 %	352	2017	-13	0	
	Sub-Total (Public)	**1,820**										
Private Sector												
1	Bosila, Keranigonj 108 MW PP (CLC Power)	108	IPP	FO	22.02.2017	2017	•Under Commercial Operation.	108	2017	0	0	
2	Power import from Tripura	60	IPP	Import	May, 2017	2017	•Under Test Run	60	2017	0	0	
3	Kamalaghat 50 MW PP	54	IPP	FO	August, 2017	2017	•Achieved: 60 %	55	2017	1	0	
4	Kusiara 163 MW CCPP	163	IPP	Gas	August, 2017	2017	•Achieved:85 %	163	2018	0	1	
	Sub-Total (Private)	**385**								-385	0	
	Total (2017)	**2205**								-2205	0	
Projects Completion by Year 2018												
Public Sector												
1	Sirajgonj 225 MW CCPP (2nd Unit)	220	NWPGCL	Gas/ HSD	SC:Sept., 2017 ST: June,2018	2018	•Achieved: 72 %	216	2019	-4	1	
2	Sirajgonj 225 MW CCPP (3rd Unit)	220	NWPGCL	Gas/ HSD	SC: March, 2018 ST: December, 2018	2018	•Achieved: 18 %	216	2020	-4	2	
3	Bibiana #3 CCPP	400	BPDB	Gas	SC: March, 2018 ST: December, 2018	2018	•Achieved: 29 %	388	2019	-12	1	
4	Barapukuria 275 MW (3rd	274	BPDB	Coal	June, 2018	2018	•Achieved: 60 %	252	2019	-22	1	

Sl. No	Name of the Power Plant	Gross Capacity (MW)	Owner-ship	Type of Fuel	Expected Commissioning Date		progress	PSMP2016		Gap analysis		Remarks
								Net Capacity (MW)	Expected Commissio-ning Date	in capacity	in COD	
	Unit)											
	Sub-Total (Public)	**1114**										
Private Sector												
1	Power import	500	IPP	Import	July, 2018	2018		500	2018	0	0	
2	Potia, Chittagong 54 MW PP (Re-located from Satkhira)	54	IPP	FO	December, 2018	2018	• LOI issued on 07.03.2017	100	2020	46	2	
3	Gazipur 150 MW PP (Summit)	149	IPP	FO	December, 2018	2018	•Contract Signed on 12.04.2017	147	2016	-2	-2	
4	Julda, Chittagong 100 MW PP (Acorn Inf) (Unit-2)	100	IPP	FO	December, 2018	2018	• Contract Signed	100	2020	0	2	
	Sub-Total (Private)	**803**										
	Total (2018)	**1917**										
Projects Completion by Year 2019												
Public Sector												
1	Khulna 330 MW CCPP (D/F) GT Unit	336	BPDB	Gas/HSD	SC: March, 2019 ST: December, 2019	2019	•Contract Signed	196	2019	-140	0	
2	Bibiana South 383 MW CCPP	383	BPDB	Gas	SC: March, 2019 ST: December, 2019	2019	•Achieved: 17 %	372	2018	-11	-1	Finance Problem and Lengthy project approval
3	Shajibazar 100 MW PP	100	BPDB	Gas	June, 2019	2019	• Tender Under Evaluation	98	2018	-2	-1	Finance Problem and Lengthy project approval
4	Ghorasal 4th Unit Repowering (Capacity Addition)	200	BPDB	Gas	May, 2019	2019	•Achieved: 14 %	388	2018	188	-1	Finance Problem and Lengthy project approval
5	Sylhet 150 MW PP Conversion	75	BPDB	Gas	June, 2019	2019	•Tender under evaluation	221	2018	146	-1	Finance Problem and Lengthy project approval
6	Ghorasal 3rd Unit Repowering (Capacity Addition)	206	BPDB	Gas	September, 2019	2019	•Achieved: 22%	388	2018	182	-1	Finance Problem and Lengthy project approval
7	Satkhira 25 MW PP	25	BPDB	FO	December, 2019	2019		50	2019	25	0	
8	Payra, Potuakhali 1320 Coal Fired Power Plant (1st Phase)	1320	BCPCL (NWPGCL)	Imp. Coal	December, 2019	2019	•Achieved: 14%	1214	2020	-106	1	
	Sub-Total (Public)	**2645**										
Private Sector												

Sl. No	Name of the Power Plant	Gross Capacity (MW)	Owner-ship	Type of Fuel	Expected Commissioning Date		progress	PSMP2016		Gap analysis		Remarks
								Net Capacity (MW)	Expected Commissio-ning Date	in capacity	in COD	
1	Sirajganj 414 MW CCPP	414	IPP	Gas/ HSD	SC:Jan, 2019 ST: May, 2019	2019	•Achieved: 24 %	414	2020	0	1	
2	Chandpur 100 MW Power Plant	115	IPP	FO	March, 2019	2019	• LOI issued on 15.05.2017			-115	-2019	
3	Choumohoni, Noakhali 100 MW Power Plant	113	IPP	FO	March, 2019	2019	• LOI issued on 15.05.2017			-113	-2019	
4	Feni 100 MW Power Plant	114	IPP	FO	March, 2019	2019	• LOI issued on 15.05.2017			-114	-2019	
5	Meghnaghat 100 MW Power Plant	104	IPP	FO	March, 2019	2019	• LOI issued on 15.05.2017			-104	-2019	
6	Thakurgao 100 MW Power Plant	115	IPP	FO	March, 2019	2019	• LOI issued on 15.05.2017			-115	-2019	
7	Rangpur100 MW Power Plant	113	IPP	FO	March, 2019	2019	• LOI issued on 15.05.2017			-113	-2019	
8	Bogra 100 MW Power Plant	113	IPP	FO	March, 2019	2019	• LOI issued on 15.05.2017			-113	-2019	
9	Jamalpur 100 MW Power Plant	115	IPP	FO	June, 2019	2019	• Tender Under Evaluation		2017	-115	-2	Finance Problem and Lengthy project approval
10	Anowara, Chittagong 300 MW PP (United Enterprise)	300	IPP	FO	May, 2019	2019	• Contract Signed	300	2022	0	3	
11	Potiya, Chittagong 100 MW PP (Pricisan Energy)	116	IPP	FO	October, 2019	2019	• LOI Issued on 18.04.2016	100	2020	-16	1	
12	Bhairab 50 MW PP	54	IPP	FO	December, 2019	2019	• LOI issued on 20.03.2012	50	2019	-4	0	
13	Gabtoli 108 MW PP	108	IPP	FO	December, 2019	2019	• Contract Signed			-108	-2019	
14	Bhola 220 MW CCPP (D/F)(Saporji Palonji)	220	IPP	Gas/ HSD	December, 2019	2019	• LOI Issued on 18.04.2016		2016	-220	-3	Finance Problem and Lengthy project approval
15	Import from Tripura (2nd Phase)	340	IPP	Import	December, 2019	2019	• Preliminary works			-340	-2019	
	Sub-Total (Private)	**2454**										
	Total (2019)	**5099**										
Projects Completion by Year 2020												
Public Sector												
1	Sayedpur 150 MW PP	150	BPDB	HSD	January, 2020	2020	• Tender Document under preparation.			-150	-2020	
2	Mymenshingh 360 MW CCPP	360	RPCL	Gas/HSD	June, 2020	2020				-360	-2020	

Sl. No	Name of the Power Plant	Gross Capacity (MW)	Owner-ship	Type of Fuel	Expected Commissioning Date		progress	PSMP2016		Gap analysis		Remarks
								Net Capacity (MW)	Expected Commissio-ning Date	in capacity	in COD	
3	Mirsorai, Chittagong 150 MW PP	150	BPDB-RPCL	Gas/HSD	June, 2020	2020	• Preliminary works			-150	-2020	
4	Borisal 225 MW CCPP (D/F)	225	BPDB	Gas/HSD	December, 2020	2020	• Preliminary works			-225	-2020	
5	Gazaria 350 MW Coal Fired Thermal Power Plant (Phase-1)	350	RPCL	Imp. Coal	December, 2020	2020				-350	-2020	
6	Sreepur 150 MW HFO Based Power Plant	150	BPDB-RPCL	FO	December, 2020	2020				-150	-2020	
	Sub-Total (Public)	**1385**										
Private Sector												
1	LNG based 750 MW CCPP (Reliance)	750	IPP	LNG	January, 2020	2020	• Preliminary works			-750	-2020	
2	Chittagong 612 MW Coal Fired Power Project(S.Alam Group)-1	612	IPP	Imp. Coal	June, 2020	2020	• Preliminary works	612	2020	0	0	
3	Chittagong 612 MW Coal Fired Power Project(S.Alam Group)-2	612	IPP	Imp. Coal	June, 2020	2020	• Preliminary works	612	2020	0	0	
4	Fenchugonj 50 MW Power Plant	55	IPP/NRB	Gas	June, 2020	2020	• Approved by purchase committee.			-55	-2020	
	Sub-Total (Private)	**2029**										
	Total (2020)	**3,414**										
Projects Completion by Year 2021										0	0	
Public Sector										0	0	
1	Ashugonj 400 MW CCPP (East)	400	APSCL	Gas	January,2021	2021	• Tender Under Evaluation			-400	-2021	
2	BIFPCL, Rampal, Coal Fired Power Plant	1,320	BIFPCL	Imp. Coal	March,2021	2021	• Contract Signed	1214	2020	-106	-1	Finance Problem and Lengthy project approval
3	Baghabari 100 MW PP Conversion	50	BPDB	Gas	June, 2021	2021	• Tender under evaluation.	102	2020	52	-1	Finance Problem and Lengthy project approval
4	Shajibazar 70 MW PP Conversion	35	BPDB	Gas	June, 2021	2021	• Tender under evaluation.			-35	-2021	
5	Raojan 550 MW CCPP	550	BPDB	LNG	December, 2021	2021	• Preliminary works			-550	-2021	
6	Gazipur 450 MW CCPP	450	RPCL	LNG	December, 2021	2021	• Land acquisition Complete.			-450	-2021	
	Sub-Total (Public)	**2,805**										
Private Sector												

Sl. No	Name of the Power Plant	Gross Capacity (MW)	Owner-ship	Type of Fuel	Expected Commissioning Date		progress	PSMP2016		Gap analysis		Remarks
								Net Capacity (MW)	Expected Commissio-ning Date	in capacity	in COD	
1	Maowa, Munshiganj 522 MW Coal Fired Power Project (Orion)	522	IPP	Imp. Coal	June, 2021	2021	•Achieved:3 %	522	2020	0	-1	Finance Problem and Lengthy project approval
2	Borisal 307 MW Coal Fired Power Plant	307	IPP	Imp. Coal	December, 2021	2021	· LOI Issued			-307	-2021	
3	Dhaka 635 MW Coal Fired Power Project (Orion Group)	635	IPP	Imp. Coal	December, 2021	2021	• Contract Signed	635	2020	0	-1	Finance Problem and Lengthy project approval
	Sub-Total (Private)	**1,464**										
	Total (2021)	**4,269**										
	Total	**16,904**	**MW**									

FO: Fuel Oil, ST: Steam Turbine, Source: BPDB System Planning, BPDB

3.2.2 Transmission and Distribution

(1) Existing facility

The power system network of 2017 made by PGCB is shown in the figure in the next page. The black lines represent 400 kV transmission lines, which are planned in a radial configuration from Dhaka toward Chittagong, Comilla, Khulna, and Bogra. A ring of 400 kV transmission lines are constructing around the Dhaka metropolitan area, with 230 kV transmission lines leading into the city, fed by the 400 kV ring.

Currently some 400 kV transmission lines were already commenced. Existing 400 kV transmission lines in 2017 are as follows:

- Beheramara-Baharampur 400kV transmission line
- Kaliakoir – Bibiyana 400 kV transmission line
- Aminbazar –Meghnaghat 400 kV transmission line (Presently operating at 230 kV)
- Comilla (N)–Surjyamaninagar, India 400 kV transmission line (Presently operating at 132kV)

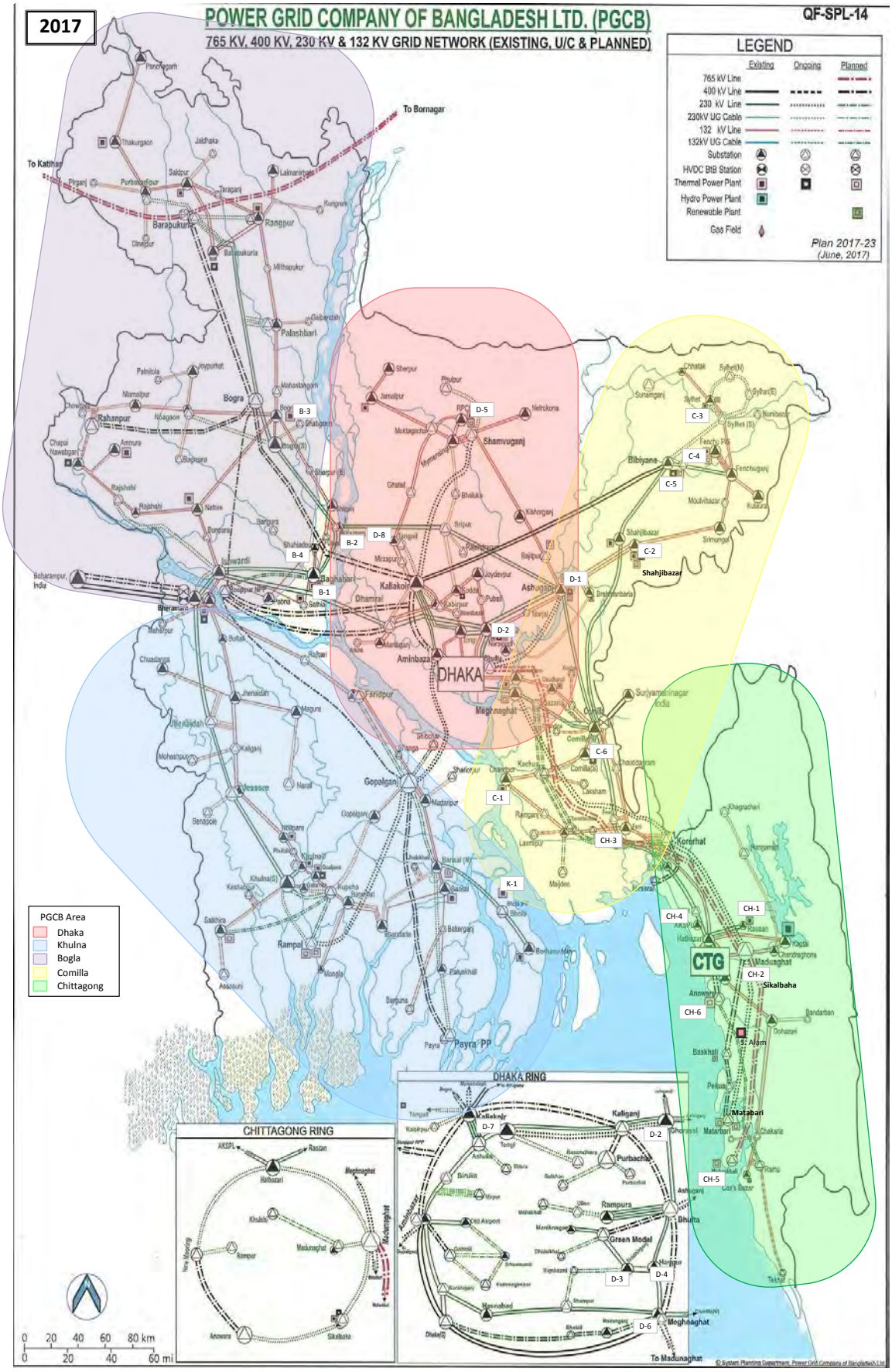
The following table summarizes transmission line infrastructure.

Table 3.2.6 The Year-Wise Transmission Infrastructures under PGCB's Management

Year	Transmission Line (Ckt. km)			Substation									
				HVDC		400/230 kV		400/132 kV		230/132 kV		132/33 kV	
	400 kV	230 kV	132 kV	No	Capacity	No	Capacity (MVA)	No	Capacity (MVA)	No.	Capacity (MVA)	No.	Capacity (MVA)
2010-11	-	2,647	6,018	-	-	-	-			13	6,675	81	8,437
2011-12	-	2,647	6,080	-	-	-	-			13	6,675	83	8,737
2012-13	-	3,021	6,080	-	-	-	-			15	6,975	84	9,705
2013-14	165	3,045	6,120	1	500 MW	-	-			18	8,775	86	10,714.30
2014-15	165	3,171	6,274	1	500 MW	1	520			19	9,075	89	11,963.72
2015-16	221	3,185	6,402	1	500 MW	1	520			19	9,375	90	12,655.50
2016-17	560	3,325	6,466	1	500 MW	2	1,560	1	650	19	9,675	91	14,154.50

Source: PGCB

Detailed data of existing transmission lines and substations are as shown in the following Tables.



Source: PGCB Transmission Line Map modified by JST

Figure 3.2.8 Map of Power Grid Network in 2017

Table 3.2.7 List of Existing Transmission Lines

Transmission Line ID	Transmission Line Name	From SS	To SS	Operating Status	Voltage Level (kV)	Route Length (km)	Circuit Length (km)	Number of Circuit	Conductor name	Conductor Size (mm2)	Capacity (MW)	Construction year
TL-001	HVDC Bheramara-Bangladesh Border (Baharampur)	SS-0001	Bangladesh Border	Existing	400	27.35	54.70	Double	Twin Finch	1113 MCM	1142.5612	2013
TL-002	Aminbazar-Meghnaghat	SS-0007	SS-0024	Existing	400	55.00	110.00	Double	Quad Egret	636 MCM	1654.0184	2014
TL-003	Comilla(N)- Bangladesh Border	SS-0015	Bangladesh Border	Existing	400	28.00	56.00	Double	Twin Finch	1113 MCM	1142.5612	2015
TL-004	Bibiyana-Kaliakoir	SS-0002	SS-0003	Existing	400	169.53	339.06	Double	Twin Finch	1113 MCM	1142.5612	2016
TL-005	Ghorasal-Ishurdi	SS-0017	SS-0021	Existing	230	175.00	350.00	Double	Mallard	795 MCM	288	Not Available
TL-006	Tongi - Ghorasal	SS-0028	SS-0017	Existing	230	27.00	54.00	Double	Mallard	795 MCM	288	Not Available
TL-007	Ghorasal - Ashuganj	SS-0017	SS-0008	Existing	230	44.00	88.00	Double	Mallard	795 MCM	288	Not Available
TL-008	Raojan - Hathazari	PS-11001-2	SS-0020	Existing	230	22.50	45.00	Double	Twin 300 sq.mm		438	Not Available
TL-009	Ashuganj - Comilla North	SS-0008	SS-0015	Existing	230	79.00	158.00	Double	Finch	1113 MCM	346	Not Available
TL-010	Ghorasal - Rampura	SS-0017	SS-0025	Existing	230	50.00	100.00	Double	Twin Mallard	2x795 MCM	575	Not Available
TL-011	Rampura - Haripur	SS-0025	SS-0018	Existing	230	22.00	44.00	Double	Twin Mallard	2x795 MCM	575	Not Available
TL-012	Haripur - Meghnaghat	SS-0018	SS-0024	Existing	230	12.50	25.00	Double	Twin Mallard	2x795 MCM	575	Not Available
TL-013	Meghnaghat - Hasnabad	SS-0024	SS-0019	Existing	230	24.50	49.00	Double	Twin Mallard	2x795 MCM	575	Not Available
TL-014	Comilla North - Hathazari	SS-0015	SS-0020	Existing	230	151.00	302.00	Double	Finch	1113 MCM	346	Not Available
TL-015	AES, Haripur - Haripur	PS-11026	SS-0018	Existing	230	2.40	4.80	Double	Finch	1113 MCM	346	Not Available
TL-016	Comilla North - Meghnaghat	SS-0015	SS-0024	Existing	230	58.00	116.00	Double	Twin Mallard	2x795 MCM	575	Not Available
TL-017	Tongi-Aminbazar	SS-0028	SS-0007	Existing	230	25.20	50.40	Double	Twin AAAC	37/4.176 mm.	501	Not Available
TL-018	Aminbazar-Hasnabad	SS-0007	SS-0019	Existing	230	21.50	43.00	Double	Twin AAAC	37/4.176 mm.	501	Not Available
TL-019	Siddhirganj 210 MW P/S -Haripur	PS-11013	SS-0018	Existing	230	1.50	1.50	Single	ACSR	600 sq. mm.	288	Not Available
TL-020	Ashuganj - Sirajganj	SS-0008	SS-0027	Existing	230	144.00	288.00	Double	Twin AAAC	37/4.176 mm.	501	2007
TL-021	Khulna-Bheramara HVDC	SS-0022	SS-0001	Existing	230	176.50	353.00	Double	Twin AAAC	37/4.176 mm.	501	2013
TL-022	Bheramara HVDC-Ishurdi	SS-0001	SS-0021	Existing	230	10.10	20.20	Double	Twin AAAC	37/4.176 mm.	501	Not Available
TL-023	Bogra-Barapukuria	SS-0013	SS-0010	Existing	230	106.00	212.00	Double	Twin AAAC	37/4.176 mm.	501	2008
TL-024	Sirajganj-Bogra	SS-0027	SS-0013	Existing	230	72.50	145.00	Double	Twin AAAC	37/4.176 mm.	501	2008
TL-025	Ishurdi-Baghabari	SS-0021	SS-0009	Existing	230	55.00	110.00	Double	Twin AAAC	37/4.176 mm.	501	Not Available
TL-026	Baghabari-Sirajganj	SS-0009	SS-0027	Existing	230	38.00	76.00	Double	Twin AAAC	37/4.176 mm.	501	2009
TL-027	Fenchuganj-Bibiyana	SS-0016	SS-0002	Existing	230	33.19	67.37	Double	Twin Mallard	2x795 MCM	575	2012
TL-028	Bibiyana-Comilla(N)	SS-0002	SS-0015	Existing	230	153.55	307.00	Double	Twin Mallard	2x795 MCM	575	2012
TL-029	Aminbazar-Old Airport (O/H)	SS-0007	Old Airport	Existing	230	3.58	7.15	Double	Twin Mallard	2x795 MCM	575	2013
TL-030	Aminbazar-Old Airport (U/G)	SS-0007	Old Airport	Existing	230	4.01	8.03	Double	XLPE	2000 sq. mm.	579	2013
TL-031	Siddhirganj-Maniknagar	SS-0026	SS-0023	Existing	230	11.00	22.00	Double	Twin Mallard	2x795 MCM	575	2014
TL-032	Bhola-Barisal	SS-0044	SS-0038	Existing	230	62.50	125.00	Double	Twin Mallard	2x795 MCM	575	2015
TL-033	LILO of Comilla(N)-Hathazari line at BSRM	LILO of Comilla(N)-Hathazari SS-0015	SS-0014	Existing	230	0.18	0.72	Double	Finch	1113 MCM	346	2015
TL-034	LILO of Comilla(N)-Hathazari line at AKSPL	LILO of Comilla(N)-Hathazari SS-0015	SS-0006	Existing	230	6.50	13.00	Double	Finch	1113 MCM	346	2015
TL-035	LILO of Aminbazar-Tongi line at Kaliakoir	LILO of Comilla(N)-Hathazari SS-0007	SS-0004	Existing	230	31.96	127.83	Four	Twin AAAC		501	Not Available
TL-036	Bheramara HVDC-Bheramara 230	SS-0001	SS-0012	Existing	230	3.00	12.00	Double	Twin AAAC		501	2017
TL-037	Shahjibazar-Brahmanbaria	SS-0129	SS-0047	Existing	132	57	114	Double	Grosbeak	636 MCM	129	Not Available
TL-038	Brahmanbaria-Ashuganj	SS-0047	SS-0030	Existing	132	16.5	33	Double	Grosbeak	636 MCM	129	Not Available
TL-039	Ashuganj-Ghorasal	SS-0030	SS-0064	Existing	132	45.32	90.64	Double	Grosbeak	636 MCM	129	Not Available
TL-040	Ghorasal-Narsingdi	SS-0064	SS-0109	Existing	132	13.35	13.35	Single	Grosbeak	636 MCM	129	Not Available
TL-041	Narsingdi-Haripur	SS-0109	SS-0069	Existing	132	34.33	34.33	Single	Grosbeak	636 MCM	129	Not Available
TL-042	Ghorasal-Bhulta	SS-0064	SS-0045	Existing	132	29.1	29.1	Single	Grosbeak	636 MCM	129	Not Available
TL-043	Bhulta-Haripur	SS-0045	SS-0069	Existing	132	15.25	15.25	Single	Grosbeak	636 MCM	129	Not Available
TL-044	Haripur-Siddhirganj	SS-0069	SS-0133	Existing	132	2	4	Double	Grosbeak	636 MCM	129	Not Available
TL-045	Shahjibazar-Srimangal	SS-0129	SS-0138	Existing	132	36.2	72.4	Double	Grosbeak	636 MCM	129	Not Available
TL-046	Srimangal-Fenchuganj	SS-0138	SS-0061	Existing	132	49	98	Double	Grosbeak	636 MCM	129	Not Available
TL-047	Fenchuganj-Fenchuganj PS	SS-0061	PS-11021	Existing	132	3.66	14.64	Four	Grosbeak	636 MCM	129	Not Available
TL-048	Fenchuganj-Sylhet	SS-0061	SS-0140	Existing	132	31.7	63.4	Double	Grosbeak	636 MCM	129	Not Available
TL-049	Sylhet-Chhatak	SS-0140	SS-0051	Existing	132	32.9	65.8	Double	Grosbeak	636 MCM	129	Not Available
TL-050	Kaptai-Hathazari	SS-0082	SS-0071	Existing	132	45	90	Double	Grosbeak	636 MCM	129	Not Available

Transmission Line ID	Transmission Line Name	From SS	To SS	Operating Status	Voltage Level (kV)	Route Length (km)	Circuit Length (km)	Number of Circuit	Conductor name	Conductor Size (mm2)	Capacity (MW)	Construction year
TL-051	Hathazari-Feni	SS-0071	SS-0062	Existing	132	85.4	170.8	Double	Grosbeak	636 MCM	129	Not Available
TL-052	Feni-Comilla (N)	SS-0062	SS-0054	Existing	132	66	132	Double	Grosbeak	636 MCM	129	Not Available
TL-053	Comilla (N)- Daudkandi	SS-0054	SS-0057	Existing	132	55	110	Double	Grosbeak/AAAC	636 MCM	129	Not Available
TL-054	Daudkandi-Sonargaon	SS-0057	SS-0137	Existing	132	61.7	123.4	Double	Grosbeak/AAAC	636 MCM	129	Not Available
TL-055	Sonargaon-Haripur	SS-0137	SS-0069	Existing	132	15	30	Double	Grosbeak/AAAC	636 MCM	129	Not Available
TL-056	Haripur-Siddhirganj	SS-0069	SS-0133	Existing	132	2.25	4.5	Double	Grosbeak	636 MCM	129	Not Available
TL-057	Khulshi-Halishahar	SS-0084	SS-0068	Existing	132	13	26	Double	Grosbeak	636 MCM	129	Not Available
TL-058	Comilla (N)-Chandpur	SS-0054	SS-0048	Existing	132	77.5	77.5	Single	Linnet + Grosbeak	(336.4 + 636) MCM	88	Not Available
TL-059	Comilla (N)-Comilla (S)	SS-0054	SS-0055	Existing	132	16	16	Single	Grosbeak	636 MCM	129	Not Available
TL-060	Comilla (S)-Chandpur	SS-0055	SS-0048	Existing	132	62	62	Single	Linnet	336.4 mCM	88	Not Available
TL-061	Ashuganj-Kishoreganj	SS-0033	SS-0085	Existing	132	52	104	Double	Grosbeak	636 MCM	129	Not Available
TL-062	Kishoreganj-Mymensingh	SS-0085	SS-0106	Existing	132	59	118	Double	Grosbeak	636 MCM	129	Not Available
TL-063	Mymensingh-Jamalpur	SS-0106	SS-0073	Existing	132	55	110	Double	Grosbeak	636 MCM	129	Not Available
TL-064	Madunaghat-Sikalbaha	SS-0095	SS-0134	Existing	132	16.5	16.5	Single	Grosbeak	636 MCM	129	Not Available
TL-065	Madunaghat-TKC	SS-0095	SS-0143	Existing	132	8.5	8.5	Single	Grosbeak	636 MCM	129	Not Available
TL-066	TKC-Sikalbaha	SS-0143	SS-0134	Existing	132	8.5	8.5	Single	Grosbeak	636 MCM	129	Not Available
TL-067	Sikalbaha-Dohazari	SS-0134	SS-0059	Existing	132	32	64	Double	Grosbeak	636 MCM	129	Not Available
TL-068	Sikalbaha-Juldah	SS-0134	SS-0078	Existing	132	7.5	7.5	Single	AAAC	804 sq.mm	129	Not Available
TL-069	Juldah-Halishahar	SS-0078	SS-0068	Existing	132	8	8	Single	AAAC	804 sq.mm	129	Not Available
TL-070	Khulshi-Baroaulia	SS-0084	SS-0039	Existing	132	15	15	single	Grosbeak	636 MCM	129	Not Available
TL-071	Khulshi-AKSML	SS-0084	SS-0031	Existing	132	11	11	single	Grosbeak	636 MCM	129	Not Available
TL-072	AKSML-Baroaulia	SS-0031	SS-0039	Existing	132	4	4	single	Grosbeak	636 MCM	129	Not Available
TL-073	Madunaghat-Khulshi	SS-0095	SS-0084	Existing	132	13	13	Single	Grosbeak	636 MCM	129	Not Available
TL-074	Madunaghat-Khulshi	SS-0095	SS-0084	Existing	132	13	13	Single	Grosbeak	636 MCM	129	Not Available
TL-075	Kaptai-Chandraghona	SS-0082	SS-0049	Existing	132	11.5	23	Double	Grosbeak	636 MCM	129	Not Available
TL-076	Chandraghona-Madunaghat	SS-0049	SS-0095	Existing	132	27	54	Double	Grosbeak	636 MCM	129	Not Available
TL-077	Madunaghat-Hathazari	SS-0095	SS-0071	Existing	132	10.2	20.4	Double	Grosbeak	636 MCM	129	Not Available
TL-078	Hathazari-Baroaulia	SS-0071	SS-0039	Existing	132	11	22	Double	Grosbeak	636 MCM	129	Not Available
TL-079	Dohazari-Cox's Bazar	SS-0059	SS-0056	Existing	132	87	174	Double	Grosbeak	636 MCM	129	Not Available
TL-080	Feni-Chowmuhani	SS-0062	SS-0052	Existing	132	32	64	Double	Grosbeak	636 MCM	129	Not Available
TL-081	Baroaulia- Kabir Steel	SS-0039	Kabir Steel	Existing	132	4	4	Single	Grosbeak	636 MCM	129	Not Available
TL-082	Mymensingh-Netrokona	SS-0106	SS-0111	Existing	132	34	68	Double	Grosbeak	636 MCM	129	Not Available
TL-083	Goalpara-Khulna (C)	SS-0065	SS-0083	Existing	132	1.5	3	Double	AAAC	804 MCM	129	Not Available
TL-084	Khulna (C)-Noapara	SS-0083	SS-0114	Existing	132	22.8	45.6	Double	AAAC	804 MCM	129	Not Available
TL-085	Noapara-Jessore	SS-0114	SS-0074	Existing	132	27.9	55.8	Double	AAAC	804 MCM	129	Not Available
TL-086	Jessore-Jhenaidah	SS-0074	SS-0075	Existing	132	47.5	95	Double	AAAC	804 MCM	129	Not Available
TL-087	Jhenaidah-Kustia	SS-0075	SS-0089	Existing	132	43	86	Double	AAAC	804 MCM	129	Not Available
TL-088	Kustia-Bheramana	SS-0089	SS-0043	Existing	132	23	46	Double	AAAC	804 MCM	129	Not Available
TL-089	Bheramara-Ishwardi	SS-0043	SS-0072	Existing	132	10	20	Double	AAAC	804 MCM	129	Not Available
TL-090	Ishwardi-Natore	SS-0072	SS-0110	Existing	132	42	84	Double	AAAC	804 MCM	129	Not Available
TL-091	Natore-Bogra	SS-0110	SS-0046	Existing	132	61	122	Double	AAAC	804 MCM	129	Not Available
TL-092	Bogra-Palashbari	SS-0046	SS-0116	Existing	132	50	100	Double	AAAC	804 MCM	129	Not Available
TL-093	Palashbari-Rangpur	SS-0116	SS-0122	Existing	132	52	104	Double	AAAC	804 MCM	129	Not Available
TL-094	Rangpur-Saidpur	SS-0122	SS-0124	Existing	132	41.5	83	Double	AAAC	804 MCM	129	Not Available
TL-095	Saidpur-Purbasadipur	SS-0124	SS-0119	Existing	132	24.5	49	Double	AAAC	804 MCM	129	Not Available
TL-096	Purbasadipur-Thakurgaon	SS-0119	SS-0142	Existing	132	45	90	Double	AAAC	804 MCM	129	Not Available
TL-097	Goalpara-Bagerhat	SS-0065	SS-0034	Existing	132	45	45	Single	AAAC	804 MCM	129	Not Available
TL-098	Barisal-Bhandaria	SS-0038	SS-0041	Existing	132	49	49	Single	HAWK	477 MCM	109	Not Available
TL-099	Bhandaria-Bagerhat	SS-0041	SS-0034	Existing	132	40	40	Single	HAWK	477 MCM	109	Not Available
TL-100	Bagerhat-Mongla	SS-0034	SS-0104	Existing	132	28	28	Single	HAWK	477 MCM	109	Not Available

Transmission Line ID	Transmission Line Name	From SS	To SS	Operating Status	Voltage Level (kV)	Route Length (km)	Circuit Length (km)	Number of Circuit	Conductor name	Conductor Size (mm2)	Capacity (MW)	Construction year
TL-101	Barisal-Patuakhali	SS-0038	SS-0118	Existing	132	38.2	38.2	Single	HAWK	477 MCM	109	Not Available
TL-102	Bheramara-Faridpur	SS-0043	SS-0060	Existing	132	105	210	Double	HAWK	477 MCM	109	Not Available
TL-103	Faridpur-Madaripur	SS-0060	SS-0093	Existing	132	65.5	131	Double	HAWK	477 MCM	109	Not Available
TL-104	Madaripur-Barisal	SS-0093	SS-0038	Existing	132	59	118	Double	HAWK	477 MCM	109	Not Available
TL-105	Rajshahi-Natore	SS-0121	SS-0110	Existing	132	37	37	Single	HAWK	477 MCM	109	Not Available
TL-106	Ishwardi-Baghabari	SS-0072	PS-11023	Existing	132	63	63	Single	HAWK	477 MCM	109	Not Available
TL-107	Baghabari-Shahjadpur	PS-11023	SS-0128	Existing	132	5	5	Single	HAWK	477 MCM	109	Not Available
TL-108	Ishwardi-Pabna	SS-0072	SS-0115	Existing	132	18	18	Single	Grosbeak	636 MCM	129	Not Available
TL-109	Pabna-Shahjadpur	SS-0115	SS-0128	Existing	132	41	41	Single	Grosbeak	636 MCM	129	Not Available
TL-110	Bogra-Sirajganj	SS-0046	SS-0135	Existing	132	66	132	Double	Grosbeak	636 MCM	129	Not Available
TL-111	Sirajganj-Shahjadpur	SS-0135	SS-0128	Existing	132	34	34	Single	Grosbeak	636 MCM	129	Not Available
TL-112	Sirajganj-Baghabari	SS-0135	PS-11023	Existing	132	39.7	39.7	Single	Grosbeak	636 MCM	129	Not Available
TL-113	Rajshahi-Chapai Nawabganj	SS-0121	SS-0050	Existing	132	48	96	Double	Grosbeak	636 MCM	129	Not Available
TL-114	Rangpur-Lalmonirhat	SS-0122	SS-0091	Existing	132	38	38	Single	Grosbeak	636 MCM	129	Not Available
TL-115	Bogra-Naogaon	SS-0046	SS-0107	Existing	132	44	88	Double	Grosbeak	636 MCM	129	Not Available
TL-116	Kabirpur-Tangail	SS-0079	SS-0141	Existing	132	51	102	Double	Grosbeak	636 MCM	129	Not Available
TL-117	Tongi-Mirpur	SS-0144	SS-0101	Existing	132	17	17	Single	Grosbeak	636 MCM	129	Not Available
TL-118	Tongi-Uttara	SS-0144	SS-0146	Existing	132	14.5	14.5	Single	Grosbeak	636 MCM	129	Not Available
TL-119	Uttara-Mirpur	SS-0146	SS-0101	Existing	132	8.5	8.5	Single	Grosbeak	636 MCM	129	Not Available
TL-120	Mirpur-Aminbazar	SS-0101	SS-0007	Existing	132	7	14	Double	Grosbeak	636 MCM	129	Not Available
TL-121	Aminbazar-Kallayanpur	SS-0007	SS-0080	Existing	132	4	8	Double	Grosbeak	636 MCM	129	Not Available
TL-122	Hasnabad-Lalbagh	SS-0070	SS-0090	Existing	132	30	30	Single	Grosbeak	636 MCM	129	Not Available
TL-123	Kamrangirchar-Lalbagh	SS-0081	SS-0090	Existing	132	2.6	2.6	Single	Grosbeak	636 MCM	129	Not Available
TL-124	Kallayanpur-Kamrangirchar	SS-0080	SS-0081	Existing	132	11	11	Single	Grosbeak	636 MCM	129	Not Available
TL-125	Kallayanpur-Keraniganj	SS-0080	Keraniganj	Existing	132	20	20	Single	Grosbeak	636 MCM	129	Not Available
TL-126	Hasnabad-Keraniganj	SS-0070	Keraniganj	Existing	132	13.6	13.6	Single	Grosbeak	636 MCM	129	Not Available
TL-127	Tongi-New Tongi	SS-0144	SS-0112	Existing	132	0.5	1	Double	Grosbeak	636 MCM	129	Not Available
TL-128	Hasnabad-Sitalakhya	SS-0070	SS-0136	Existing	132	12.6	12.6	Single	Grosbeak	636 MCM	129	Not Available
TL-129	Madanganj-Sitalakhya	SS-0092	SS-0136	Existing	132	4	4	Single	Grosbeak	636 MCM	129	Not Available
TL-130	Hasnabad-Shyampur	SS-0070	SS-0132	Existing	132	21	21	Single	Grosbeak	636 MCM	129	Not Available
TL-131	Shyampur-Haripur	SS-0132	SS-0069	Existing	132	30	30	Single	Grosbeak	636 MCM	129	Not Available
TL-132	Madanganj-Haripur	SS-0092	SS-0069	Existing	132	12.4	12.4	Single	Grosbeak	636 MCM	129	Not Available
TL-133	Siddhirganj-Ullon	SS-0133	SS-0145	Existing	132	16	32	Double	Grosbeak	636 MCM	129	Not Available
TL-134	Haripur-Matuail	SS-0069	SS-0099	Existing	132	5.65	5.65	Single	Grosbeak	636 MCM	129	Not Available
TL-135	Maniknagar-Matuail	SS-0098	SS-0099	Existing	132	16	16	Single	Grosbeak	636 MCM	129	Not Available
TL-136	Siddhirganj-Maniknagar	SS-0133	SS-0098	Existing	132	10	10	Single	Grosbeak	636 MCM	129	Not Available
TL-137	Maniknagar-Bangabhaban	SS-0098	SS-0036	Existing	132	3	6	Double	Cu.Cable	240 sq.mm	99	Not Available
TL-138	Maniknagar-Narinda	SS-0098	SS-0108	Existing	132	5	10	Double	Cu.Cable	240 sq.mm	99	Not Available
TL-139	Ullon-Dhanmondi	SS-0145	SS-0058	Existing	132	5.5	11	Double	Cu.Cable	240 sq.mm	99	Not Available
TL-140	Ullon-Dhanmondi	SS-0145	SS-0058	Existing	132	5.5	11	Double	XLPE	500 sq.mm	152	Not Available
TL-141	Tongi-Kabirpur	SS-0144	SS-0079	Existing	132	22.5	45	Double	Grosbeak	636 MCM	129	Not Available
TL-142	Kabirpur-Manikganj	SS-0079	SS-0097	Existing	132	32	64	Double	Grosbeak	636 MCM	129	Not Available
TL-143	Ullon-Rampura	SS-0145	SS-0025	Existing	132	4	8	Double	Grosbeak	636 MCM	129	Not Available
TL-144	Rampura-Bashundhara	SS-0025	SS-0040	Existing	132	8	16	Double	Grosbeak	636 MCM	129	Not Available
TL-145	Bashundhara-Tongi	SS-0040	SS-0144	Existing	132	11	22	Double	Grosbeak	636 MCM	129	Not Available
TL-146	Rampura-Moghbazar	SS-0025	SS-0103	Existing	132	4.5	9	Double	Grosbeak	636 MCM	129	Not Available
TL-147	Ghorasal-Joydevpur	SS-0064	SS-0076	Existing	132	28	56	Double	Grosbeak	636 MCM	129	Not Available
TL-148	Baghabari-Shahjadpur	PS-11023	SS-0128	Existing	132	5.5	5.5	Single	Grosbeak	636 MCM	129	Not Available
TL-149	Chandpur-Chowmuhani	SS-0048	SS-0052	Existing	132	68	136	Double	Grosbeak	636 MCM	129	Not Available
TL-150	Barapukuria-Rangpur	SS-0037	SS-0122	Existing	132	42	84	Double	Grosbeak	636 MCM	129	Not Available

Transmission Line ID	Transmission Line Name	From SS	To SS	Operating Status	Voltage Level (kV)	Route Length (km)	Circuit Length (km)	Number of Circuit	Conductor name	Conductor Size (mm2)	Capacity (MW)	Construction year
TL-151	Barapukuria-Saidpur	SS-0037	SS-0124	Existing	132	36	72	Double	Grosbeak	636 MCM	129	Not Available
TL-152	Madaripur-Gopalganj	SS-0093	SS-0066	Existing	132	45	45	Single	AAAC	804 MCM	129	Not Available
TL-153	Khulna (C)-Khulna(S)	SS-0083	SS-0022	Existing	132	9	18	Double	Twin AAAC	37/4.176 mm.	259	Not Available
TL-154	Khulna(S)-Satkhira	SS-0022	SS-0125	Existing	132	47	94	Double	AAAC	804 MCM	129	Not Available
TL-155	Rajshahi-Natore	SS-0121	SS-0110	Existing	132	40	40	Single	Grosbeak	636 MCM	129	Not Available
TL-156	Rampura-Gulshan	SS-0025	SS-0067	Existing	132	3.3	6.6	Double	XLPE	800 sq.mm	193	Not Available
TL-158	Sikalbaha-Bakulia	SS-0134	SS-0035	Existing	132	4	8	Double	Grosbeak	636 MCM	129	Not Available
TL-159	Juldah-Shahmirpur	SS-0078	SS-0130	Existing	132	6	12	Double	Grosbeak	636 MCM	129	Not Available
TL-160	Khulshi-Bakulia	SS-0084	SS-0035	Existing	132	15	30	Double	Grosbeak	636 MCM	129	Not Available
TL-161	Haripur-Maniknagar	SS-0069	SS-0098	Existing	132	13	13	Single	Grosbeak	636 MCM	129	Not Available
TL-162	Joydevpur-Kodda PP	SS-0076	SS-0086	Existing	132	8	16	Double	Grosbeak	636 MCM	129	Not Available
TL-163	Kodda PP-Kabirpur	SS-0086	SS-0079	Existing	132	10	20	Double	Grosbeak	636 MCM	129	Not Available
TL-164	Sikalbaha-Shahmirpur	SS-0134	SS-0130	Existing	132	9	18	Double	Grosbeak	636 MCM	129	Not Available
TL-165	Khulshi-Halishahar (Open atKhulshi)	SS-0084	SS-0068	Existing	132	13	13	Single	Grosbeak	636 MCM	129	Not Available
TL-166	BograOld-BograNew	SS-0046	SS-0013	Existing	132	1.5	3	Double	Twin AAAC	37/4.176 mm.	259	Not Available
TL-167	Ashuganj-Shahjibazar	SS-0033	SS-0129	Existing	132	53	53	Single	Grosbeak	636 MCM	129	2009
TL-168	Khulna (S) -Gallamari	SS-0022	SS-0063	Existing	132	4.2	8.4	Double	Grosbeak	636 MCM	129	2009
TL-169	Naogaon-Niyamatpur	SS-0107	SS-0113	Existing	132	46	46	Single	AAAC	804 MCM	129	2010
TL-170	Aminbazar-Savar	SS-0007	SS-0127	Existing	132	15.8	31.6	Double	Grosbeak	636 MCM	129	2010
TL-171	Jhenaidah-Magura	SS-0075	SS-0096	Existing	132	26.5	26.5	Single	Grosbeak	636 MCM	129	2010
TL-172	Jhenaidah-Chuadanga	SS-0075	SS-0053	Existing	132	39.3	39.3	Single	Grosbeak	636 MCM	129	2010
TL-173	Naogaon-Joypurhat	SS-0107	SS-0077	Existing	132	46.2	46.2	Single	Grosbeak	636 MCM	129	2010
TL-174	Thakurgaon-Panchagarh	SS-0142	SS-0117	Existing	132	45	45	Single	AAAC	636 MCM	129	2010
TL-175	Sonargaon S/S to Megnaghat Rental PP	SS-0137	PS-31026	Existing	132	5	10	Double	Grosbeak	636 MCM	129	2011
TL-176	Shiddhirganj to Siddhirganj Dutch Bangla PP	SS-0133	PS-31027	Existing	132	2.4	2.4	Single	Grosbeak	636 MCM	129	2011
TL-177	Goalpara-Khulna (C)	SS-0065	SS-0083	Existing	132	2.4	2.4	Single	XLPE		193	2011
TL-178	Noapara PP to Noapara SS	PS-31024	SS-0114	Existing	132	1.6	1.6	Single	Grosbeak	Grosbeak	129	2011
TL-179	Daudkandi PP to Daudkandi SS	PS-31005	SS-0057	Existing	132	1.3	1.3	Single	Grosbeak	Grosbeak	129	2011
TL-180	Gopalganj PP to Gopalganj SS	PS-31008	SS-0066	Existing	132	1.2	1.2	Single	Grosbeak	Grosbeak	129	2011
TL-181	Shiddhirganj desh energy PP to Siddhirganj SS	PS-21011	SS-0133	Existing	132	2.5	2.5	Single	Grosbeak	Grosbeak	129	2011
TL-182	Faridpur PP to Faridpur -Bheramara	PS-31007	SS-0060	Existing	132	1	1	Single	Grosbeak	Grosbeak	129	2011
TL-183	Bera PP to Baghabari -Ishwardi line	PS-31010	SS-0072	Existing	132	4.5	4.5	Single	Grosbeak	Grosbeak	129	2011
TL-184	Amnura PP to Rajshahi-Chapai	PS-31028	SS-0121	Existing	132	12.6	12.6	Single	Grosbeak	Grosbeak	129	2011
TL-185	Madanganj-Munsiganj	SS-0092	SS-0105	Existing	132	4	8	Double	Grosbeak	Grosbeak	129	Not Available
TL-186	Old Airport-Cantonment	Old Airport	Cantonment	Existing	132	6.99	13.98	Double	XLPE	800 sq.mm	193	2013
TL-187	Fenchuganj- Kulaura	SS-0061	SS-0088	Existing	132	25	50	Double	Grosbeak	636 MCM	129	2014
TL-188	Jamalpur- Sherpur	SS-0073	SS-0131	Existing	132	20	40	Double	Grosbeak	636 MCM	129	2014
TL-189	Old Airport-Sajmasjid	Old Airport	SS-0126	Existing	132	8.294	16.588	Double	XLPE	800 sq.mm	193	2014
TL-190	Rampura-Madertek	SS-0025	SS-0094	Existing	132	4.5	9	Double	XLPE	500 sq.mm	152	2015
TL-191	Comilla(N)- Comilla(S)	SS-0054	SS-0055	Existing	132	19	38	Double	Grosbeak	636 MCM	129	2015
TL-192	Goalpara-Bagerhat New	SS-0065	SS-0034	Existing	132	45	90	Double	Grosbeak	636 MCM	129	2016
TL-193	LILO of Kabirpur-Tangail at Kaliakoir	SS-0079	SS-0141	Existing	132	4.28	17.12	Four	Grosbeak	636 MCM	129	2016
TL-194	Tangail-RPCL	SS-0141	PS-11025	Existing	132	93.44	186.88	Double	Grosbeak	636 MCM	129	Not Available

Source: PGCB

Table 3.2.8 List of Existing Substations

Substation ID	Station Name	Facility category	Operating Status	PGCB Grid Division	Latitude	Longitude	Nos of Transformer	Capacity of transformer	Total Capacity (MVA)	Type of insulation	Construction year
SS-0001	Bheramara HVDC	400/230	Existing	HVDC	89.001182	24.067198	1	1x500 MW	500 MW	AIS	2013
SS-0002	Bibiyana	400/230	Existing	Srimangal	91.657406	24.634435	2	2x520	1040	AIS	2015
SS-0003	Kaliakoir	400/230	Existing	Dhaka(N)	90.197913	24.092692	2	2x325	650	AIS	2016
SS-0004	Kaliakoir 230	400/230	Existing	Dhaka(N)	90.197913	24.092692	1	1x520	520	AIS	2017
SS-0005	Agargaon	230/132	Existing	Dhaka(N-W)	90.37341552	23.78119462	2	2x300	600	GIS	2013
SS-0006	AKSPL	230/132	Existing	-	91.733244	22.471727	3	2x130/150, 1x80	380	GIS	2015
SS-0007	Aminbazar	230/132	Existing	Dhaka(N-W)	90.31622303	23.78828048	3	3x225	675	AIS	Not Available
SS-0008	Ashuganj	230/132	Existing	-	91.01660444	24.04354795	2	2x150	300	AIS	Not Available
SS-0009	Baghabari	230/132	Existing	Ishwardi	89.59462957	24.13683245	1	1x225(4x75)	225	AIS	2009
SS-0010	Barapukuria	230/132	Existing	Rangpur	88.95307033	25.54961457	2	2x225	450	AIS	Not Available
SS-0011	Barisal (N)	230/132	Existing	Barisal	90.308879	22.753807	2	2x300	600	AIS	2015
SS-0012	Bheramara	230/132	Existing	-	89.016598	24.050144	2	2x255/300	600	AIS	2017
SS-0013	Bogra	230/132	Existing	Bogra	89.35065828	24.82944068	2	2x225(7x75)	450	AIS	2008
SS-0014	BSRM	230/132	Existing	-	91.54759	22.856856	2	2x130/140	280	GIS	2015
SS-0015	Comilla (N)	230/132	Existing	Comilla	91.10155702	23.50887223	2	2x225	450	AIS	Not Available
SS-0016	Fenchuganj	230/132	Existing	Srimangal	91.93311509	24.65839813	1	1x300	300	AIS	2012
SS-0017	Ghorasal	230/132	Existing	-	90.63743708	23.9790212	2	2x125	250	AIS	Not Available
SS-0018	Haripur	230/132	Existing	Dhaka(E)	90.53339937	23.68415289	3	3x225(10x75)	675	AIS	Not Available
SS-0019	Hasnabad	230/132	Existing	Dhaka(S)	90.42865337	23.68066392	3	3x225(10x75)	675	AIS	Not Available
SS-0020	Hathazari	230/132	Existing	CTG(N)	91.80727456	22.49203869	4	4x150	600	AIS	Not Available
SS-0021	Ishurdi	230/132	Existing	Ishwardi	89.08441773	24.09592995	3	3x225	675	AIS	Not Available
SS-0022	Khulna (S)	230/132	Existing	Khulna	89.50752887	22.79513634	2	2x225(7x75)	450	AIS	2006
SS-0023	Maniknagar	230/132	Existing	Dhaka(C)	90.4358658	23.72218567	2	2x300	600	GIS	2014
SS-0024	Meghnaghat Switching	230	Existing	Dhaka(E)	90.60157822	23.61087286	–	–	–	AIS	Not Available
SS-0025	Rampura	230/132	Existing	Dhaka(C)	90.43140716	23.7674602	3	3x225(10x75)	675	AIS	Not Available
SS-0026	Siddhirganj	230/132	Existing	Dhaka(E)	90.51715638	23.68559957	2	2x300	600	AIS	2014
SS-0027	Sirajganj Switching	230	Existing	Bogra	89.74414712	24.38864581	–	–	–	AIS	2007
SS-0028	Tongi	230/132	Existing	Dhaka(N)	90.41288499	23.89726017	3	3x225(10x75)	675	AIS	Not Available
SS-0029	Sikalbaha	230/132	Existing	#N/A	91.867559	22.323119	1	1x300	300	AIS	2017
SS-0030	Agargaon	132/33	Existing	Dhaka(N-W)	90.37341552	23.78119462	2	2x80/120	240	GIS	2013
SS-0031	AKSML	132/33	Existing	CTG(N)	91.74268083	22.4456504	1	1x25/30	30	AIS	Not Available
SS-0032	Amnura	132/33	Existing	Rajshahi	88.40196	24.633954	2	2x35/50	100	AIS	2015
SS-0033	Ashuganj	132/33	Existing	-	91.01484094	24.04285608	2	2x25/41	82	AIS	Not Available
SS-0034	Bagerhat	132/33	Existing	Khulna	89.79781522	22.64732946	2	2x25/41	82	AIS	Not Available
SS-0035	Bakulia	132/33	Existing	CTG(C)	91.85104594	22.35303221	3	2x48/64 1x50/75	203	AIS	Not Available
SS-0036	Bangabhaban	132/33	Existing	-	90.42095851	23.7239721	2	2x28/35	70	AIS	Not Available
SS-0037	Barapukuria	132/33	Existing	Rangpur	88.95307077	25.54963007	4	2x25/41, 2x15/20	122	AIS	Not Available
SS-0038	Barisal	132/33	Existing	Barisal	90.34473404	22.67687846	2	2x50/75	150	AIS	Not Available
SS-0039	Baroaulia	132/33	Existing	CTG(N)	91.72298644	22.47476349	2	2x48/64	128	AIS	Not Available
SS-0040	Bashundhara	132/33	Existing	-	90.43584003	23.81757314	3	3x50/75	225	AIS	Not Available

Substation ID	Station Name	Facility category	Operating Status	PGCB Grid Division	Latitude	Longitude	Nos of Transformer	Capacity of transformer	Total Capacity (MVA)	Type of insulation	Construction year
SS-0041	Bhandaria	132/33	Existing	Barisal	90.06999313	22.48036385	2	2x25/41	82	AIS	Not Available
SS-0042	Bhasantek	132/33	Existing	Dhaka(N-W)	90.38999756	23.80726171	2	2x80/120	240	GIS	2013
SS-0043	Bheramara PGCB	132/33	Existing	Jhenaidah	89.01635253	24.04361378	3	2x25/41, 1x15/20	102	AIS	Not Available
SS-0044	Bhola	132/33	Existing	-	90.710229	22.479463	1	1x60 (230/33kV)	60	AIS	Not Available
SS-0045	Bhulta	132/33	Existing	Dhaka(E)	90.58588701	23.80389583	2	1x35/50 1x50/75	125	AIS	Not Available
SS-0046	Bogra	132/33	Existing	Bogra	89.35082833	24.84095441	4	2x25/41, 2x50/75	390	AIS	Not Available
SS-0047	Brahmanbaria	132/33	Existing	Srimangal	91.10680681	23.95903536	3	3x25/41	123	AIS	2011
SS-0048	Chandpur	132/33	Existing	Comilla	90.66754779	23.22057257	2	2x50/75	150	AIS	Not Available
SS-0049	Chandraghona	132/33	Existing	CTG(S)	92.1226125	22.48162162	2	2x15/20	40	AIS	Not Available
SS-0050	Chapai Nawabganj	132/33	Existing	Rajshahi	88.28991989	24.58008421	4	3x15/20, 1x25/41	101	AIS	Not Available
SS-0051	Chhatak	132/33	Existing	Srimangal	91.66339923	25.03132909	3	2x15/20, 1x25/41	81	AIS	Not Available
SS-0052	Chowmuhani	132/33	Existing	Comilla	91.10430045	22.94604699	3	1x80/120 1x50/75	270	AIS	Not Available
SS-0053	Chuadanga	132/33	Existing	Jhenaidah	88.85730632	23.62256319	2	2x25/41	82	AIS	2010
SS-0054	Comilla (N)	132/33	Existing	Comilla	91.10234997	23.50830356	2	2x50/75	150	AIS	Not Available
SS-0055	Comilla (S)	132/33	Existing	Comilla	91.17001734	23.42905973	4	2x50/75, 2x25/41	232	AIS	Not Available
SS-0056	Cox's Bazar	132/33	Existing	CTG(S)	92.01403275	21.42377053	3	2x25/41, 1x50/75	157	AIS	Not Available
SS-0057	Daudkandi	132/33	Existing	Comilla	90.78365289	23.55335324	2	2x50/75	150	AIS	2011
SS-0058	Dhanmondi	132/33	Existing	-	90.39188278	23.73918985	4	4x50/75	300	AIS	Not Available
SS-0059	Dohazari	132/33	Existing	CTG(S)	92.07193213	22.15344797	2	2x50/75	150	AIS	Not Available
SS-0060	Faridpur	132/33	Existing	Faridpur	89.79899801	23.59132576	2	2x50/75	150	AIS	Not Available
SS-0061	Fenchuganj	132/33	Existing	Srimangal	91.93397112	24.65930035	3	2x15/20, 1x25/41	81	AIS	Not Available
SS-0062	Feni	132/33	Existing	Comilla	91.38430949	23.01058051	2	1X50/75 1x50/75	150	AIS	Not Available
SS-0063	Gallamari	132/33	Existing	Khulna	89.53622403	22.78833839	2	2x25/41	82	GIS	2009
SS-0064	Ghorasal	132/33	Existing	-	90.63545022	23.97962483	2	2x41/63	126	AIS	Not Available
SS-0065	Goalpara	132/33	Existing	Khulna	89.53794421	22.86788562	2	2x12.5/16.67	33	AIS	Not Available
SS-0066	Gopalganj	132/33	Existing	Faridpur	89.82738364	23.03066726	2	2x25/41	82	AIS	Not Available
SS-0067	Gulshan	132/33	Existing	Dhaka(C)	90.41737434	23.78029104	2	2x80/120	240	GIS	2007
SS-0068	Halishahar	132/33	Existing	CTG(C)	91.78686595	22.27215646	3	2x44.1/63, 1x48/64	190	AIS	Not Available
SS-0069	Haripur	132/33	Existing	-	90.53339536	23.68412769	2	2x80/120	240	AIS	Not Available
SS-0070	Hasnabad	132/33	Existing	Dhaka(S)	90.42861001	23.68118175	3	3x66/100	300	AIS	Not Available
SS-0071	Hathazari	132/33	Existing	CTG(N)	91.80727859	22.49202021	2	1x50/75, 1x50/83	158	AIS	Not Available
SS-0072	Ishurdi	132/33	Existing	Ishwardi	89.08442071	24.09594548	3	2x15/20, 1x25/41	81	AIS	Not Available
SS-0073	Jamalpur	132/33	Existing	Mymensingh	89.96003565	24.92030235	4	3x25/41, 1x15/20	143	AIS	Not Available
SS-0074	Jessore	132/33	Existing	Jhenaidah	89.2082289	23.14692985	3	1x50/83.3, 1x40 1x80/120	243.3	AIS	Not Available
SS-0075	Jhenaidah	132/33	Existing	Jhenaidah	89.17723974	23.52990171	2	1x25/41 1x80/120	161	AIS	Not Available

Substation ID	Station Name	Facility category	Operating Status	PGCB Grid Division	Latitude	Longitude	Nos of Transformer	Capacity of transformer	Total Capacity (MVA)	Type of insulation	Construction year
SS-0076	Joydevpur	132/33	Existing	Dhaka(N)	90.38252583	23.99195596	3	2x35/50, 1x80/120	220	AIS, GIS mixed	Not Available
SS-0077	Joypurhat	132/33	Existing	Bogra	89.01025126	25.10636248	4	4x25/41	164	AIS	2010
SS-0078	Juldah	132/33	Existing	CTG(C)	91.8075535	22.29982615	1	1x48/64	64	AIS	Not Available
SS-0079	Kabirpur	132/33	Existing	Dhaka(N)	90.25359725	24.00154533	3	2x50/75, 1x80/120	270	AIS	Not Available
SS-0080	Kallayanpur	132/33	Existing	Dhaka(N-W)	90.34792468	23.7821128	3	3x50/75	225	AIS	Not Available
SS-0081	Kamrangirchar	132/33	Existing	-	90.37216886	23.72332809	3	3x50/75	225	AIS	2008
SS-0082	Kaptai	132/33	Existing	-	92.2156078	22.49871154	1	1x15/20 (132/11kV)	20	AIS	Not Available
SS-0083	Khulna (C)	132/33	Existing	Khulna	89.52571054	22.85882667	3	3x48/64	192	AIS	Not Available
SS-0084	Khulshi	132/33	Existing	CTG(N)	91.79557839	22.36176406	3	2x80/120 1x64/80	320	AIS	Not Available
SS-0085	Kishoreganj	132/33	Existing	Mymensingh	90.79023924	24.41864637	3	1x15/20, 2x25/41	102	AIS	Not Available
SS-0086	Kodda	132/33	Existing	Dhaka(N)	90.343593	23.99062	4	4x50/75	300	AIS	2016
SS-0087	KSRM	132/33	Existing	-	91.713827	22.502843	2	2x35/50	100	AIS	Not Available
SS-0088	Kulaura	132/33	Existing	Srimangal	92.01807972	24.51212911	2	2x25/41	82	AIS	2014
SS-0089	Kustia	132/33	Existing	#N/A	89.09492471	23.88073392	2	2x50/75	150	AIS	Not Available
SS-0090	Lalbagh	132/33	Existing	-	90.39035413	23.71343486	2	2x50/75	150	GIS	2014
SS-0091	Lalmonirhat	132/33	Existing	Rangpur	89.45432533	25.91800932	5	4X15/20 1X25/33	113	AIS	Not Available
SS-0092	Madanganj	132/33	Existing	-	90.51548649	23.59372878	2	2x35/50	100	AIS	Not Available
SS-0093	Madaripur	132/33	Existing	Faridpur	90.14138933	23.14780038	3	2x25/41 1x50/75	157	AIS	Not Available
SS-0094	Madartek	132/33	Existing	-	90.44103053	23.74358052	2	2x50/75	150	GIS	2015
SS-0095	Madunaghat	132/33	Existing	CTG(S)	91.87049103	22.43237895	2	2x25/41	82	AIS	Not Available
SS-0096	Magura	132/33	Existing	Jhenaidah	89.3992929	23.47298635	2	2x25/41	82	AIS	2010
SS-0097	Manikganj	132/33	Existing	Aricha	90.01209737	23.87218577	3	3x35/50	150	AIS	Not Available
SS-0098	Maniknagar	132/33	Existing	Dhaka(C)	90.43523416	23.72193486	2	2x50/75	150	AIS	Not Available
SS-0099	Matuail	132/33	Existing	-	90.48665424	23.65987937	2	2x50/75	150	AIS	Not Available
SS-0100	MI Cement	132/33	Existing	-			1	1x28	28	AIS	Not Available
SS-0101	Mirpur	132/33	Existing	Dhaka(N-W)	90.35979201	23.83092126	3	1x35/50, 2x50/75	200	AIS	Not Available
SS-0102	MSML	132/33	Existing	CTG(C)	91.810286	22.38718	1	1x25/30	30	AIS	Not Available
SS-0103	Moghbazar	132/33	Existing	-	90.4011209	23.75418735	3	3x50/75	225	AIS	Not Available
SS-0104	Mongla	132/33	Existing	Khulna	89.59535303	22.50573448	2	2x25/41	82	AIS	Not Available
SS-0105	Munshiganj	132/33	Existing	Dhaka(S)	90.4970881	23.57194699	2	2x50/75	150	AIS	2012
SS-0106	Mymensingh	132/33	Existing	Mymensingh	90.42143862	24.73473456	3	1x50/75 2x80/120	315	AIS	Not Available
SS-0107	Naogaon	132/33	Existing	Rajshahi	88.96343112	24.80308167	3	2x50/75 1x25/41	191	AIS	Not Available
SS-0108	Narinda	132/33	Existing	-	90.42085721	23.71365368	2	2x50/75	150	AIS	Not Available
SS-0109	Narsingdi	132/33	Existing	Dhaka(E)	90.70474362	23.91363119	2	2x50/75	150	AIS	2009
SS-0110	Natore	132/33	Existing	Rajshahi	89.00886458	24.41172627	5	2x25/41, 1x35/50, 2x15/20	172	AIS	Not Available

Substation ID	Station Name	Facility category	Operating Status	PGCB Grid Division	Latitude	Longitude	Nos of Transformer	Capacity of transformer	Total Capacity (MVA)	Type of insulation	Construction year
SS-0111	Netrokona	132/33	Existing	Mymensingh	90.69806948	24.86742648	3	2x25/41, 1x25/33	115	AIS	Not Available
SS-0112	New Tongi	132/33	Existing	Dhaka(N)	90.4107	23.895329	2	2x50/75	150	AIS	2008
SS-0113	Niyamatpur	132/33	Existing	Rajshahi	88.58360628	24.83361873	3	2x35/50, 1x25/41	141	AIS	2010
SS-0114	Noapara	132/33	Existing	Khulna	89.4053835	23.02350331	3	2x20, 1x44.1/63	103	AIS	Not Available
SS-0115	Pabna	132/33	Existing	Ishwardi	89.23423942	24.023599	2	2x50/75	150	AIS	Not Available
SS-0116	Palashbari	132/33	Existing	Bogra	89.34992522	25.27714717	5	3X15/20 2X25/41	142	AIS	Not Available
SS-0117	Panchagarh	132/33	Existing	Rangpur	88.55700775	26.35403217	2	2x25/41	82	AIS	2010
SS-0118	Patuakhali	132/33	Existing	Barisal	90.31805184	22.35861054	3	2x15/20, 1x25/41	81	AIS	Not Available
SS-0119	Purbasadipur	132/33	Existing	Rangpur	88.6785732	25.75414601	4	1x25/41, 1x20,2x50/75	211	AIS	Not Available
SS-0120	RSRM	132/33	Existing	-	90.53326689	23.70062278	1	1x20/25	25	AIS	Not Available
SS-0121	Rajshahi	132/33	Existing	Rajshahi	88.67602745	24.36622519	3	2x50/75, 1x35/50	200	AIS	Not Available
SS-0122	Rangpur	132/33	Existing	Rangpur	89.25210187	25.72884097	4	2x50/75, 2x10/13.3	176.6	AIS	Not Available
SS-0123	Rooppur	132/33	Existing	Ishwardi	89.049713°	24.072135°	1	1x25/41	41	AIS	2017
SS-0124	Saidpur	132/33	Existing	Rangpur	88.88522712	25.81296779	3	2x25/41, 1x35/50	132	AIS	Not Available
SS-0125	Satkhira	132/33	Existing	Khulna	89.09307983	22.74347519	2	2x25/41	82	GIS	Not Available
SS-0126	Satmasjid	132/33	Existing	Dhaka(N-W)	90.3620503	23.75634343	2	2x80/120	240	GIS	2014
SS-0127	Savar	132/33	Existing	Dhaka(N-W)	90.25516585	23.81642316	2	2x50/75	150	AIS	2010
SS-0128	Shahjadpur	132/33	Existing	Ishwardi	89.58428227	24.17261349	4	2x15/20, 1x25/41, 1x35/50	131	AIS	Not Available
SS-0129	Shahjibazar	132/33	Existing	Srimangal	91.37927877	24.25369771	3	2x25/41, 1x50/75	157	AIS	Not Available
SS-0130	Shahmirpur	132/33	Existing	CTG(C)	91.8481379	22.26742751	2	2x48/64	128	AIS	Not Available
SS-0131	Sherpur	132/33	Existing	Mymensingh	90.0833137	25.04825697	2	2x35/50	100	AIS	2014
SS-0132	Shyampur	132/33	Existing	Dhaka(S)	90.44579926	23.67660809	4	4x50/75	300	AIS	Not Available
SS-0133	Siddhirganj	132/33	Existing	Dhaka(E)	90.51715827	23.68564612	2	2x50/83.3	166.6	AIS	Not Available
SS-0134	Sikalbaha	132/33	Existing	-	91.8656961	22.32208451	2	1x25/41.6, 1x50/75	116.6	AIS	Not Available
SS-0135	Sirajganj	132/33	Existing	Bogra	89.67008236	24.44821905	4	1x15/20, 1x35/50, 2x25/41	152	AIS	Not Available
SS-0136	Sitalakhya	132/33	Existing	-	90.49459881	23.60165278	3	3x50/75	225	AIS	Not Available
SS-0137	Sonargaon	132/33	Existing	Dhaka(E)	90.59068851	23.64187926	2	2x50/75	150	AIS	2011
SS-0138	Srimangal	132/33	Existing	Srimangal	91.70211804	24.30772062	3	3x15/20	60	AIS	Not Available
SS-0139	SSML	132/33	Existing	-	91.722529	22.474345	1	1x25/30	30	AIS	Not Available
SS-0140	Sylhet	132/33	Existing	Srimangal	91.83014981	24.90922413	3	2x25/41, 1x50/83	165	AIS	Not Available
SS-0141	Tangail	132/33	Existing	Dhaka(N)	89.92135491	24.27695587	3	3x50/75	225	AIS	Not Available
SS-0142	Thakurgaon	132/33	Existing	Rangpur	88.42560234	26.03873375	2	2x25/41	82	AIS	Not Available
SS-0143	TKCCL	132/33	Existing	CTG(S)	91.89104055	22.38392767	1	1x50/75	75	AIS	Not Available
SS-0144	Tongi	132/33	Existing	Dhaka(N)	90.41288468	23.89727813	3	3x50/75	225	AIS	Not Available
SS-0145	Ullon	132/33	Existing	Dhaka(C)	90.41443383	23.76247117	3	3x35/50	150	AIS	Not Available
SS-0146	Uttara	132/33	Existing	-	90.37920697	23.87293901	2	2x50/75	150	AIS	Not Available

(2) Investment planning

We reviewed the development plan for transmission line and substation based on the development plan of PSMP 2016. The list of the on-going projects as of September 2017 is as shown in the following Table.

Table 3.2.9 On-going Projects by PGCB on September 2017

SN	Projects Name	Scope of works	Main Objectives of the Project	Project Cost (M US$)		Foreign Financing Status	Project Completion Year	Present Status (PSMP2016)	2017 Status	Remarks
				Local	Foreign (PA)					
1	**Bibiyana-Kaliakoir 400 kV and Fenchuganj-Bibiyana 230 kV Transmission Line (NG2)**	i) 168.64 km 400 kV Bibiyana-Kaliakoir Double ckt line. ii) 33.18 km Fenchuganj-Bibiyana 230 kV double ckt line iii) Installation of 400/230 kV 1x520 MVA transformer at Bibiyana. iv) 400/230 kV, 1x520 MVA & 400/132 kV, 2x325 MVA S/S at Kaliakoirv) 230/132 kV, 1x300 MVA S/S at Fenchuganj and renovation & extension of existing 132 kV substation at Fenchuganj vi) Construction of 36 km 230 kV line for turn-in and out of existing Aminbazar-Tongi230 kV line on four ckt tower at Kaliakoir. vii) Construction of 5 km 132 kV line for turn-in and out of existing Kabirpur-Tangail 132 kV line on four ckt tower at Kaliakoir. viii) Construction of16 km Kaliakoir-Dhamrai double circuit 132 kV line. ix) Construction of about 3.75 km 132 kV Four circuit transmission line on Four circuit tower from Fenchuganj SS to Fenchuganj PS	To build the power evacuation facilities for upcoming 2x450 MW CCPP at Bibiyana & to evacuate the surplus power of Sylhet area and also to supply adequate power to the northern part of Dhaka city.	**100.01**	**146.73**	**EDCF Korea & GOB**	**July,2017 (Revised)**	**91.30%**	**Completed**	**Completed**
2	**National Power Transmission Network Development Project**	i) 230 kV Line: (a) 25 km Hathazari- Sikalbaha d/c TL (b) 25 km Hathazari- Rampur d/c TL (c) 5 km Hathazari- Rampur d/c u/g line ii) 132 kV Line: (a) 6 km d/c In Out u/g line of Khulshi-Halishaharline at new Rampur 132/33 kV GIS SS (b) 7 km d/c Rampur-Agrabad u/g (c) 132 kV interconnection line : 354 Ckt.km. iii) Two nos. 230/132 kV, 2×300 MVA Sub Stations at Rampur and Sikalbaha, Ctg. iv) 132/33 kV SS: 11 Sub Stations(1536 MVA) at Agrabad, Chowddagram, Benapole, Shariatpur, Ramganj, Baroirhat (Chg.), Bhaluka (Mymensingh), Barisal- (N), Mahastangarh (Bogra), Jaldhaka (Nilfamari), Rajshahi-2. v) Bay Extension:	i) To evacuate power from the proposed 225MWpower plant at Sikalbaha ii) Provide reliable power to Chittagong citythrough Rampur & Sikalbaha iii) Meet the growing load demand of the areas under the proposed new 132/33 kV substations atAgrabad (Ctg).; Chouddagram, Ramganj,Bhaluka (Myn), Baroirhat (Ctg), Benapol, Shariatpur, Barisal- (N), Mahastangarh (Bogra), Jaldhaka (Nilfamari) & Rajshahi-2	**134.62**	**168.70**	**JICA**	**June, 2019**	**5.40%**	**31.85%**	**Running**
3	***132 kV Grid Network Development Project in Eastern Region***	i) 132 kV line: (a) 100 km RPCl-Tangail double circuitLine (b) 80 km Chandraghona-Rangamati-Khagrachari double circuit line (c) 55 km Brahmanbaria-Narsingdi double circuit line (d) 28 km Beanibazar-Sylhet(S) single circuit line on double circuit tower (e) 30 kmSunamganj-Chhatak single circuit line on double circuit tower ii) 132/33 kV SS: 4 nos. atRangamati, Khagrachari, Beanibazar, Sunamganj (each 82 MVA) iii) 132 kV Bay Extension : 17 nos. at Tangail (2), RPCL (2), Chandraghona (4), Brahmanbaria (2), Chhatak (1), Narsingdi (6). iv) 3 nos. of 132 kV Bay Modification at Narsingdi v) Conversion of Single Bus-bar configuration into Double Bus-bar at Narsingdi 132/33 kV S/S vi) Installation of one 132/33 kV 50/75 MVA transformer at Narsingdi S/S.	i) To increase the power supply reliability of Mymensingh area. ii) To reduce dependency on Ashuganj-Kishorganj 132kV line. iii) To evacuate the Power from the upcoming Power Plant in Mymensingh area. iv) To meet the growing demand of Rangamati, Khagrachari, Beanibazar & Sunamganj. v) To supply reliable power to Hill Tract area. vi) To minimize the accumulation of huge power at Ashuganj 132 kV bus bar. vii) To minimize the overloading of existing "Ashuganj-Ghorasal 132 kV transmission	**36.00**	**85.00**	**ADB**	**June, 2018**	**39.90%**	**8471%**	**Running**

SN	Projects Name	Scope of works	Main Objectives of the Project	Project Cost (M US$)		Foreign Financing Status	Project Completion Year	Present Status (PSMP2016)	2017 Status	Remarks
				Local	Foreign (PA)					
4	***400/230/132 Network Development project***	(i)Construction of substations. a) 230 kV GIS Switching,Substation at Ghorasal b) 230/132 kV GIS, Substation at Ullon(2x225/300 MVA) , Basundhara (2x225/300MVA) & Shyampur(3x225/300 MVA) and 230/132 kV AIS Substation at Sripur(2x225/300MVA) c) 132/33 kV GIS, 2x80/120 MVASubstation at Ullon (d) 132/33kV SS at Rampur, Sholosahar,Sylhet(S), Kodda, Dhamrai, Kalurgaht, Kachua, Sitakunda, Rupshi, Sripur, Mirzapur. (ii) Construction of Lines. a) Construction of Ghorasal-Tongi 28 km 400 kV double circuit line. b) Construction of 132 kV line : 358 Ckt.km. c) Construction of 230 kV line : 62.6 Ckt.km. d) Re-conductoring 54 Ckt.km Ghorasal-Tongi 230kV line. e) 132/33 kV SS Renovation: Manikganj, Comilla(S), Madunaghat. f) 132 kV bay Extension : 4 g) 230 kV bay Extension : 6	i) To evacuate power from upcoming power plant at Ghorasal. (ii) To minimize the overloading of existing "Tongi-Ghorasal 230 kV transmission line". (iii) To meet up upcoming demand of Ullon and Dhanmondi area. (iv) To replace aged Ullon 132kV substation. (v) To strengthen the power supply stability, reliability & transmission capability in Ullon, Dhanmondi as well as inner of Dhaka city.(vi) To relieve the overloaded adjacent substations in different areas of the country(vii) To meet up upcoming demand of potential areas. (viii) To strengthen the power supply stability, reliability & transmission capability all over the country.	**117.57**	**311.56**	**IDB & ADB**	**June, 2019**	**20.96%**	**40%**	**Running**
5	***Enhancement of Capacity of Grid Substations and Transmission Line (Phase-I)***	i)Capacity Enhancement offive existing 132/33 kV S/S. ii)Construction of one new 230/132/33 kV S/S. iii) Construction of five new 132/33kV S/Ss. iv) Renovation / Upgradation of some existing transmission lines.	To meet the growing demand of respective area.	**43.00**	**115.00**	***WB***	**June, 2018**	**10.40%**	**43.21%**	**Running**
6	***Ashuganj-Bhulta 400 kV Transmission line***	(i) **70 km** double ckt 400 kV line. (ii) **400/230 kV S/S at Bhulta**	To strengthing the power evacuation capability from Ashuganj to Dhaka.	**30**	**89**	***GOB & PGCB financing***	**June, 2018**	**40.70%**	**90.50%**	**Running**
7	***Aminbazar-Maowa - Mongla 400 kV Transmission line***	i) 174 km 400 kV line ii) 400/230 kV 3x520 MVA at **Aminbazar**	To evacuate the Generated power of upcoming Rampal 1320 MW Coal Power Plant toDhaka & Khunla.	**89**	**85.22**	***ADB***	**June, 2020**	**ECNEC approved DPP on 26.04.2016**	**6.20%**	**Running**
8	***Capacity Upgradation(500MW) of Existing Bheramara HVDC Station Project***	i.500MW BtB HVDC Station ii.Bheramara – Ishurdi 230 kV Double Circuit: 12km ii. Two 230 kV bay extension at Bheramara & Ishwardi	To import additional 500MW power from India.	**74.65**	**109.72**	***ADB***	**June, 2018**	**3.30%**	**51.78%**	**Running**
9	***Western Grid Network Development Project***	i)Two no. of230/132 kV,2x225 MVA S/S at **Rajshahi & Jhenaidah** ii) 70 km Ishurdi-Rajshahi 230 kV Lines iii) 3 new 132/33 kVS/S at **Rajbaari, Mithapukur & Bangura(Pabna)** (iv) 60 km Khulna(S)-Gopalganj132 kV double ckt transmission line, (v) 45km Gopalganj-Madaripur & 56 km Khulna(S)-Satkhira 132 kV 2nd ckt stringing (vi) Bagerhat-Mongla & Baghabari-Bhangura 132 kV Double ckt tower line with single ckt stringing & 80 km (Bherama-Rajbari)132 kV double ckt line re-conductoring (vii) Eight 132 kV bay extension	i)To meet the growing demand of Rajshahi area. ii) To enhance the power supply capacity & reliability of western Region.	**65**	**77**	***KfW***	**June, 2018**	**1.82%**	**8.41%**	**Running**
10	***Dhaka-Chittagong Main Power Grid Strengthening Project***	i) 400 kV line : 214 km ii) 230kV line: 38 km iii)400/230 kV, GIS SS at **Madunaghat (3x750MVA) & Meghnaghat (2x750MVA)** iii) 230/132 kV, 2x300 MVA S/S at **Madunaghat old** v) 2 no. of 230 kV bay extension at Meghnaghat	i) To create facilities to transmit power from upcoming Matarbari 1200 MW Power Station. Ii) To enhance the power transmission capability between Chittagong and Dhaka.	**232.30**	**357.10**	***JICA***	**December, 2020**	**NA**	**6.84%**	**New**

SN	Projects Name	Scope of works	Main Objectives of the Project	Project Cost (M US$)		Foreign Financing Status	Project Completion Year	Present Status (PSMP2016)	2017 Status	Remarks
				Local	Foreign (PA)					
11	***Matarbari Ultra Super Critical Coal-Fired Power Project (II) (PGCB Part: "Matarbari-Madunaghat 400 kV Transmission Line")***	i) 400 kV line: **92 km**	i) To create facilities to evacuate power from upcoming Matarbari 1200 MW Power Station ii) To create power transmission capacity/ facility between Matarbari and Madunaghat.	**39.20**	**101.60**	***JICA***	**December, 2020**	**NA**	**a) Bid Document Preparation in progress**	**New**
12	***Patuakhali – Gopalganj 400 kV Line & Gopalganj 400 kV Super Grid Sub-Station Project***	i) 400/230/132 kV SS: **Gopalganj** (2x325MVA) ii) Patuakhali – Gopalganj 400 kV Double Circuit Line :**330 Ckt. km**	• To ensure power evacuation from coal based power projects of Patuakhali area • To create a high capacity power evacuation node at Gopalganj.	**179.00**	**158.00**	**Expected from ADB & GoB**	**December, 2019**	**NA**	**1.00%**	**New**
13	***Barisal-Bhola-Borhanuddin 230 kV line project***	(i) 230KV Line (Double Circuit) : 61 km (ii) New 230/132 kV S/S:1 No (Barisal). 600 MVA (AIS)	To evacuate power to generated in upcomming Bhola power plant.	**40.06**	**23.36**	**PGCB Own Fund (HSBC)**	**June, 2016**	**96.58%**	**Completed**	**Completed**
14	***Energy Efficiency in Grid Based Power Supply Project***	i) Construction of 5 nos of 230/132 kV, 2x300 MVA s/s at **Purbasadipur, Naogaon, Feni, Bhulta & Biruli(Savar)**with interconnecting lines. ii) Construction of 8 nos of 132/33 kV s/s in rural areas (**Pubail, Gazaria, Ullapara, Bajitpur,Ghatail, Araihzar, Nabinagar & Rajendropur**) & interconnecting lines. iii) Renovation & upgragation of 9 nos of 132/33 kV s/s. vi) Upgradation & modification of 744 ckt-km 132 kV transmission line.	To meet the growing power demand & quality improvement of- -Dhaka City Adjacent -Greater Noakhali -Naogaon District -Saidpur District	**109.00**	**199.00**	***KfW***	**June, 2021**	**NA**	**10.00%**	**New**
15	***Two New 132/33 kV Substations at Kulaura & Sherpur with InterconnectingLines***	(i)132 KV Line (Double Circuit) : 45 km (ii)New 132/33 kV S/S:2 Nos. (AIS) 1) Kulaura & 2) Sherpur (iii) 132 kV Bay Extension:4 Nos.	To meet the growing demand of the respective areas	**11.72**	**16.52**	**PGCB Own Fund**	**June, 2016**	**99.60%**	**Completed**	**Completed**
16	***Goalpara-Bagerhat 132 kV Double Circuit Transmission Line***	(i) 45 km. 132 kV Double circuit lineand (ii) 4 nos. 132kV bay extension	To evaquite power from Goalpara Power Plant	**5.4**	**5.3**	**PGCB Own Fund**	**June, 2016**	**91.62%**	**Completed**	**Completed**
17	***Power Grid Network Strengthening Project under PGCB***	i.400/132kV New Substation :1 **no. ,650 MVA** ii.230/132kV New Substation :**13 nos. ,9200 MVA** iii.230/132kV Old Substation (Capacity Upgradation) :**7 nos. ,3075 MVA** iv.132/33kV New Substation :**28 nos. ,7240 MVA** v.132/33kV Old Substation (Capacity Upgradation) :**28 nos. ,3383 MVA** vi.Substation Renovation :**18 nos.** vii.New Transmission Line: - 400kV Line:**200 Ckt. km** - 230kV Line:**680 Ckt. km** - 132kV Line: **676 Ckt. km** viii.Old Transmission Line (All 132kV):6 nos. - Second Ckt. Stringing:**147 Ckt. km** - Conductor Upgradation :**312 Ckt. km viii. 7 Nos. Spacialized Engineering Facilities**	• To build up and renovate necessary infrastructure for reliable transmission of power	**503.00**	**1,221.00**	***Expected from EXIM Bank, China (G-G)***	**June, 2021**	**NA**	**10.00%**	**New**
18	***Bangladesh Power System Reliability and Efficiency Improvement Project***	i) NLDC upgradation ii) DLR Installation: 400km iii) Conductor Upgradation: 80 ckt. km	To address some fundamental measure that must be put in place so that the power system can be operated in a secure and economic manner in line with the longer term goals to deliver much greater quantum of power.	**27.00**	**33.00**	***Expected from WB***	**June, 2020**	**NA**	**DPP Approved on 18.07.2017 in ECNEC meeting.**	**New**

SN	Projects Name	Scope of works	Main Objectives of the Project	Project Cost (M US$)		Foreign Financing Status	Project Completion Year	Present Status (PSMP2016)	2017 Status	Remarks
				Local	Foreign (PA)					
19	***Mongla-Khulna (S) 230 kV Transmission Line Project***	i) 230 kV Mongla-Khulna d/c line :24km ii) Two 230kV bay extension at Khulna.	Power evacuation from coal based power plant at Mongla.	**9.28**	**8.64**	**PGCB Own Fund**	**Dec, 2017**	**5.00%**	**57.05%**	**Running**
20	***Construction of Patuakhali-Payra 230 kV Transmission Line***	i) 230 kV line: **94 ckt. km** ii) 132kV switchyard: **Payra** iii) 132kV Bay Extension: 2 no's at Patuakhali	i) To supply back feed power to upcoming 1st unit of Payra 1320 MW PP	**5.17**	**37.66**	***GoB***	**June, 2019**		**DPP Approved on 31.01.2017 in ECNEC meeting.**	**New**
21	***Amnura 132/33 kV Grid Substation with Associated 132kV Transmission Line***	i) 132/33 kV AIS Substation, 1x35/50 MVA ii) 132kV line 15 km	To evacuate power to generated in upcomming 100MW power plant.	**5.37**	**6.46**	**Bidders Finance**	**June, 2017**	**11.44%**	**91.55%**	**Running**

Source: PGCB

The list of the currently planned projects made by PGCB on September 2017 is as shown in the following Table.

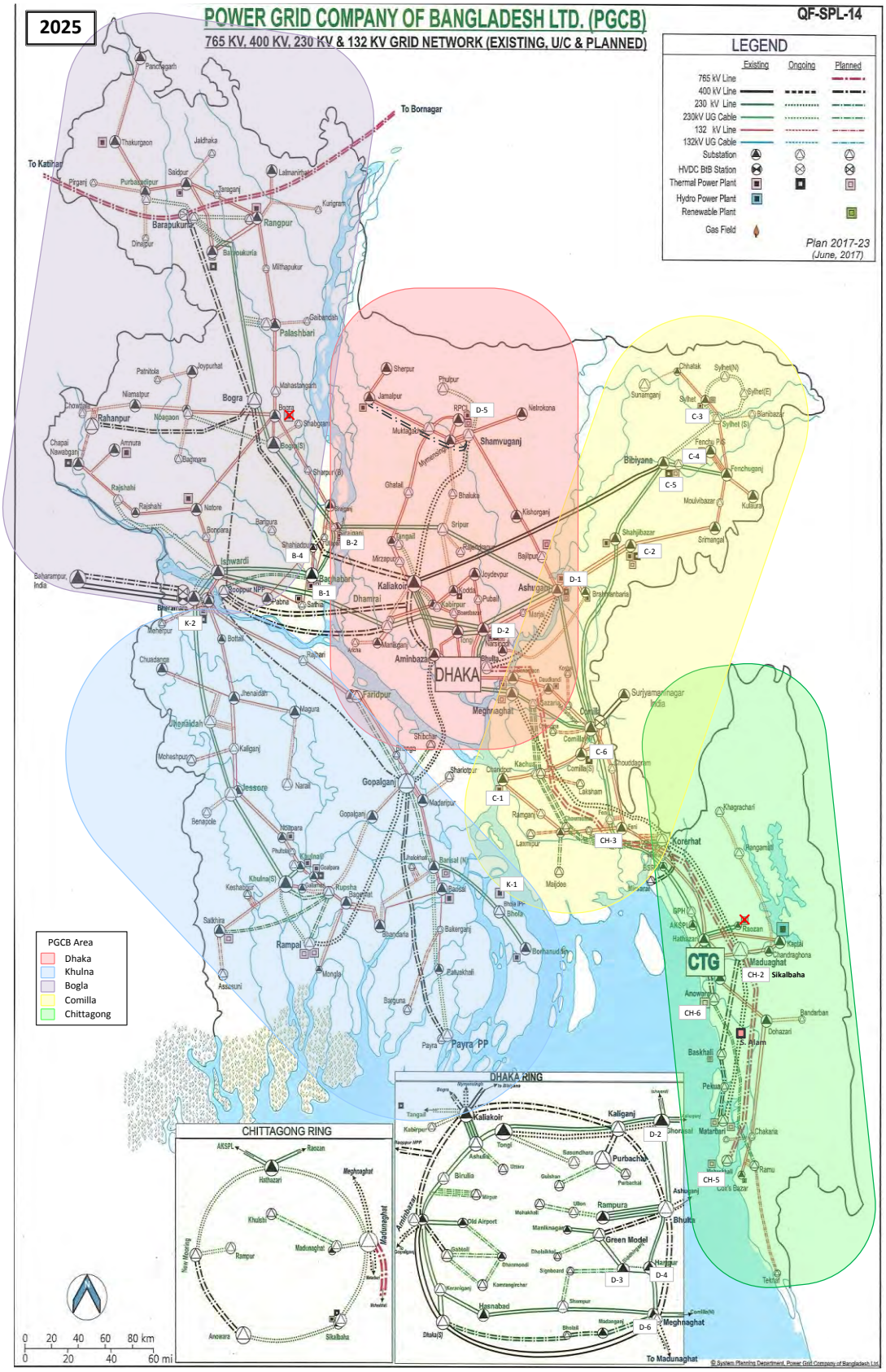
Table 3.2.10 Projects Planned by PGCB on September 2017

SN	Projects Name	Scope of works	Main Objectives of the Project	Project Cost(M US$)			*Foreign Financing*	Project Completion Year	Present Status
				Local	Foreign	Total			
1	***Expansion and Strengthening of Power System Network Under DPDC Area***	i.400/230kV New Indoor GIS Substation :**2 nos. ,3000 MVA** ii.230/132kV New Indoor GIS Substation :**7 nos. ,7650 MVA** iii.New Transmission Line: - 400kV Line:**370 Ckt. km** - 230kV Line:**111 Ckt. Km** - 230kV Cable:**96 Ckt. Km** -132kV Line: **8.8 Ckt. km** iv.Bay Extension work at other Substations : **8 nos.**	To meet the growing power demand & quality improvement of- -Dhaka City & Adjacent	**98.00**	**850.00**	**948.00**	***Expected from EXIM Bank, China (G-G)***	June, 2022	a) Financial Negotiation in progress. b) Feasibility study in progress
2	***Enhancement & Strengthening of Power Network in Eastern Region***	i. 230/132kV GIS Substation: **2 nos (Chowmohoni, Kachua, 1750 MVA),** ii. 132/33kV Substation: **9no.(Muradnagar, Laksham, Maijdee, Paitya, Chandina, New Mooring, Basurhat, Laxmipur, Kosba, 1920 MVA)** iii. 230kV Line: **246 Ckt. km** iv. 132kV Line: **304 Ckt. km** v. 132/33kV SS Renovation: **01 no. (360 MVA)**	i. To enhance & strengthen existing grid network of Eastern Region. ii. To meet up the growing demand of Eastern Region. iii. To ensure reliable power supply to Industrial/ Commercial /Residence points of Greater Comilla, Chittagong, Greater Noakhali area.	**144.00**	**293.00**	**437.00**	**Expected from WB**	June, 2022	a) PGCIL has been appointed as Feasibility Consultant. B) Interim Report submitted
3	***Madunaghat - Moheskhali 765kV Transmission line***	i) 765 kV Line: **200 Ckt. km** ii) Two 400 kV bay at Madunaghat	* To establish transmission infrastructure for evacuation of power to be generated from proposed power plants at Maheshkhali. * To provide reliable power to all over the country.	**149.00**	**194.00**	**343.00**	***Proposed for AIIB (Initailly Proposed for EDCF, Korea)***	June, 2022	a) PDPP sent to Power Division on 30-08-2015 b) Feasibility consultant appointment in progress
4	***Grid Network Development Project at Southern Area***	i) 230kV Switching Station: **Gogalganj (400/230kV, 2x350/450 MVA), Bhola (230/33, 2x120/150 MVA)** ii) 230/132KV SS: **Faridpur (2x350/450 MVA),** iii) 132/33 kV SS: **Jhalokhati, Kolapara, Bangha**(2x50/75 MVA Each) , **Shibchar** (2x80/120 MVA) , **Barguna Switching** v) 230 kV Line: 338Ckt. km. vi) 132 kV Line: 106 Ckt. Km. vii) 132kV line Strining:50 Ckt. Km	To improve Southern Area power supply reliability To ensure adequate and reliable power supply for Mirsarai Economic Zone	**145.00**	**278.00**	**423.00**	***Expected from ADB***	June, 2023	a) PDPP sent to Power Division on 06-12-2015 b) Feasibility consultant appointment in progress
5	***Expansion and Strengthening of Power System Network Under Chittagong Area***	i) 230/132/33 kV GIS SS: **Anowara, Khulshi** (2x350/450 MVA, 3x80/120 MVA) ii) 230/132kV GIS Switching: **New Mooring** ii) 400 kV Line: **54 Ckt. km.** (OH & UG) iv) 230kV U/G line: 44 Ckt. km v) 230kV bay extension: 2 no's	To improve CTG city power supply reliability To meet growing demand of CTG City Adjacent Area	**85.00**	**199.00**	**283.00**	***Expected from AIIB***	June, 2022	a) PDPP sent to Power Division on 31.01.16 b) Feasibility study in progress c) Draft IEE submitted
6	***230 & 132 kV Transmission Network Development Project in Western Zone***	i) 230/132/33 KV SS: **Rupsha** (3x350/450, 2x80/120 MVA) ii) 132/33 kV SS: **Meherpur,Kesabpur, Mahespur, Assasuni** (2x50/75 MVA Each) ,**Phultola** (2x80/120MVA) iii) 230 kV Line: 212 Ckt. km. iv) 132 kV Line: 298 Ckt. Km. v) 132 kV Line Stringing: 82 Ckt. km. vi) 230 kV bay extension: 4 no's vii) 132 kV Bay extension : 8 No's	i)To meet the growing demand of Khulna & Barisal area. ii) To enhance the power supply capacity & reliability of Khulna & Barisal Region.	**45.00**	**106.00**	**152.00**	***Expected from ADB***	June, 2023	a) PDPP sent to Power Division on 18.02.16 b) Feasibility consultant appointment in progress

SN	Projects Name	Scope of works	Main Objectives of the Project	Project Cost(M US$)			*Foreign Financing*	Project Completion Year	Present Status
				Local	Foreign	Total			
7	***Banshkhali-Madunaghat 400kV Transmission Line Project***	i) 400 kV line: **130 Ckt. km.** ii) 400 kV GIS Bay Extension: 2 no's	(i) To ensure reliable transmission facilities to evacuate power from proposed coal based thermal PP project at Banshkhali (1320 MW). (ii) To meet the growing demand of the Chittagong zone in more reliable way.	**29.00**	**69.00**	**99.00**	***Proposed for AIIB***	June, 2021	a) PDPP sent to Power Division on 27.04.16 b) Feasibility consultant appointment in progress c) Waiting for Funding conformation
8	***Expansion and Strengthening of Power System Network in DESCO & its Adjacent Area (Phase-1)***	i) 400/230 kV GIS SS: **Kaliganj, Purbachal** ii) 230/132 kV GIS/GIT SS: **Gulshan, Uttara, Mirpur, Ashulia, Mohakhali, Purbachal-2** iii) 400 kV (O/H+U/G) line: **56 Ckt. km** iv) 230 kV (O/H+U/G) line: **102 Ckt. km**	To meet the growing power demand & quality improvement of- -DESCO & Adjacent area	**174.00**	**356.00**	**530.00**	***Proposed for ADB***	December,2023	a) PDPP sent to Power Division on 02.11.16 b) Feasibility consultant appointment in progress
9	***Infrastructure Development for Power Evacuation facilities of Rooppur Nuclear Power Plant***	i) 400 kV Line: **889 Ckt. km.** ii) 230 kV Line: **120 Ckt. km.** iii) 400/230 kV SS: **Bogra GIS** (2x 520MVA) iv) 400kV Bay extension: 5 no's (Kaliakoir-2, Aminbazar-2, Gopalganj-1) v) 230kV Bay Extension: 2 no at Baghabari vi) Implementing frequency control & drop projection, Projection System, Emergency Control System etc.	• To ensure power evacuation from Rooppur NPP • To upgrade the standard of Bangladesh Power System for the integration & safe operation of Rooppur NPP	**477.00**	**963.00**	**1,440.00**	***Proposed for New Credit Loan (India)***	December,2022	a) PDPP sent to Power Division on 15.12.16 b) Environmental Studies in progress.
10	***Bogra-Chapainawabganj (Rahanpur) 400 kV Transmission Line Project***	i) 400kV line: 250 Ckt. Km ii) 132kV line: 68 Ckt. Km iii) 400/230 GIS Substation: **Bogra** (2x750 MVA), iv) 400/132 kV GIS Substation: **Chapainawabganj** (2x325MVA)	• To supply adequate, quality and relaible power for Bangladesh Largest agriculture area.	**101.00**	**177.00**	**278.00**	***Proposed for ADB***	June,2022	a) Feasibility consultant appointment in progress b) PDPP under Preparation
11	***Replacement of Ashuganj Old 132kV AIS Substation by New 132 kV GIS Substation Project***	i) Replacement of Ashuganj Old 132kV AIS to GIS. Ii) Replacement of existing 230/132kV Transformer by 2x225/300MVA	• To increase reliable power supply Ashuganj and it's adjacent area including Dhaka • To minimize Grid Fail risks.	**20.00**	**44.00**	**64.00**	**Expected from GoB**	December,2020	DPEC meeting held on 02.07.2017
12	***Development of Transmission Infrastructure at BEZA Areas for reliable power supply (Phase-1)***	i) 230 kV line: 414 ckt. Km ii) 132 kV line: 32 ckt. Km iii) 132/33 kV SS: Ramu (2x80/120 MVA), Teknaf (2x50/75 MVA)	• To ensure adequate & reliable power supply for Economic Zone in Misrarai & Cox's Bazar Area. • To ensure reliable power supply to Commercial /Residence points of Cox's Bazar	**85.00**	**118.00**	**203.00**	**Expected from GoB**	December,2020	a) DPP under Preparation b) Feasibility consultant appointment in progress
13	***Bornagar-Parbitipur-Katihar 765 kV Bangladesh-India Grid Interconnection Project (Bangladesh Part)***	i.500MW HVDC Station at **Barapukuria** ii.765kV double circuit transmission Line: **308 Ckt. Km**	* To connect the huge hydroelectric potential of Bhutan and Arunachal Province to India through Bangladesh territory * To draw 500-100MW power at Barapukuria from Cross Border Interconnection	**177.00**	**413.00**	**590.00**	***Proposed for New Credit Loan (India)***	December,2022	Scope of the Project will be finalize after JSC meeting.
14	***HVDC BtB Station at Comilla for 500 MW Import from Tripura & Assam (India)***	i. 500MW HVDC Station at **Comilla** ii. 132kV bay extension: 2 no's at Comilla (N)	i. To import 500MW power from India	**28.00**	**102.00**	**130.00**	**Yet to be funded**	December,2019	Scope of the Project will be finalize after JSC meeting
15	***Madunaghat-Bhulta 765 kV Transmission Line Project***	i) 765 kV line: 500 ckt. Km (Conductor: Hexa Cardinal) ii) 400kV bay extension: 4 no's (Bhulta & Madunaghat)	i) To establish high capacity transmission infrastructure for evacuation of power from Chittagong to Dhaka ii) To provide reliable power to all over the country	**293.00**	**412.00**	**705.00**	**Yet to be funded**	December,2024	a) PDPP sent to Power Division on 06.09.16 b) Feasibility consultant appointment in progress
Total Cost (M US$)				**2,050.00**	**4,574.00**	**6,624.00**			
Total Cost (Crore BDT)				**16,004.00**	**35,669.00**	**51,673.00**			

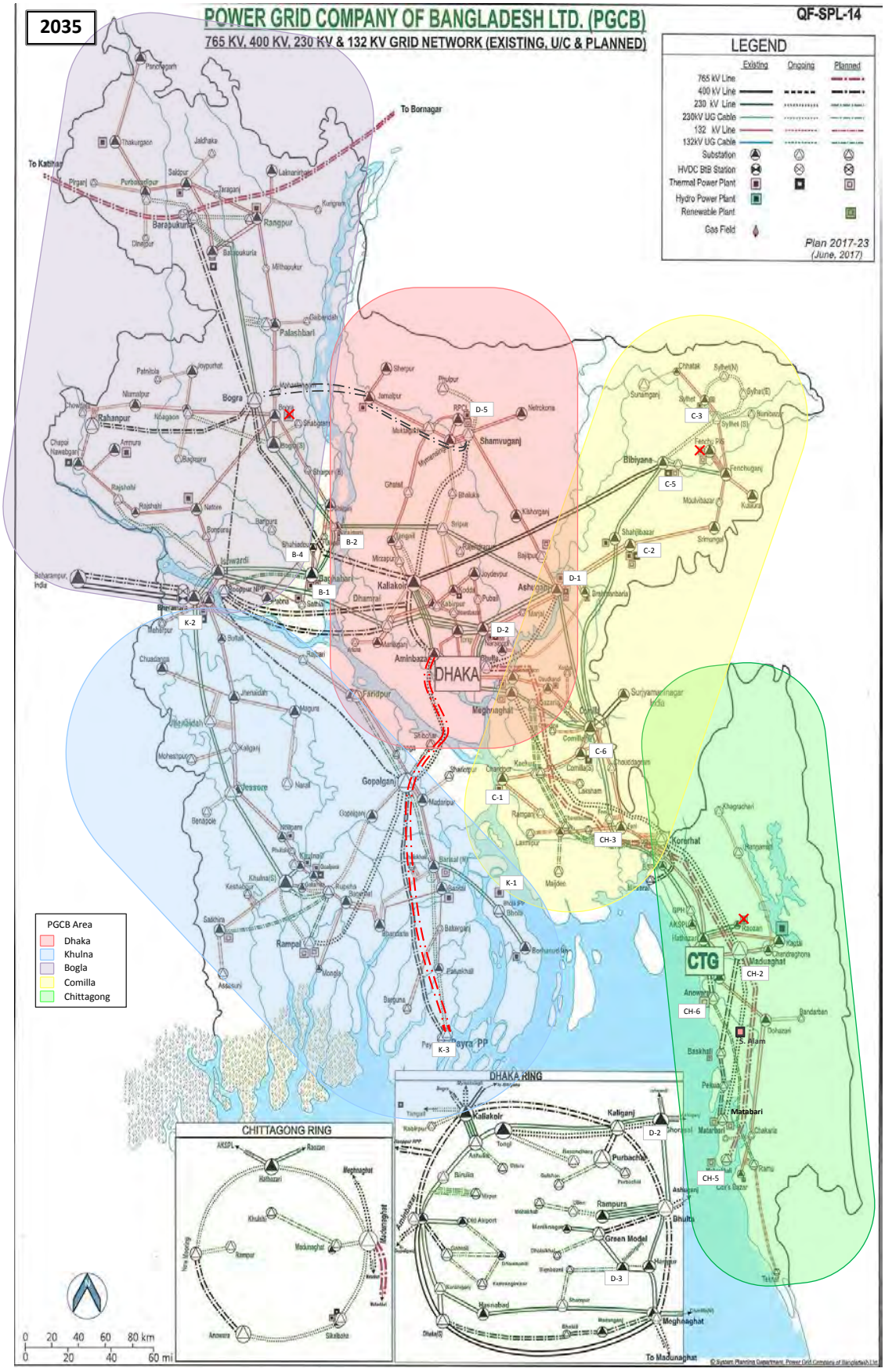
Source: PGCB

Based on above lists, the development plan of the power system network in 2025 and in 2035 are as shown in the following Figures.



Source: PGCB Transmission Line Map, modified by JST

Figure 3.2.9 Map of Power Grid Network in 2025



Source: PGCB Transmission Line Map, modified by JST

Figure 3.2.10 Map of Power Grid Network in 2035

Table 3.2.11 List of Gas-fired Thermal Power Development Plan

Category	Fuel	ID	Power Station Name	PGCB Grid Division/ Circle	Power Grid connection	Output (MW)	COD	Retirement	Capacity (MW)			Gas Consumption (mmcfd)			Location data		Map index	Gas supply company name	Acco
									2017	2025	2035	2017	2025	2035	Latitude (N) in deg	Longitude (E) in deg			
Comitted	Gas	PS-12001	Bhola 225 MW CCPP	Khulna		189	2016	2041	189	189	189	38	34	20	22.478529	90.710174	K-1		
Comitted	Gas	PS-12002	Siddirganj 335 MW CCPP	Dhaka		328	2016	2041	328	328	328	66	58	35	23.682712	90.526347	D-3		
Comitted	Gas	PS-12003	Ashuganj (North) CCPP	Comilla	132kV	370	2017	9999	370	370	370	74	66	39	24.037906	91.009083	D-1	Bakhrabad	Ashugonj
Comitted	Gas	PS-12004	Ashuganj (South) CCPP	Comilla	132kV	361	2016	2041	361	361	361	72	64	38	24.037342	91.00843	D-1	Bakhrabad	Ashuganj
Comitted	Gas	PS-12005	Ghorasal 363 MW (7th Unit) CCPP	Dhaka		352	2017	9999	352	352	352	71	63	37	23.980512	90.638189	D-2		
Comitted	Gas	PS-12006	Shajibazar CCPP	Comilla	132kV	322	2016	2041	322	322	322	65	57	34	24.25331	91.375713	C-2	Jalalabad	Shahjibaza
Comitted	Gas	PS-12007	Shikalbaha 225 MW CCPP	Chittagong		218	2017	9999	218	218	218	44	39	23	22.324971	91.86718	CH-2		
Comitted	Gas	PS-12008	Bibiana South CCPP BPDB	Comilla		372	2018	9999	0	372	372	0	66	40	24.637275	91.660716	C-5		
Comitted	Gas	PS-12009	Bibiana III CCPP BPDB	Comilla		388	2019	9999	0	388	388	0	69	41	24.637275	91.660716	C-5		
Comitted	Gas	PS-12010	Bheramara 414 MW CCPP	Khulna	132kV	402	2018	9999	0	402	402	0	71	43	24.048519	89.016255	K-2	Sundarban	Bheramar
Comitted	Gas	PS-12011	Fenchugonj 50 MW Power Plant (NRB)	Comilla		50	2019	2034	0	50	0	0	9	0	24.684574	91.917779	C-4		
Comitted	Gas	PS-12012	Sylhet 150 MW PP Conversion	Comilla		221	2018	9999	0	221	221	0	39	23	24.909378	91.829196	C-3		
Comitted	Gas	PS-12013	Ghorasal 3rd & 4th Unit Repowering (Capacity Addition)	Dhaka		776	2018	9999	0	776	776	0	138	83	23.980542	90.638149	D-2		
Comitted	Gas	PS-12014	Kushiara 163 MW CCPP	Comilla		163	2018	9999	0	163	163	0	29	17	24.688712	91.917632	D-9		
Comitted	Gas	PS-12015	Bagabari 71MW PP Conversion	Bogra		102	2020	2042	0	102	102	0	18	11	24.134873	89.59288	B-1		
Comitted	Gas	PS-12016	Sirajganj 414 MW CCPP (4th unit)	Bogra		414	2020	9999	0	414	414	0	74	44	24.385855	89.743056	B-2		
Comitted	Gas	PS-12017	Shahajibazar 100 MW	Comilla		98	2018	2038	0	98	98	0	17	10	24.25196	91.377239	C-2		
Candidate	Gas	PS-13001	CC800 Mohesikali	Chittagong		800	2032	9999	0	0	800	0	0	85			CH-5		
Candidate	Gas	PS-13002	CC800 Mohesikali	Chittagong		800	2033	9999	0	0	800	0	0	85			CH-5		
Candidate	Gas	PS-13003	CC800 Mohesikali	Chittagong		800	2034	9999	0	0	800	0	0	85			CH-5		
Candidate	Gas	PS-13004	CC800 Pyra	Khulna		800	2034	9999	0	0	800	0	0	85			K-3		
Candidate	Gas	PS-13005	CC800 Pyra	Khulna		800	2035	9999	0	0	800	0	0	85			K-3		
Candidate	Gas	PS-13006	CC800 Pyra	Khulna		800	2035	9999	0	0	800	0	0	85			K-3		
Candidate	Gas	PS-13007	CC800 Pyra	Khulna		800	2035	9999	0	0	800	0	0	85			K-3		
Candidate	Gas	PS-13015	CC500 Mohesikali	Chittagong		500	2028	9999	0	0	500	0	0	53			CH-5		
Candidate	Gas	PS-13016	CC500 Mohesikali	Chittagong		500	2029	9999	0	0	500	0	0	53			CH-5		
Candidate	Gas	PS-13017	CC250 Anowara	Chittagong		250	2026	9999	0	0	250	0	0	27			CH-6		
Candidate	Gas	PS-13018	CC250 Anowara	Chittagong		250	2029	9999	0	0	250	0	0	27			CH-6		
Candidate	Gas	PS-13019	CC250 Anowara	Chittagong		250	2031	9999	0	0	250	0	0	27			CH-6		
Candidate	Gas	PS-13020	CC250 Pyra	Khulna		250	2032	9999	0	0	250	0	0	27			K-3		
Candidate	Gas	PS-13021	CC250 Pyra	Khulna		250	2033	9999	0	0	250	0	0	27			K-3		
Candidate	Gas	PS-13022	CC250 Pyra	Khulna		250	2034	9999	0	0	250	0	0	27			K-3		
Candidate	Gas	PS-13023	CC250 Pyra	Khulna		250	2035	9999	0	0	250	0	0	27			K-3		

Source: Prepared by JST

3.3 Operation & Maintenance

3.3.1 Generation

Almost all power stations mentioned the delay in maintenance work, which is mainly caused by a delay in BPDB approval of maintenance plan/budget, and a delay in shutdown permission from Power Division of MoPEMR. BPDB has to check all of the maintenance plans and budget of power plants. However, every power plant submits its plan and budget one by one. It is thought that it is hard to make an objective, rough estimate of the necessary expense for BPDB as a whole beforehand. It is also found that Power Division does not have all power maintenance plans of power plants; therefore, there are few judgment grounds to shut down a power station in a particular time. It is necessary to coordinate with individual power stations and to judge accordingly and, as a result, judgment for the shutdown permission is delayed.

The survey result shows some issues, including the case in which facility runs until it is broken, i.e., run-to-failure practice, or absence of manufacturer's support, and/or the procurement delay of spare parts.

3.3.2 Transmission

In order to maintain the 132 kV and above transmission lines, an annual maintenance planning: (Scheduled) and planning for monthly inspection & maintenance are prepared by the respective division of PGCB. The planning is implemented in the following way as required:

(1) For scheduled maintenance

The respective division follows the checklist for inspection and maintenance. When shutdown of line is required for maintenance work, the engineer in charge will submit a requisition for shutdown of the lines in prescribed format through proper channel. After getting the approval, maintenance works is done during the requested shutdown period. After completion of the maintenance works, both Load Dispatch Centre (LDC) and concerned Grid sub-station control room are informed.

(2) For Emergency Maintenance

Senior executive concerned is informed over telephone about the required outage. Team leader of the working party from grid substation directly contacts LDC control room over telephone for the outage of line(s) and submit the work permit form (duly filled-up and signed in) to the grid substation control room requesting shutdown of the line. Clearance is issued to the team leader of the working party. After getting the requested shutdown of the line, maintenance work is done as required. Proper safety measures must be followed throughout by the maintenance gang. After completion of work, team leader of the working party will give clearance to both LDC and concerned Grid sub-station control room.

(3) For Break Down Maintenance

Whenever a fault occurs in transmission line, the tripping record is analyzed to confirm whether there is a breakdown. The concerned officials are informed about the break down within the quickest possible time. Line patrol groups will move for total line inspection (tower to tower basis) and send feedback information confirming the nature of fault. Action plan for repairing and maintenance of the line is taken up immediately. Team leader of working party will submit the work permit form, filled-up and signed in to the grid sub-station control room for isolation of the line. After getting the requested shutdown of the line and necessary clearance, repair work is done (as required). Proper safety measures must be followed throughout the work by the maintenance gang. After completion of maintenance work, team leader of the working party will give clearance to both LDC and concerned Grid sub-station control room ensuring suitability of the line for charging and safety.

(4) For Monthly Line Inspection and Maintenance

Officer in charge of the line inspects the line twice a month. Each line is inspected visually twice a month by lineman/foreman. Every tower of the line is inspected. Maintenance to be carried out in the line is identified. Repair works are carried out, if no outage is required. Trees growing under and/or

around are immediately trimmed if outage and police protection is not required. Proper safety measures must be followed throughout by the maintenance gang.

3.3.3 Substation

In order to maintain the substations, a master list of Substation equipment is maintained. Maintenance Instruction for the following equipment is maintained and followed (as applicable and required).

- 400/230 kV 230/132 kV and 132/33 kV Power Transformer
- 400 kV, 230 kV and/or 132 kV Circuit Breaker
- 400 kV, 230 kV and/or 132 kV Isolator
- Battery Charger
- Battery Sets, etc.

In substation maintenance planning, the first consideration should be:

- Substation bus-bar and bay arrangement,
- Available manpower for maintenance,
- Minimum interruption,
- Minimum outage time, and
- Minimum cost involvement

Maintenance plan should be in such a way that the maintenance of all equipment in the bay or feeder can be carried out in single interruption and to implement it. All bay equipment should be kept in one shutdown plan as far as possible.

Annual maintenance planning (Scheduled): Planning for monthly maintenance are prepared. The maintenance of substation is implemented in the following ways as required:

(1) For Scheduled Maintenance

The frequency of the scheduled maintenance should be decided by the equipment manufacturer's maintenance guide/manual, location of equipment and also the condition of the system. If there is a question of shutdown of the equipment for the implementation of maintenance schedule, the engineer in charge will submit a requisition for shutdown in prescribed format through proper channel. After getting approval for shutdown copies should be sent to grid sub-station control room and LDC Control Room. After getting the requested shutdown of the equipment and necessary clearance, maintenance work is done as planned in the annual/monthly maintenance program. Proper safety measures must be followed throughout by the maintenance gang. After completion of maintenance work, team leader of the working party will give clearance to both LDC and concerned Grid substation control room.

(2) For Emergency Maintenance

Senior executive concerned is informed over telephone about the outage required. Working party from grid substation directly contacts LDC control room over telephone for the outage of equipment/ lines and submit the work permit form and safety meeting form QF-GMD-41 duly filled-up and signed in, to grid sub-station control room. Clearance will be issued to the team leader of the working party following form WI-PSO-03. After getting the requested shutdown of the equipment and necessary clearance, maintenance work is done. Proper safety measures must be followed throughout the work by the maintenance gang. After completion of maintenance work, team leader of the working party will give clearance to both LDC and concerned Grid sub-station control room.

(3) For Break Down Maintenance

Whenever a fault occurs in substation equipment, the tripping record is analyzed to confirm whether there is a break down. Senior executives concerned are informed over telephone about the break down within the quickest possible time. Maintenance personnel inspect the equipment and send feedback information confirming the fault nature. Action plan for repairing and maintenance of the equipment is taken up immediately. The Engineer in Charge will (i) Contact LDC control room over telephone for the outage of equipment/ lines, and (ii) submit the work permit form and safety meeting form QF-GMD-41duly filled-up and signed in, to grid sub-station control room. Clearance will be issued to the team leader of the working party following form WI-PSO-03. After getting the requested shutdown of the equipment and necessary clearance, maintenance work is done. Proper safety measures must be followed throughout the work by the maintenance gang. After completion of maintenance work, team leader of the working party will give clearance to both LDC & concerned Grid substation control room.

(4) For Monthly Equipment Inspection and Maintenance

All equipment is visually inspected monthly, maintenance works to be carried out in the equipment is earmarked, and immediate repair works are carried out if no outage is required, proper safety measures must be followed throughout the work by the maintenance gang. Program schedule for maintenance works will be submitted for necessary approval of outage.

(5) For Hot Spot Check of Junction Points in Switchyard

Junction point temperatures of lines, transformers etc. in the switchyard will be measured by thermos-vision camera, and temperature will be recorded. If any abnormality is observed, then remedial action will be carried out and record shall be maintained.

(6) For Insulation Oil Test

Insulation oil for transformer, etc. shall be tested for determining;

- Break Down voltage: once in a year
- Tan Delta value: once in 2 years
- Acidity number: once in 2 years
- Dissolved gas content: once in 2 years

If any abnormality is observed, then remedial action will be carried out and record shall be maintained.

(7) For Ground Resistance Test

During annual maintenance, ground resistance value in several points shall be measured (0-1 Ohm). Extra electrode will be driven to minimize ground resistance (as necessary and applicable).

3.4 Budget for Operation & Maintenance

3.4.1 BPDB (Generation)

The economics of power generation is largely a matter of costing. As with any other production technology, power generation entails fixed and variable costs. The fixed costs are relatively straightforward, but the variable cost of power generation is remarkably complex.

The fixed costs of power generation are essentially capital costs and land. The capital cost of building varies from region to region, largely as a function of labour costs and "regulatory costs", which include things such as obtaining siting permits, environmental approvals, and so on. It is important to realize that building power station takes an enormous amount of time.

Operating costs for power plants include fuel, labour and maintenance costs. Unlike capital costs which are "fixed" (don't vary with the level of output), a plant's total operating cost depends on how much electricity the plant produces. The operating cost required to produce each MWh of electric energy is referred to as the "marginal cost". Fuel costs dominate the total cost of operation for

fossil-fuel fired power plants. For renewables, fuel is generally free (perhaps with the exception of biomass power plants in some scenarios); and the fuel costs for nuclear power plants are actually very low. For these types of power plants, labour and maintenance costs dominate total operating costs.

In general, power plants face a trade-off between capital and operating costs. Those types of power plants that have higher capital costs tend to have lower operating costs. Further, generators which run on fossil fuels tend to have operating costs that are extremely sensitive to changes in the underlying fuel price.

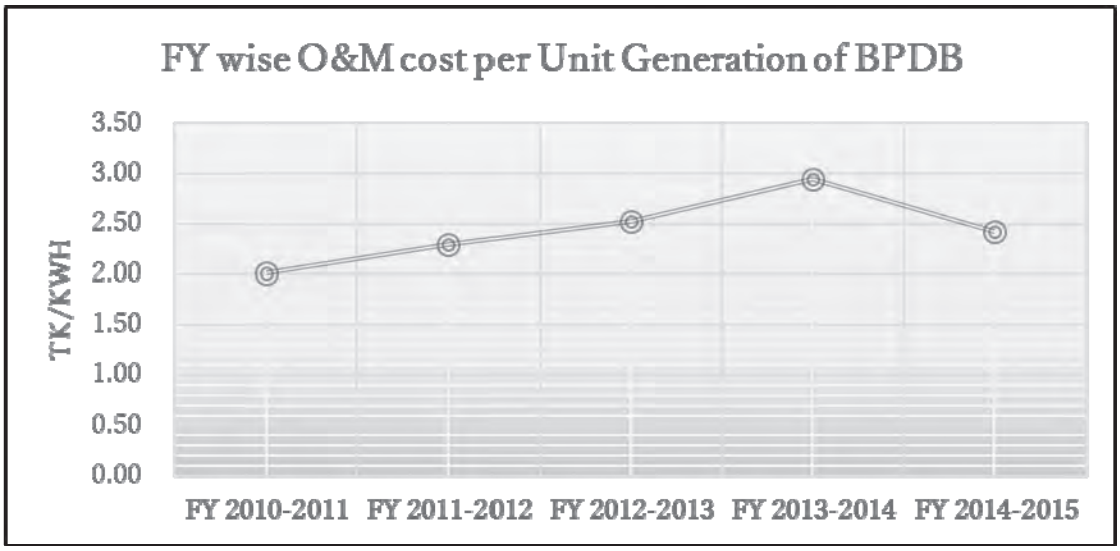
In BPDB, operating expenses for power generation include fuel expenses, personnel expenses, office expenses, repairs and maintenance expenses, and Depreciation. Operating expenses against energy generation (kWh) of BPDB for fiscal year 2010- 2011, 2011-2012, 2012-2013, 2013-2014, and 2014-2015 are given in Table 3.4.1

Table 3.4.1 FY Wise O&M Cost Per Unit Generation

Item	Unit	FY2010-2011	FY2011-2012	FY2012-2013	FY2013-2014	FY2014-2015
OPERATING EXPENSES	BDT	29,505,956,634	34,753,469,336	45,327,755,638	57,750,593,504	51,116,440,247
Generation(GWh) by BPDB	GWh	14,673	15,201	17,994	19,645	21,103
Generation O&M Expense/kWh	BDT/kWh	2.01	2.29	2.52	2.94	2.42

Source: BPDB Annual Report

The FY wise O&M cost per unit generation of BPDB shown in chart is given in Figure 3.4.1.



Source: BPDB Annual Report

Figure 3.4.1 FY wise O&M Cost Per Unit Generation of BPDB

3.4.2 PGCB (Transmission and Substation)

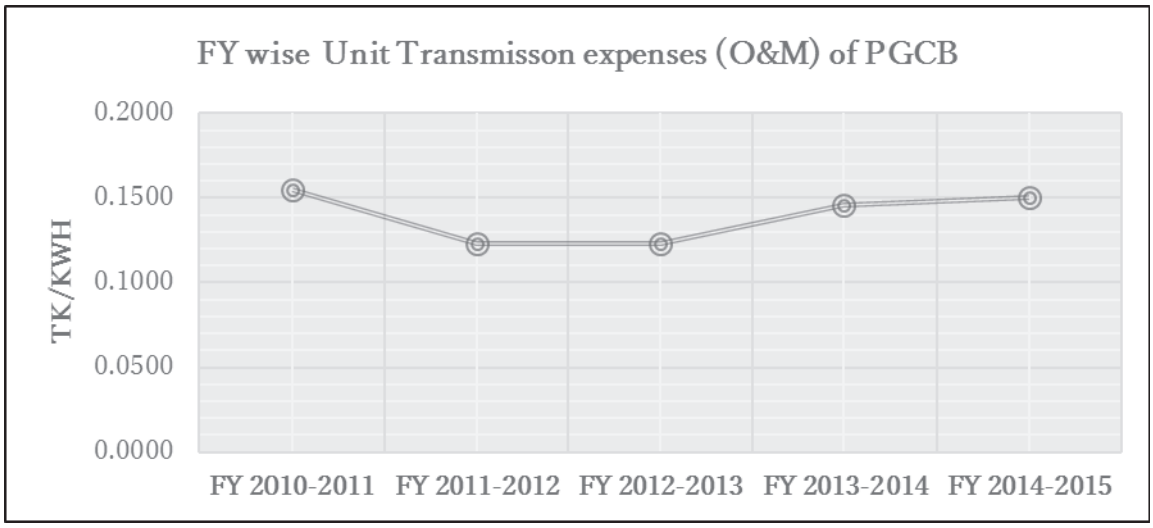
The cost structure for transmission and distribution is different from that of power generation, since there is basically no fuel cost involved with operating transmission and distribution wires (and their associated balance-of-systems, like substations). Capital cost thus dominates the economics of transmission and distribution.

In PGCB, operating expenses for power transmission include personnel expenses, office expenses, repairs and maintenance expenses, and depreciation. Operating expenses against total energy transmission (kWh) of Bangladesh for fiscal year 2010-2011, 2011-2012, 2012-2013, 2013-2014, and 2014-2015 are given in Table 3.4.2.

Table 3.4.2 FY Wise O&M Cost Per Unit Transmission

Item	Unit	FY2010-2011	FY2011-2012	FY2012-2013	FY2013-2014	FY2014-2015
OPERATING EXPENSES	BDT	4,574,983,949	4,320,538,770	4,718,696,940	6,145,559,935	6,903,893,347
Generation(GWh) by BPDB	GWh	29,485	35,118	38,229	42,195	45,834
Generation O&M Expense/kWh	BDT/kWh	0.1552	0.1230	0.1234	0.1456	0.1506

Source: PGCB Annual Report



Source: PGCB Annual Report

Figure 3.4.2 FY wise O&M Cost per unit Transmission of PGCB

3.5 Asset Management

3.5.1 BPDB

BPDB is responsible for power generation partly and distribution partly. There are some generation companies responsible for power generation. Similarly, there are several distribution companies responsible for power distribution. However, PGCB is solely responsible for power transmission at grid level. So, BPDB has different category of assets for power generation and distribution. The major category of assets belonged to BPDB are given in Table 3.5.1.

Table 3.5.1 List of Main Assets of BPDB Facility

Sl. No.	Major Category of Assets	Sub-Category of Assets
1	Land	
2	Building	• Office • Residence • Power station • Substation • Others
3	Civil Works	• Road • Boundary walls • Pump House • Sentry Post (Guard Room) • Toilet • Others
4	Power Plants	• Boiler, • Turbine (GT, ST) • Reciprocating Engine • Generator

Sl. No.	Major Category of Assets	Sub-Category of Assets
		• Heat Recovery Steam Generator (HRSG) • Power transformer • Others
5	Power Plant Structure	• Pump • Fuel Tank • Cooling Tower • Others
6	Substations	• 132/11 kV substations • 33/11 kV substations
7	Transmission Lines	• 132 kV
8	Distribution Lines	• 33 kV, 11kV • 11/0.4kV, 0.4/0.23 kV
9	Distribution Transformers	• 250 kVA, 200 kVA, 100 kVA • Others
10	Protective Devices	• Circuit Breakers • Drop Out Fuse/ Isolator/ Disconnector • Lightning Arrester • Others
11	Distribution Service Drops and Meters	• Service Drops (3-phase/ 1-phase) • Meters (3-phase/ 1-phase)

Source: IVVR, BPDB

3.5.2 PGCB

PGCB is solely responsible for power transmission at grid level. So, PGCB has different category of assets for power transmission at grid level. The major category of assets belonged to PGCB are given in Table 3.5.2.

Table 3.5.2 List of Main Assets of PGCB Facility

Sl. No.	Major Category of Assets	Sub-Category of Assets
1	Land	
2	Building	• Office • Residence • Power station • Substation • Others
3	Civil Works	• Road • Boundary walls • Pump House • Sentry Post (Guard Room) • Toilet • Others
4	Substations	• 400/230/132 kV substations • 230/132 kV substations • 132/33 kV substations • Switching Station
5	Transmission Lines	• 400 kV transmission lines • 230 kV transmission lines • 132 kV transmission lines
6	Protective Devices	• Circuit Breakers • Drop Out Fuse/ Isolator/ Disconnector • Lightning Arrester • Others

Source: PGCB

3.5.3 Methodology for Valuation of Fixed Assets

For the valuation of Fixed Assets as per International Accounting Standard, i.e., IAS-16, the following methodologies are used with priority:

1) Historical Cost
2) Replacement Value
3) Fair Value

For calculation of depreciation, straight line method is used.

Revaluation of assets is normally done after every five years. However, in BPDB, revaluation is being done after 17 years. In 2000, revaluation was done under “Identification, Verification, Valuation, Recording of Fixed Asset & Store Project” (IVVR project). BPDB has undertaken IVVR Phase-2 Project in 2017 to re-evaluate the assets of BPDB.

3.5.4 Recommendation on Asset Management in Power Sector

In BPDB and PGCB, assets in local stores are managed with manual ledger, and there is no central asset management system. Currently, a consultant is engaged to prepare the database for asset.

Information and Communications Technology (ICT) road map is being prepared by Power Cell with the support of World Bank for organizations in power sector. It proposes introduction of Enterprise Resource Planning (ERP) system for respective organization. However, as stated in Section 2.1.4. ERP requires customization for each organization, and requires continuous effort to cope with changeable situation over years. Basic system with documentation management and database is necessary. In addition, database for operation data with SCADA, maintenance record, field service, and engineering design needs to be developed.

In this regard, it is proposed to introduce Network Infrastructure Management System of asset management system platform, as illustrated in Chapter 2.1.4.

3.6 Prospective Improvement Project for Power Sector

Currently National Load Dispatch Centre (NLDC) in Bangladesh is using the Energy Management System (EMS) and Supervisory Control and Data Acquisition (SCADA) system called “e-terra” manufactured by GE/Alstom. Therefore, in this survey, we discussed with GE engineers about the collaboration between GE's Smallworld and "e-terra" described later. Our team explained the current situation of frequency in Bangladesh and we also discussed about functions of current EMS/SCADA system and necessary improvement for improving frequency quality as follows.

(1) Issues of frequency control

- Grid Code stipulates that the frequency must be kept within 50 ± 1.0 Hz, while it is stipulated to control frequency within ±0.2 Hz normally in developing countries. Even under such circumstances frequency is currently deviating from ± 1.0 Hz range.
- Communication networks between the NLDC and power stations are not in place. Therefore, all instructions of changing power output from the NLDC to power stations are implemented by telephone.
- In order to instruct automatically from the NLDC to power stations, it is necessary to check whether the functions of Automatic Generation Control (AGC) and Automatic Frequency Control (AFC) are installed.
- Free Governor Operation Mode (FGMO) is used only by a few power stations.
- There is insufficient description of the system for providing reserve for frequency control in the Grid Code.

(2) Fact findings from the discussion with GE engineer

From the discussion with GE engineer, JST have found the following fact findings regarding EMS/SCADA system.

- The "e-terra" is a platform. It is possible to combine various functions (supply-demand control, supervising the transmission lines and substations and asset management, so on) on the platform by customizing it according to user's request.
- AGC function for automatic output control of generator has already installed in the EMS/ SCADA system in NLDC. However, an engineer who is in charge of Bangladesh at the Indian office of GE confirmed to NLDC and received a reply that the AGC function is not used.
- Since LFC function is included in as part of the AGC function, EMS detect minute fluctuations of demand and can keep frequency to 50 Hz.
- Preparation for using the AGC function. The AGC function requires the data of generator such as Maximum Output, Minimum Output, Ramp Rate (Output Change Speed) and so on. The collected data is input to the EMS.
- Economic Dispatching Control (EDC) function can also be used in cooperation with AGC function. EDC function takes into consideration the fuel cost of the generator to be controlled, and the generator output is determined so as to achieve the optimal and economical operation.
- GE/ Alstom does not deal with the communication network between NLDC, power stations, and the receiving terminal on the power plant side.
- There are various kinds of communication networks such as an optical fiber, micro wave, Virtual Private Network (VPN) and so on. There is no particular restriction on the communication method. Therefore, communication method generally adopted in Bangladesh can be used.
- Since there is no particular restriction on the receiving terminal, anything can be used as long as it can receive a signal from a communication network.
- Supply demand control and supervising transmission network functions contain the detailed functions in package. If a user pays the license fee, they can use these functions immediately.

It was confirmed that the current EMS/SCADA system already has AGC function which is necessary for automatic control of generator from NLDC. However, currently NLDC have not used the AGC function, because it needs modification of configuration in the communication network system and equipment in power stations to realize the AGC control.

(3) Recommendations for improving frequency quality

1) Bangladesh Electricity Grid Code 2012

Grid Code has the rule that all Generators are subject to instructions of NLDC and shall regulate generation according to these instructions, however, it have not yet been realized. The existing frequency range needs to be modified.

Therefore, it is recommended that the terminal of receiving AGC instruction and FGMO function be installed in all new generators. It is also recommended that penalties be added when a generator greatly deviates from the scheduled output.

2) Communication network

In order to realize LFC control, it is recommended that the communication network between NLDC and power stations are installed.

In addition, all power stations need to provide PGCB/NLDC with the necessary parameters of generator for setting AGC function.

It is also recommended that the information system with SCADA installed in NLDC be incorporated when Network Infrastructure Management System is established in the future. The visual mapping and asset database information in Network Infrastructure Management System will enable more advanced operation when it is incorporated with SCADA, as follows:

- Sharing gas generation data and demand forecast data with gas sector through SCADA will help demand-oriented gas supply system. This improves power generation and supply quality.
- Middle term and long term monitoring of SCADA operation data with asset data can be used for the preparation of preventive maintenance and system improvement plan.

Network Infrastructure Management System and SCADA will enable system improvement and advance d operation, as described in section 5.6.1 later.

CHPTER 4 ENVIRONMENT

This chapter refers various document, maps and database which is possible to be applied for strategic environmental assessment for network infrastructure. Then, environmental scoping for proposed sub-sea pipeline was conducted and major impact was summarized for pipeline corridor, pipeline construction and operation. The preliminary route of the proposed new pipeline is overlapped with environmental maps and recommendation for route selection was made.

4.1 Possibility about the Environmental Supporting Database

National spatial database like the Small-world could be used for the integrated Environmental and social database for conservation, monitoring and planning too. If the various spatial maps prepared by various organizations in one place, sustainability analysis and sustainability planning could be possible. In order to see the possibility of the special database, designated areas maps, development policy maps, and monitoring maps are examined.

4.1.1 Restricted or Designated Areas by the Bangladesh Regulations

There are various Ordinance, Laws, Act, Rules and Regulations. For example, Industrial areas or Sensitive areas designated by Environment Conservation Rules, 1997, Ecologically Critical Areas designated by Environment (Conservation) Act, 1995, Reserved forest designated by Forest act 1927 or others. This information should be referred at the concept stage of all the infrastructure development. Table 4.1.1 shows a part of designated areas by laws and regulations. But some of them have not been identified the areas yet or have not been opened to the public yet. When Gas and electricity sector project owners select the project location, they have to examine these regulations in detail and have to follow the various environmental standards, keep the air quality and water quality, and avoid the prohibited activities.

Table 4.1.1 Designated areas by Laws and Regulations

ID	Category	Item	Standard/ Condition	Spatial map	Authority	Ordinance, Law, Act, Rule, Regulation
R1	Air	Ambient air	AIR QUALITY STANDARDS	Industrial and mixed, (i) National Monument; ii) Health Centres, Hospitals; Archaeological sites, educational institutions; and ECA areas)	Department of Environment (DOE)	Schedule 2, Environment Conservation Rules, 1997
R2	Air	Emission standard	Vehicles, Mechanized Vessels, Industry	-	Department of Environment (DOE)	The Motor Vehicles Ordinance, 1983 Environment Conservation Rules, 1997
R3	Air	Emission from brick burning	Industries Brick burning	i. Residential, Commercial and restricted area. ii. City Corporation, Paurashava and	Department of Environment (DOE)	The Environment Pollution Control Ordinance, 1977

ID	Category	Item	Standard/ Condition	Spatial map	Authority	Ordinance, Law, Act, Rule, Regulation
				Upazila Sadar iii. Government and private forest, reserve forest, Garden or Wetland iv. Agriculture land v. ECA areas vi. Degraded Air Shed		Brick Burning Act, 1989 Burning of Bricks (Control) Act, 1989
R3-2	Noise	Sounds	Standards for sound (Table 4.1.3)	Silent zone, Residential area, Mixed area, Commercial area, Industrial area	Department of Environment (DOE)	Schedule 4, Environment Conservation Rules, 1997
R4	Water	Ambient water	Standards for Water	-	Department of Environment (DOE)	The Environment Pollution Control Ordinance, 1977 Environment Conservation Rules, 1997
R5-1	Water	River water	Unknown	Water stress area (Article 17),	Bangladesh Water Development Board (BWDB) National water council	Water Act 2013 National River Protection Commission Act, 2013
R5-2	Water	River water	Unknown	The lowest safe yield level of aquifer (Article 19)	Bangladesh Water Development Board (BWDB)	Article 19, Water Act 2013
R5-3	Water	River water	Unknown	Conservation of water source and management (ECA river, Haor, Baor, 24/10/2017, Hakaluki, Tanguar Haor on 09.10.2017)	Bangladesh Water Development Board (BWDB)	Article 22, Water Act 2013
R5-4	Water	River water	Unknown	Water zone (Article 23)	Bangladesh Water Development Board (BWDB)	Article 23, Water Act 2013
R5-5	Water	River water	Unknown	Restrictions on water storing (Article 24)	Bangladesh Water Development Board (BWDB)	Article 24, Water Act 2013

ID	Category	Item	Standard/ Condition	Spatial map	Authority	Ordinance, Law, Act, Rule, Regulation
R5-6	Water	River water	Unknown	Flood control zone and management (under processed by Rajuk.)	Bangladesh Water Development Board (BWDB)	Article 25, Water Act 2013
R6	Water	Water supply	-	-	Department of Public Health Engineering Dhaka Water Supply & Sewerage Authority (DWASA)	Water Supply and Drainage Authority Act, 1996
R7	Water	Irrigation	Water rights	-		The Irrigation Act, 1876 The Tanks Improvement Act, 1939
R7-2	Water	Water discharge	Standards for Waste From Industrial Units or Projects Waste (Table 4.1.4)	Inland Surface Water, Public Sewerage system connected to treatment at second stage, Irrigated Land	Department of Environment (DOE)	Schedule 10, Environment Conservation Rules, 1997
R8	Water	River	Construction rules (Table 4.1.5)	Foreshore area	Bangladesh Inland Water Transport Authority (BIWTA)	Construction & Installation control rules on Inland waterways & foreshore 2010 The Ports Act, 1908
R9	Water	Water zone		The Territorial Waters and Maritime Zones (Figure 4.1.1)	Bangladesh Water Development Board (BWDB)	The Territorial Waters and Maritime Zones Act, 1974
R10	Forest	Protected Area	Land use condition in the protected area	Protected Area	Forest department	Environment Conservation Rules, 1997
R11	Forest	Ecologically Critical Areas	Land use condition in the ECA (Table 4.1.6)	Ecologically Critical Areas (Figure 4.1.1)	Forest department	Environment (Conservation) Act, 1995 Ecologically Critical Area Management Rules, 2016
R12	Forest	Reserved forest	Rules or restricted activities in the Reserved forest (Table 4.1.6)	Chapter II: Reserved forest (Figure 4.1.1) Chapter III: Village-Forests and Social Forestry Chapter IV:	Forest department	Forest act 1927

ID	Category	Item	Standard/ Condition	Spatial map	Authority	Ordinance, Law, Act, Rule, Regulation
				Protected forest		
R13	Land use	City planning	Land use rules or restrictions in the city planned area	City planning map in Dhaka (Detailed Area Plan DAP), Chittagong (Land use plan), Khulna and Rajshahi division.	RAJUk for Dhaka, Chittagong Development Authority (CDA) for Chittagomg, Khulna Development Authority (KDA) for Khulna and Rajshahi Development Authority (RDA) for Rajshi	Local Government (Municipal) Act, 2009 Local Government (City Corporation) Act. 2009 Local Government (Union Council) Act
R14	Land use	Real Estate Development	Allowed development areas	Proposed Detailed Area Plan (Dap) by development control authority (RAJUK, CDA, RDA and KDA)		Real Estate Development and Control Act, 2010
R15	Water	Water traffic	Water traffic routes	BIWTA Routes: Class 1: Class II: Class III: Class IV: (Table 4.1.5)	Bangladesh Inland Water Transport Authority (BIWTA)	The Canal Act, 1864
R16	Water	River bank	River bank	Four rivers bank of Dhaka city's (Buriganga, Turag, Shitalakhya, Balue)	Bangladesh Inland Water Transport Authority (BIWTA)	The Embankment & Drainage Act, 1952
R18	Culture	Heritage, cultural asset	-	-	Ministry of Cultural Affairs Department of Archaeology Bangladesh Parjatan Corporation, Ministry of Civil Aviation and Tourism	National Cultural Policy-2006 Law of Archaeology 2015
R19	Fisheries	Fisheries	Fish catch control areas (Table 4.1.7)	Hilsha Sancturies	Department of Fisheries, Ministry of Fisheries And Livestock	East bangal Protection and Conservation of Fish Act 1950 Part 01 East bangal Protection and Conservation of Fish Act 1950

ID	Category	Item	Standard/ Condition	Spatial map	Authority	Ordinance, Law, Act, Rule, Regulation
						Part 02 Animal and Fish Act, 2010
R20	Economy	Economy	Unknown	Economic exclusive zone	Bangladesh Economic Zones Authority (BEZA)	Bangladesh Economic Zones Act, 2010

Source: Prepared by JST

Environment Conservation Rules 1997 stipulates environmental standards. The following table summarizes the environmental standard of Air.

Table 4.1.2 Standard of Air

Categories of Area	Suspended Particulate Maters (SPM) (mg/m^3)	Sulphur dioxide (mg/m^3)	Carbon Monoxide (mg/m^3)	Oxides Nitrogen (mg/m^3)
a. Industrial and mixed	500	120	5000	100
b. Commercial and mixed	400	100	5000	100
c. Residential and rural	200	80	2000	80
d. Sensitive	100	30	1000	30

Notes:

(1) At national level, sensitive area includes monuments, health center, hospital, archaeological site, educational institution, and government designated areas (if any).

(2) Industrial units located in areas not designated as industrial areas shall not discharge pollutants which may contribute to exceeding the standard for air surrounding the areas specified at Sl. nos. c and d above.

(3) Suspended Particulate Matter means airborne particles of a diameter of 10 micron or less.

Source: Schedule 2, Environment Conservation Rules, 1997

Standards for sound in decibel are stipulated in five categories of areas, as shown in the table below.

Table 4.1.3 Standards for Sound

Sl. No.	Category of areas	Standards determined at dB unit	
		Day	Night
a.	Silent zone	45	35
b.	Residential area	50	40
c.	Mixed area (mainly residential area, and also simultaneously used for commercial and industrial purposes)	60	50
d.	Commercial area	70	60
e.	Industrial area	75	70

Notes:

1. The time from 6 a.m. to 9 p.m. is counted as daytime.
2. The time from 9 p.m. to 6 a.m. is counted as night time.
3. Area up to a radius of 100 meters around hospitals or educational institutions or special institutions/ establishments identified/to be identified by the Government is designated as Silent Zones where use of horns of vehicles or other audio signals, and loudspeakers are prohibited.

Source: Schedule 4, Environment Conservation Rules, 1997

Waste standard is settled for inland surface water, public sewerage system connected to treatment, and irrigated land. The following table indicates the standards for waste from industrial activities or projects by places.

Table 4.1.4 Standards for Waste From Industrial Units or Projects

Sl. No.	Parameter	Unit	Places for determination of standards		
			Inland Surface Water	Public Sewerage system connected to treatment at second stage	Irrigated Land
1	Ammoniacal Nitrogen (as elementary N)	mg/l	50	75	75
2	Ammonia (as free ammonia)	mg/l	5	5	15
3	Arsenic (As)	mg/l	0.2	0.05	0.2
4	BOD5 at 20 ˚C	mg/l	50	250	100
5	Boron	mg/l	2	2	2
6	Cadmium (as CD)	mg/l	0.50	0.05	0.05
7	Chloride	mg/l	600	600	600
8	Chromium (as total Cr)	mg/l	0.5	1.0	1.0
9	COD	mg/l	200	400	400
10	Chromium (as hexavalent Cr)	mg/l	0.1	1.0	1.0
11	Copper (as Cu)	mg/l	0.5	3.0	3.0
12	Dissolved Oxygen (DO)	mg/l	4.5 – 8	4.5 – 8	4.5 – 8
13	Electro-conductivity (EC)	Micro mho/ cm	1200	1200	1200
14	Total Dissolved Solids	mg/l	2,100	2,100	2,100
15	Fluoride (as F)	mg/l	2	15	10
16	Sulfide (as S)	mg/l	1	2	2
17	Iran (as Fe)	mg/l	2	2	2
18	Total Kjeldahl Nitrogen (as N)	mg/l	100	100	100
19	Lead (as Pb)	mg/l	0.1	1.0	0.1
20	Manganese (as Mn)	mg/l	5	5	5
21	Mercury (as Hg)	mg/l	0.01	0.01	0.01
22	Nickel (as Ni)	mg/l	1.0	2.0	1.0
23	Nitrate (as elementary N)	mg/l	10.0	Not yet Fixed	10
24	Oil and Grease	mg/l	10	20	10
25	Phenolic Compounds (as C_6H_5OH)	mg/l	1.0	5	1
26	Dissolved Phosphorus (as P)	mg/l	8	8	15
27	Radioactive substance		To be specified by Bangladesh Atomic Energy Commission		
28	pH		6 – 9	6 – 9	6 – 9
29	Selenium (as Se)	mg/l	0.05	0.05	0.05
30	Zinc (as Zn)	Degree	5	10	10
31	Total Dissolved Solids	mg/l	2,100	2,100	2,100
32	Temperature	Centigrade	40-Summer	40-Summer	40-Summer

Sl. No.	Parameter	Unit	Places for determination of standards		
			Inland Surface Water	Public Sewerage system connected to treatment at second stage	Irrigated Land
			45-Winter	45-Winter	45-Winter
33	Suspended Solids (SS)	mg/l	150	500	200
34	Cyanide (as Cn)	mg/l	0.1	2.0	0.2

Notes:

(1) These standards shall be applicable to all industries or projects other than those specified under the heading "Standards for sectorwise industrial effluent or emission."

(2) Compliance with these standards shall be ensured from the moment an industrial unit starts trial production, and in other cases, from the moment a project starts operation.

(3) These standards shall be inviolable even in case of any sample collected instantly at any point of time. These standards may be enforced in a more stringent manner if considered necessary in view of the environmental conditions of a particular situation.

(4) Inland Surface Water means drains/ponds/tanks/water bodies/ ditches, canals, rivers, springs and estuaries.

(5) Public sewerage system means treatment facilities of the first and second stage and also the combined and complete treatment facilities.

(6) Irrigable land means such land area which is sufficiently irrigated by waste water taking into consideration the quantity and quality of such water for cultivation of selected crops on that land.

(7) Inland Surface Water Standards shall apply to any discharge to a public sewerage system or to land if the discharge does not meet the requirements of the definitions in notes 5 and 6 above.

Source: Schedule 10, Environment Conservation Rules, 1997

Related with R15 in Table 4.1.1, the following clearance distance/set back distance is regulated in the each class.

Table 4.1.5 Clearance distance/set back distance of Foreshore area

Class	Vertical clearance	Horizontal clearance
I	18.30 meter	76.22 meter
II	12.20 meter	76.22 meter
III	7.62 meter	30.48 meter
IV	1.50 meter	20.00 meter

Note: Any type of overhead electricity line, if crossed on the BIWTA routes additional vertical distance 3.05 meter should be added with above mentioned vertical distance.
Source: BIWTA

Ministry of Environment and Forests regulates prohibited activities in the protected areas. The name of regulation, type of protected area, allowed activities and prohibited activities are summarized in the following table

Table 4.1.6 Allowed and Prohibited Activities in the Protected Areas

Act	Name	Number	Allowed activities	Prohibited activities
Wildlife (Preservation) Act, 1973	National Park	17	• The following persons can enter or reside in protected areas, namely: (a) an officer on duty under this Act or rules made thereunder; (b) a person permitted by the Chief Warden or an officer authorized by him in this behalf ; (c) a person nominated by the Forest Department for	• cultivate any land; • establish or undertake any industrial operation; • harvest, destroy or collect any plant; • set any kind of fire; • enter into a sanctuary with any weapon without the permission of the Chief Warden or the officer authorized by him in this behalf; • disturb or threat any wildlife, or use chemicals, explosives or any other weapon or substances which may destroy wildlife
	Wildlife Sanctuary	20		

Act	Name	Number	Allowed activities	Prohibited activities
			conservation- work; (d) a person passing through highway, road and waterway constructed in the sanctuary; and (e) a person necessary for the purpose of management or conservation of, who is permitted by the Chief Warden or an officer authorized by him in this behalf. • Permit to enter may be granted to enter in sanctuary for the following purposes, namely: (a) study or investigation on relevant and helpful subject on wildlife; (b) photography; (c) research; and (d) ecotourism.	habitat; • introduce any exotic animal or plant; • introduce any domestic animal or allow any domestic animal to stray; • dump any materials detrimental to wildlife; • explore or dig for extraction of minerals; • fell any plant or part thereof except silvicultural operations required for natural regeneration of plants; • divert, stop or pollute watercourse; or • introduce any alien and invasive plant species • no person, institution or company shall establish or operate any industrial factory or brick-field within 2 (two) kilometers from the boundary of a sanctuary.
Environment (Conservation) Act, 1995 Ecologically Critical Area Management Rules, 2016	Ecologically Critical Areas: area	9	Subject to the approval of village conservation team and/or Department of Environment(DOE) to the scheme/ project beneficial for the ECA conservation and development.	Polluting water by discharging waste or any other activities that could destroy or change the natural characteristics and land cover of an ECA.
	Ecologically Critical Areas: River	4 (Buriganga, Sitalakhya, Balu and Turag river around the Dhaka city)		
Forest Act, 1927	Forest reserve	4	Any act done with the permission in writing of the Forest-officer	• Kindles, keeps or carries any fire except at such seasons as the Forest-Officer may notify in this behalf. • trespasses or pastures cattle, or permits cattle to trespass; • causes any damage by negligence in felling any tree or cutting or dragging any timber; • quarries stone, burns lime or charcoal, or collects, subjects to any manufacturing process, or removes, any forest produce other than timber; • enters a reserved forest with fire arms without prior permission from the Divisional Forest Officer concerned, • makes any fresh clearing • removes any timber from a reserved forest; • fells, girdles, lops, taps or burns any tree or strips off the bark or leaves from or otherwise damages, the same; • clears or breaks up any land for cultivation or any other purpose or cultivates or attempts to cultivate any land in any other manner • hunts, shoots, fishes, poisons water or sets traps or snares; • establishes saw-pits or saw-benches or converts trees into timber without lawful authority

Act	Name	Number	Allowed activities	Prohibited activities
Ex-situ Conservation Areas	Botanical Garden	2	• The following persons can enter or reside in protected areas, namely: a) an officer on duty under this Act or rules made thereunder; b) a person permitted by the Chief Warden or an officer authorized by him in this behalf ; c) a person nominated by the Forest Department for conservation- work; d) a person passing through highway, road and waterway constructed in the sanctuary; and e) a person necessary for the purpose of management or conservation of, who is permitted by the Chief Warden or an officer authorized by him in this behalf. • Permit to enter may be granted to enter in sanctuary for the following purposes, namely: a) study or investigation on relevant and helpful subject on wildlife; b) photography; c) research; and d) ecotourism.	• cultivate any land; • establish or undertake any industrial operation; • harvest, destroy or collect any plant; • set any kind of fire; • enter into a sanctuary with any weapon without the permission of the Chief Warden or the officer authorised by him in this behalf; • disturb or threat any wildlife, or use chemicals, explosives or any other weapon or substances which may destroy wildlife habitat; • introduce any exotic animal or plant; • introduce any domestic animal or allow any domestic animal to stray; • dump any materials detrimental to wildlife; • explore or dig for extraction of minerals; • fell any plant or part thereof except silvicultural operations required for natural regeneration of plants; • divert, stop or pollute watercourse; or • introduce any alien and invasive plant species • no person, institution or company shall establish or operate any industrial factory or brick-field within 2 (two) kilometers from the boundary of a sanctuary.
	Eco-parks and Safari Park	8		
	Marine protected area	1		
	Marine reserve	1		

Source: MOFE

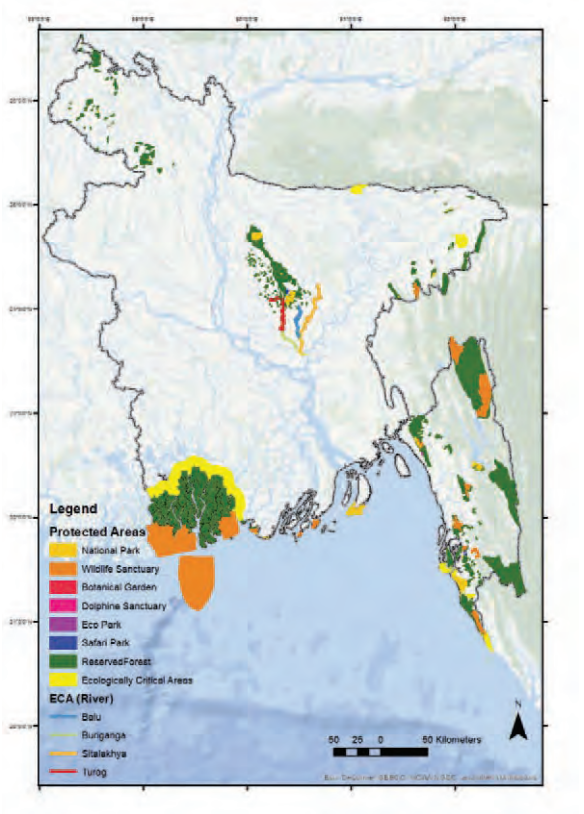
Related with R19 in Table 4.1.1, the following information is obtained. Hilsha is the one of the national food for Bangladeshis and to control the amount to be caught, the catch is banned in the following periods.

Table 4.1.7 Hilsha Sancturies

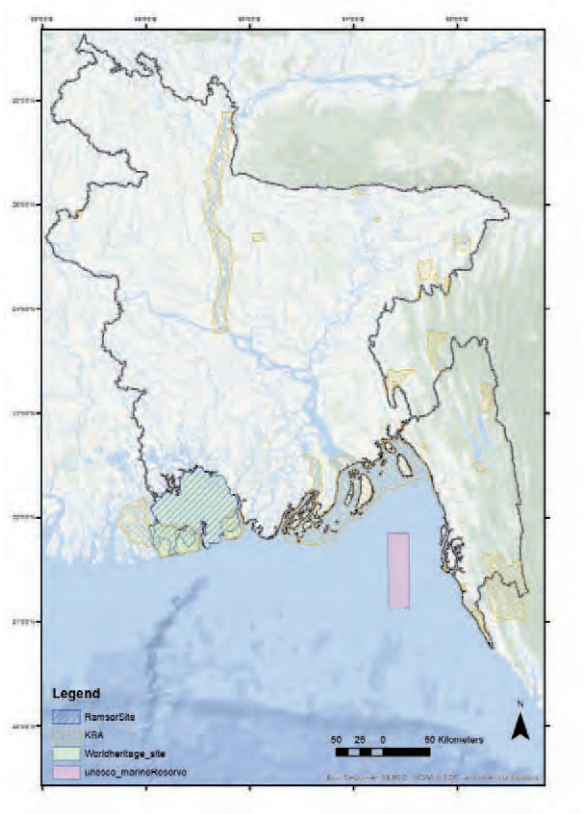
Area	Ban period
i. 100 Km stretch of the lower Meghna River from Shatnol, Chandpur District to Char Alexander, Laxmipur District	March to April
ii. 90 km strtch of Shahbazpur Channel, tributary of the Meghna River, Char Ilisha to Char Pial, Bhola District	March to April
iii. 100 Km stretch of the Tetulia River from Bheduria, Bhola District to Char Rustam. Patuakhali District	March to April
iv. Whole 40 Km stretch of the Andarmanik River in Kalapara Upazila Patuakhali District	November to January
v. 20 Km stretch of lower Padilla river, between Naria-Bhedorganj Upazila, Shariatpur District in the north and Matlab Upazila, Chandpur District and Bhedorganj Upazila, Shariatpur District in the south	March to April

Source: Department of Fisheries, Ministry of Fisheries and Livestock

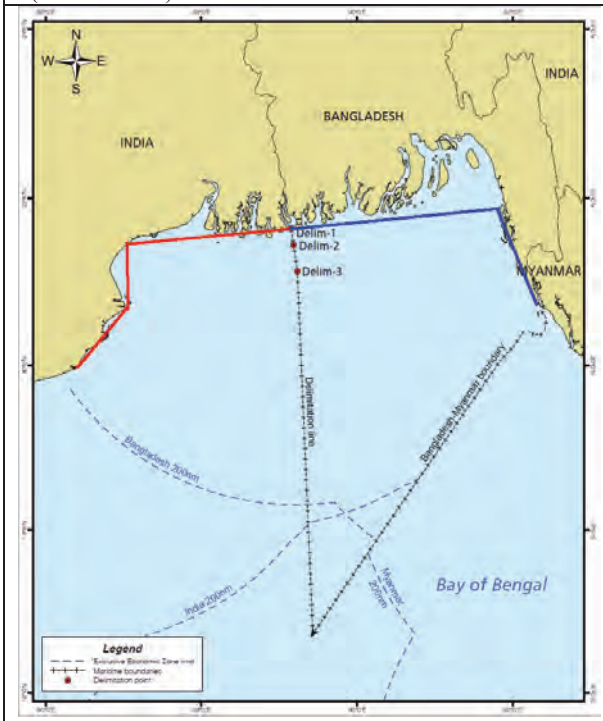
The environmental maps indicating regulated areas are issued from various organizations. Following figures are examples of regulation maps.



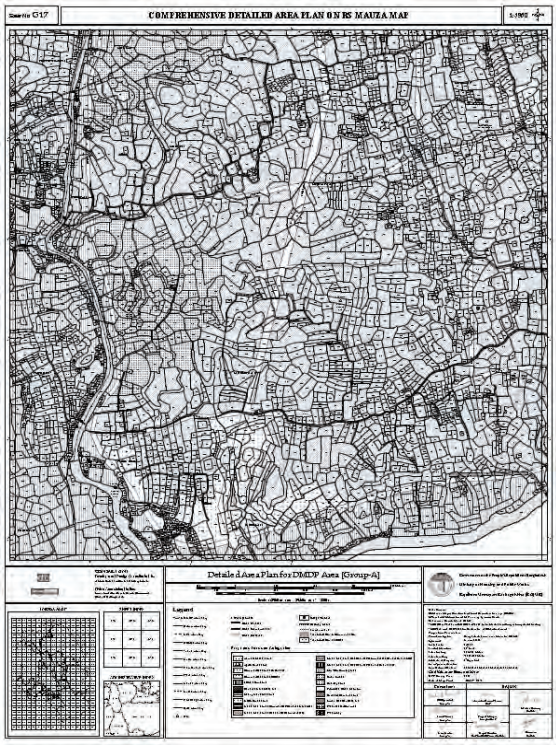
Domestic Protected Area
(Source: DOF)



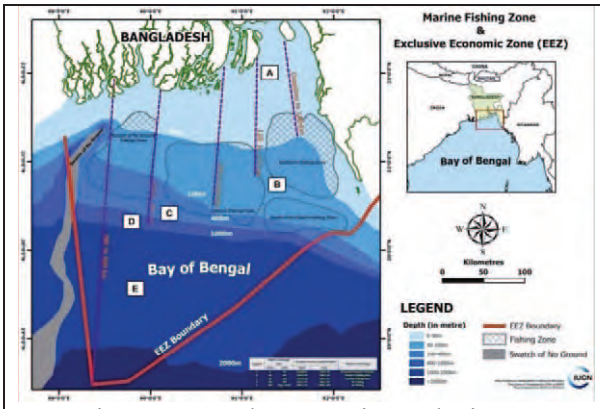
International Protected Areas
(Source:WDPA)



The Territorial Waters and Maritime Zones
(Source: BWDB)



City Planning Map in Dhaka
(Source: Dhaka city)



Marine zones and Economic Exclusive Zone
(Source: IUCN)

Figure 4.1.1 Examples of Regulation Maps

4.1.2 Policy and Plans related to Environment

Other than designated areas there are many zonings or target areas planned by many sectors. Some actions in the zones or areas are encouraged and targets are set by the plans or policies. Developers should refer the zonings and targets and make their plans fit for them. Table 4.1.7 shows zoning, target areas and policy. When Gas and electricity sector project owner start designing, they have to see all the other sector's policy and plan and examine whether their plan will be in consistent with the other sectors policy and plan or not.

Table 4.1.8 Zoning or Target Areas

ID	Category	Item	Plan/ Strategy	Spatial map	Authority	Ordinance, Law, Act, Rule
P1	Air	Ambient air	Air Quality Management Project (AQMP)	11 project sites	Department of Environment (DOE)	The Environment Conservation Rules, 1997
P2	Air	Emission from Industry, transportation,	Environment Policy, 1992 National Land Transport Policy 2004 Strategic Transport Plan 2005 Bangladesh Climate Change Action Plan 2009 Air Pollution Reduction Strategy for Bangladesh (2012, DOE)	-	Department of Environment (DOE)	The Environment Conservation Rules, 1997
P3	Water	Water right	National water Management Plan (NWMP)-2004 National Water Management Plan (NWMP) 2001	Hydrological zone	Bangladesh Water Development Board (BWDB) Water Resource Planning	Water Resource Planning Act, 1992 National Water Policy (NWPo)-1999 Bangladesh Water Act 2013

ID	Category	Item	Plan/ Strategy	Spatial map	Authority	Ordinance, Law, Act, Rule
					Organization (WARPO) National Water Resources Council (NWRC)	
P3-2	Water	Coast	Integrated Coastal Zone Management Plan (ICZMP)	Coastal Zone (Figure 4.1.2)	Planning Organization (WARPO)	National Water Policy (NWPo)-1999
P3-3	Water	Flood	Bangladesh Flood Action Plan (FAP) 2015	Unknown	Planning Organization (WARPO)	National Water Policy (NWPo)-1999
P3-4	Water	Disaster	Integrated Coastal Zone Management Plan (Table 4.1.9)	Water zone (Figure 4.1.2) Coastal districts	Planning Organization (WARPO)	Article 23, Bangladesh Water Act 2013
P4	Water	Flood	Flood Control. Drainage and Irrigation (FCDI) project	Flood Control. Drainage and Irrigation (FCDI) project areas (Figure 4.1.2)	Ministry of Food and Disaster Management Disaster Management Bureau (DMB) Planning Organization (WARPO)	Disaster Management Act (DMA) 2012
P4-2	Water	Water resource	The Traditional Approach To Management Of The Water Resources System (NWP II, 2015)	Unknown	Planning Organization (WARPO)	National Water Policy (NWPo)-1999
P5	Water	Water supply	National Policy for Safe Water Supply and Sanitation 1998 National Policy for Arsenic Mitigation 2004 National Sanitation Strategy	Whole country except Dhaka, Narayanganj and Chittagong cities where WASAs operate	Department of Public Health and Engineering (DPHE)	National Drinking Water Policy (1999) National Water Supply and Drainage Policy (1998)
P6	Water	Irrigation water use	Planning for irrigation water due to scarcity in cropping	Coastal Region of Bangladesh	Department of Agricultural Extension (DAE)	National Agriculture Policy (1999)

ID	Category	Item	Plan/ Strategy	Spatial map	Authority	Ordinance, Law, Act, Rule
			season Master Plan for Agricultural Development in Coastal Region of Bangladesh 2013			
P7	Water	Underground water (Arsenic)	Unknown	Unknown	Department of Public Health Engineering (DPHE)	National Policy for Arsenic Mitigation 2004
P8	Fishery	Fishery		Unknown	Bangladesh Fisheries Development Corporation Ministry of Fisheries and Livestock	National Fish Polity (1998)
P9	Forest	Forest protection	Forest Management Strategy	Unknown	Bangladesh Forest Industries Development Forest department	National forest policy 2016
P10	Forest	Wildlife	Management Plans	Unknown	Strengthening Regional Cooperation for Wildlife Protection Project, FD, MOEF	Environment Conservation Rules, 1997
P11	Wildlife	Coastal and Wetland Biodiversity	Coastal and Wetland Biodiversity Management (CWBMP)	Cox's Bazar and Hakaluki Haor	Department of Environment (DOE)	Environment Conservation Act, 1995
P12	Wildlife	Bird	(1) Action Plan for the Management of Birds in Bangladesh , (2) Strengthening Regional Cooperation for Wildlife Protection Project	19 sites (Table 4.1.10, Figure 4.1.2)	Forest department (FD) MOEF	WILDLIFE (CONSERVATION AND SECURITY) ACT, 2012
P13	Wildlife	Vulture	Bangladesh vulture conservation action plan 2016-2025	Two Vulture Safe Zones (Table 4.1.10)	Forest Department (FD)	WILDLIFE (CONSERVATION AND SECURITY) ACT, 2012
P14	Wildlife	Herpetofauna	Herpetofauna Management	Unknown	Forest Department	WILDLIFE (CONSERVATION

ID	Category	Item	Plan/ Strategy	Spatial map	Authority	Ordinance, Law, Act, Rule
			Strategy, Strengthening Regional Cooperation for Wildlife Protection Project		(FD)	AND SECURITY) ACT, 2012
P15	Wildlife	Mammal	Mammal Management Strategy, Strengthening Regional Cooperation for Wildlife Protection Project	Unknown	Forest Department (FD)	WILDLIFE (CONSERVATION AND SECURITY) ACT, 2012
P17	Road	Road development	Road Master Plan	Road plan maps	Ministry of Road Transport and Bridges Road Transport and Highways Division	
P18	Gas	Gas field, Gas pipeline, Storage facility	National Energy Policy-2004	Planned Gas storage facilities, Planned gas field Planned Gas pipelines (to be confirmed)	Ministry of Power, Energy and Mineral Resources Energy and Mineral Resources Division	Gas Act-2010
P19	Electricity	TML, Power plant	Power System Master Plan-2016	Planned Power plant map, TML plan (to be confirmed)	Ministry of Power, Energy and Mineral Resources Power Division	Electricity Act 2015
P20	People	Poverty	The National Food Policy Plan of Action (NFP PoA)	Unknown	Food Planning and Monitoring Unit (FPMU), Ministry of Food	
P21	Waste	Waste	Solid Waste Management Action Plan for Eight Secondary Towns in Bangladesh (2005)	-	Local Government Engineering Department Ministry of Local Government, Rural Development and Co-operatives	Draft National Solid Waste Management Handling Rules, 2005 National Sanitation Strategy 2005

ID	Category	Item	Plan/ Strategy	Spatial map	Authority	Ordinance, Law, Act, Rule
P23	Industry	Export processing	Export Processing Zones	EPZ's location map (Figure 4.1.2)	Bangladesh Export Processing Zones Authority (BEPZA)	The Bangladesh Export Processing Zones Authority Act, 1980
P23-2	Industry	Industry	Industrial zones	Unknown	Ministry of Industry	National Industry Policy (2010)
P24	Coast	Coast protection	Integrated Coastal Zone Management (ICZM)	Coastal Zone map (Figure 4.1.2)	Bangladesh Inland Water Transport Authority (BIWTA)	Land Use Policy (2001), Coastal Zone Policy (2005), Tsunami Vulnerability Map (2005), Coastal Development Strategy (2006)

Source: Prepared by JST

National Water Management Plan (NWMP) conducts several projects according to problems in hydrological Zones. The following table summarizes water projects by regions.

Table 4.1.9 Hydrological Zones by National Water Management Plan (NWMP) 2001

Regions	Problems	Projects
North West	• Erosion along the right bank of the Brahmaptura, which threatens to break through to the Bangali River and is the cause of much hardship to those living in the area. A major project to prevent this happening, the River Bank Protection Project, has recently been completed. A long-term master plan for extending bank protection was formulated under FAP. • Flooding and drainage problems in areas such as the Lower Atrai and Chalan Beel, and remedial measures for the numerous existing FCD(I) schemes in such areas. • Drought in the western fringes, especially the High Barind. The existing BMDA DTW irrigation development is one successful attempt at addressing this issue. • The need for flood proofing of the dwellings of the numerous people living in the Brahmaputra and Ganges river charlands, which are heavily flooded in most years (this is also covered in the RE Region). • The possible eventual need for a Brahmaputra barrage (its eastern end would be in NC Region).	MC 005 Rajshahi Bulk Water Supply and Distribution Systems MC 009 Rajshahi Sanitation and Sewerage Systems MC 016 Rajshahi Flood Protection MC 017 Rajshahi Stormwater Drainage AW 004 New Public Deep Tubewell Irrigation Schemes
North Central	• Further raw water supplies for Dhaka City. At present, these come largely from DTWs, with a consequent severe over-exploitation of the local aquifer. The only long-term solution is to bring surface water from one or more of the major rivers. • Flooding and drainage problems in various parts of the region. These are most serious in the low-lying parts of Manikganj, Dhaka and Munshiganj Districts on the left banks of the Brahmaputra and Padma rivers. However, due to topographic and drainage conditions in this area, it will be difficult to reduce such flooding appreciably. • Flood proofing needs in the Brahmaputra and Padma river charlands (also covered in the RE Region) • The possible eventual need for barrages on the Brahmaputra and Meghna rivers.	MC 002 Dhaka Bulk Water Supply and Distribution Systems MC 006 Dhaka Sanitation and Sewerage Systems MC 010 Dhaka Flood Protection MC 011 Dhaka Stormwater Drainage
North East	• The arsenic problem, which is found in most of the region • Environmental management of the wetlands of the Haor Basin, for	EA 007 Improved Water Management in the Haor

Regions	Problems	Projects
	fisheries and bio-diversity purposes • Remedial actions for existing FCD schemes. About half the existing FCD area of 0.56Mha has partial rather than full flood protection (i.e. submersible embankments), which has been found to be preferable to full protection is economic and environmental terms. • Flood proofing of the 1,000 or so villages in the Haor Basin • Reducing drainage congestion in the Kalni–Kushiyara and other major rivers • Local development of hill irrigation	Basins of the North East Region
South West	• The arsenic problem • For environmental and other purposes, restoration of dry season freshwater inflows to the region from the Ganges through the Gorai and possibly other channels • Maintenance, rehabilitation and, where necessary, improvement of the coastal embankment system and alleviation of its associated drainage congestion • Remedial actions for the large areas of existing FCDI schemes, especially the GK Irrigation Project. • Flood proofing in the Ganges river charlands (also covered in the RE Region).	MC 004 Khulna Bulk Water Supply and Distribution Systems MC 008 Khulna Sanitation and Sewerage Systems MC 014 Khulna Flood Protection MC 015 Khulna Stormwater Drainage EA 009 Improved Water Management and Salinity Control in the Sundarbans
South Central	• The arsenic problem • Maintenance of the existing coastal embankment system • Siltation and drainage congestion • Improved cyclone protection • Flood proofing adjacent to the Padma and in the Padma river charlands (also covered in the RE Region)	None
South East	• The arsenic problem • Gaseous aquifers • Improved cyclone protection • The existing coastal embankment system and its drainage congestion • Protection of newly accreted lands against tidal flooding • Remedial action for existing inland FCDI schemes.	None
Rivers and Estuaries	• An affordable long-term strategy for erosion protection of the main rivers • An affordable long-term strategy for regional augmentation from the main rivers • Flood proofing in the Brahmaputra, Ganges and Padma river charlands • Improved cyclone protection in the Meghna Estuary • Flood protection on newly accreted lands in the Meghna Estuary, where these have had long enough to build up sufficient height through alluvial deposition. • The arsenic problem, although this is less severe than in adjoining mainland areas along the rivers.	MR 002 Main Rivers Abstraction Projects MR 003 Ganges Barrage and Ancillary Works MR 004 Meghna Barrage and Ancillary Works MR 005 Brahmaputra Barrage and Ancillary Works MR 010 Main Rivers Erosion Control at Selected Locations MR 011 River Dredging for Navigation
Eastern Hills	• Small-scale irrigation development in the CHT • Mini-hydropower development in the CHT • Improved cyclone protection in the CCP • Maintenance of the existing coastal embankment system in the CCP	MR 012 Hydropower Development and Upgrading MC 003 Chittagong Bulk Water Supply and Distribution Systems MC 007 Chittagong Sanitation and Sewerage Systems MC 012 Chittagong Flood Protection MC 013 Chittagong Stormwater Drainage

Source: Prepared by JST

Related with P10-P15 in Table 4.1.8, the Action Plans for wildlife conservation are planned like as the following table.

Table 4.1.10 Action plans for wildlife conservation

Action plan/ Project	Areas
Action Plan for the Management of Birds in Bangladesh	19 sites (Madhupur National Park, Tanguar Haor and Pana beel, Aila Beel, Hakaluki haor, Lawachara/West Bhanugach Reserved Forest, Hail Haor, Rajkandi Reserved Forest, Rema-Kalenga Wild life Sanctuary, Jamuna-Brahmaputra river, Sundarbans (East, South, West Wildlife Sancturies), Ganges-Brahmaputra-Meghna delta, Muhuri dam, Hazarikhil Wildlife Sanctury, Pablakhali Wildlife Sanctury, Rampahar-Sitapahar Wildlife Sanctury, Patenga Beach, Sangu Matamuhuri, Himchari National Park, and Teknaf Game Reserve)
Bangladesh vulture conservation action plan 2016-2025	The government of Bangladesh has declared two Vulture Safe Zones (VSZ-1: 19,663.18 km2 and VSZ-2: 27717.26 km2) on 23 December, 2014 under the Wildlife (Conservation and Security) Act, 2012, as specialized 'Landscape zones'. These are the only government declared safe zones in the world and share boundary with India
Herpetofauna Management Strategy, Strengthening Regional Cooperation for Wildlife Protection Project	19 sites (Madhupur National Park, Tanguar Haor and Pana beel, Aila Beel, Hakaluki haor, Lawachara/West Bhanugach Reserved Forest, Hail Haor, Rajkandi Reserved Forest, Rema-Kalenga Wild life Sanctuary, Jamuna-Brahmaputra river, Sundarbans (East, South, West Wildlife Sancturies), Ganges-Brahmaputra-Meghna delta, Muhuri dam, Hazarikhil Wildlife Sanctury, Pablakhali Wildlife Sanctury, Rampahar-Sitapahar Wildlife Sanctury, Patenga Beach, Sangu Matamuhuri, Himchari National Park, and Teknaf Game Reserve)
Mammal Management Strategy, Strengthening Regional Cooperation for Wildlife Protection Project	19 sites (Madhupur National Park, Tanguar Haor and Pana beel, Aila Beel, Hakaluki haor, Lawachara/West Bhanugach Reserved Forest, Hail Haor, Rajkandi Reserved Forest, Rema-Kalenga Wild life Sanctuary, Jamuna-Brahmaputra river, Sundarbans (East, South, West Wildlife Sancturies), Ganges-Brahmaputra-Meghna delta, Muhuri dam, Hazarikhil Wildlife Sanctury, Pablakhali Wildlife Sanctury, Rampahar-Sitapahar Wildlife Sanctury, Patenga Beach, Sangu Matamuhuri, Himchari National Park, and Teknaf Game Reserve)

Source: Forest Department

Related with P24 in Table 4.1.8, the integrated costal area is clasified as follows.

Table 4.1.11 Integrated Coastal Zone

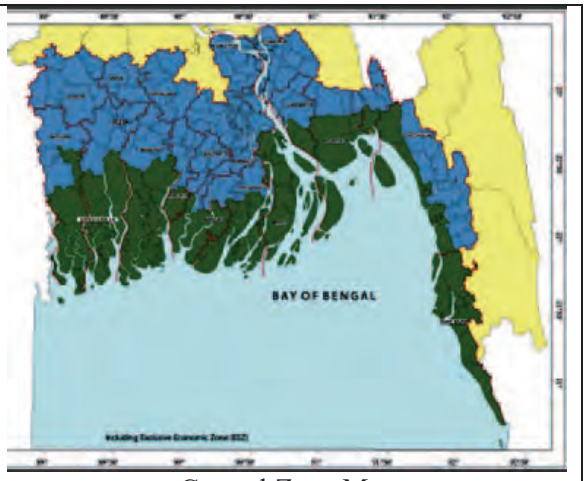
Name	Type	Policy
Water Zone	Industrial water zone	Unknown
	Agricultural water zone	Unknown
	Brackish water and aquaculture zone	Unknown
	Hatchery water zone	Unknown
Coastal districts	19 districts	Unknown

Source: Integrated Coastal Zone Management Plan (Bangladesh Water Act 2013)

There are various types of maps that can be used for environmental policy and plans and formulation of environmental management plan, such as potential habitats of birds, industrial parks, coastal zones, roads, flood control drainage and irrigation (FCDI), and water zones. Following figures shows examples of such maps.

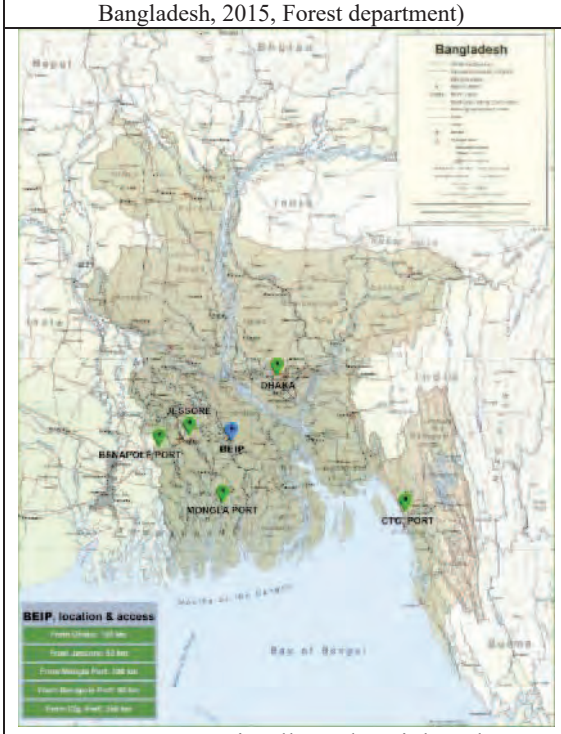
Most Potential Habitats of Birds

(Source: Action Plan for the Management of birds in Bangladesh, 2015, Forest department)



Coastal Zone Map

(Source: WARPO)

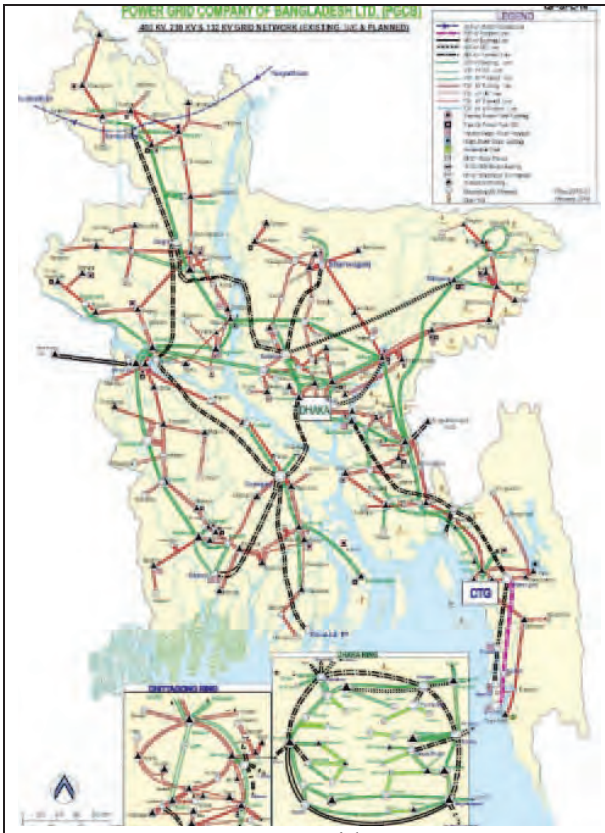


Eco-Friendly Industrial Park

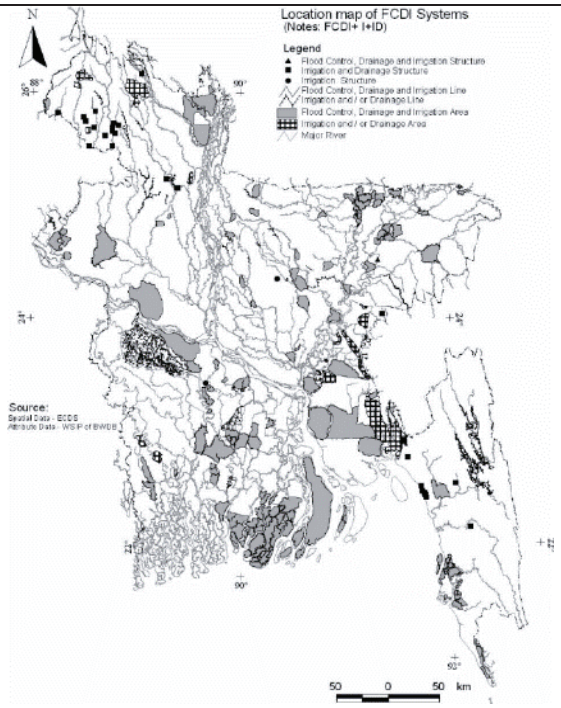
(Source: MOI)

National Highway and Regional Road Rehabilitations Maintenance Intervention, Chittagong Zone

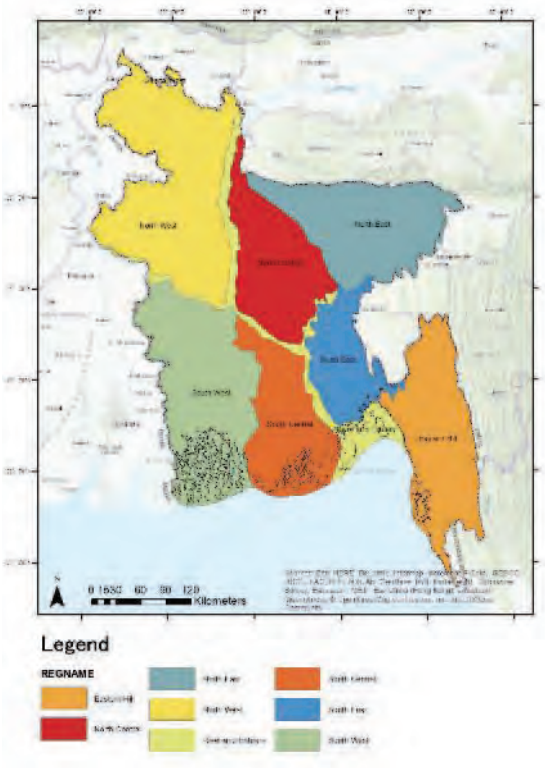
(Source: Road Transport and Highways Division, Ministry of Road Transport and Bridges)



Power Grid Map
(Source: PGCB)



FCDI Systems Map
(Source: WARPO)



Water Zones
(Source: WARPO)

Figure 4.1.2 Examples of Planning Maps

4.1.3 Baseline and Monitoring Data

Not only regulations and planning information but also baseline information which records past and current condition is useful for examine the proposed planning. Table 4.1.9 shows availability of the monitoring and baseline data. In the designing stage of the gas and electricity project, these baseline data will provide current critical areas. In the future these chronological baseline data will be examined multi-directionally and used for the forecasting.

Table 4.1.12 Monitoring and Baseline Data

ID	Category	Item	System/ map	GIS (y/n)	Authority	Ordinance, Law, Act, Rule
M1	Air	Ambient air	National Ambient Air Quality Monitoring Programme	Y (station only)	Department of Environment (DOE), Dhaka South City Corporation (DSCC), Dhaka North City Corporation (DNCC), Dhaka Transport Coordination Authority (DTCA)	Environment Conservation Rules, 1997
M2	Air	Industry Air emission	Bangladesh Air Pollution Studies (BAPS)	Y (mesh data)	Department of Environment (DOE)	Environment Conservation Rules, 1997
M3	Air	Mobile air emission	-	N	Department of Environment (DOE)	
M4	Air	CH_4 leakage	-	N	Department of Environment (DOE)	
M5	Noise	City	-	N	Department of Environment (DOE)	
M6	Noise	Airport	-	N	Department of Environment (DOE)	
M7	Water	Surface water, River water, Underground water	-	N	Monitoring cell of Department of Environment (DOE)	Environment Conservation Rules, 1997
M8	Water	All available information related to water	National Water Resources Database (NWRD) Integrated Coastal Resources Database (ICRD)	Y	Water Resources Planning Organization (WARPO)	BWDB Act, 2000
M9	Water	Ground water	National Water Management Plan (2001)	Y	National Water Resources Council (NWRC) Water Resources Planning Organization (WARPO)	Water Act 2013
M10	Water	Salinity	-	Y	Bangladesh Agricultural Research Council (BARC) Bangladesh Water Development Board (BWDB)	BARC Act, 2012
M11	Water	Flood	Processing and Flood	y	Bangladesh Water Development Board	BWDB Act, 2000

ID	Category	Item	System/ map	GIS (y/n)	Authority	Ordinance, Law, Act, Rule
			Forecasting Circle		(BWDB)	
M11-2	Water	Flood	Smart scheme information system (Smart-SIMS)	N	Institute of Water Modelling (IWM) Flood Forecasting and warning Center (FFWC)	Unknown
M12	Water	River environment	Environmental Baseline	N	Bangladesh Water Development Board (BWDB)	BWDB Act, 2000
M13	Water	River morphology and sediment transportation	INTEGRATED RIVER MONITORING SYSTEM (IRMSRG)	Y	Water Resources Division of SPARRSO	SPARRSO Act 1991
M14	Water	Ocean and Coast	Satellite based Coastal Monitoring System (SCMS)	Y	Water Resources Division of SPARRSO	SPARRSO Act 1991
M15	Water	Drought	NATIONAL DROUGHT MONITORING SYSTEM (NDMS)	Y	Water Resources Division of SPARRSO	SPARRSO Act 1991
M16	Water	Flood	National Flood Monitoring System (NFMS)	Y	Water Resources Division of SPARRSO	SPARRSO Act 1991
M17	Water	Flood	Bangladesh flood 2017	N	ICIMOD	
M18	Water	Water-logging	National Water-logging Monitoring system (WLMS)	N	Water Resources Division of SPARRSO	SPARRSO Act 1991
M19	Water	Water usage, water right	Surface water availability	N	Bangladesh Agricultural Development Corporation (BADC)	
M20	Water	Water quality of industrial effluent	-	N		
M21	Sea	Bathymetric feature, periodic current	-	N	National Oceanographic & Maritime Institute (NOAMI)	
M22	Weather	Rainfall, Temperature, Humidity, Sunlight, Evaporation, Wind speed	36 weather stations	Y	Bangladesh Meteorological Department (BMD)	
M23	Weather	Rainfall, Flood	304 rainfall stations under BMD	N	Flood Forecasting and warning Center (FFWC)	

ID	Category	Item	System/ map	GIS (y/n)	Authority	Ordinance, Law, Act, Rule
			Rainfall Distribution Map Flood map		INSTITUTE OF WATER MODELLING (IWM)	
M24	Climate change	Climate change	Climate Information Management System	Y	Bangladesh Agricultural Research Council (BARC) Cell for Climate Change Research and Impact Study (CRAIST)	BARC Act, 2012 SPARRSO Act 1991
M25	Topography	Administrative Boundary Building and Structure Facilities Forest Geodetic Control Point Hydrographic Feature Industrial Relief Transportation Vegetation	1:25,000 and 1:5,000 Geo-database	Y	Survey of Bangladesh	
M26	Soil	Flood and drought, Edaphic, Salinity, Climate	Land Resources Information and Maps	Y	Bangladesh Agricultural Research Council (BARC)	BARC Act, 2012
M27	Forest		National Forest and Tree Resources Assessment 2005-07	Y	Bangladesh Forest Research Institute (BFRI) Forest Department (FD)	Forest act 1927
M28	Wildlife	Gharials	Gharials of Bangladesh (IUCN, 2016)	N	Forest Department (FD)	Forest act 1927
M28-2	Wildlife	Elephant	Status of Asian elephants in Bangladesh (IUCN, 2016)	Y	Forest Department (FD)	Forest act 1927
M28-3	Wildlife	Elephant	Atlas : elephant routes and corridors in Bangladesh (IUCN, 2016)	Y	Forest Department (FD)	Forest act 1927
M28-4	Wildlife	Wild life	Red list of Bangladesh: Mammals, Birds, Reptiles and Amphibians, Freshwater Fishes, Crustaceans, Butterflies	Y	Forest Department (FD)	Forest act 1927

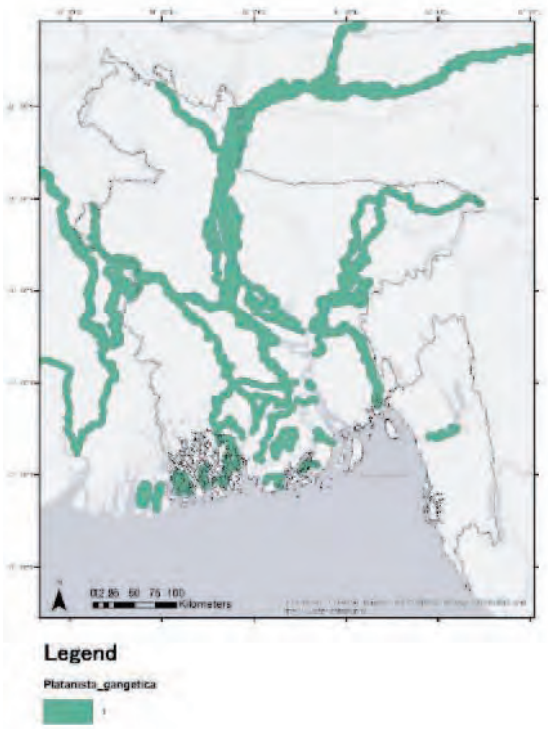
ID	Category	Item	System/ map	GIS (y/n)	Authority	Ordinance, Law, Act, Rule
			(IUCN, 2016)			
M29	Waste	Domestic waste	-	N	Ministry of Local Government, Rural Development and Co-operatives	National Policy for Water Supply and Sanitation, 1998 Draft National Urban Policy- 2006
M30	Waste	Industrial waste	-	N	Ministry of Local Government, Rural Development and Co-operatives	National Policy for Water Supply and Sanitation, 1998
M31	Waste	Hazardous waste	-	N	Ministry of Local Government, Rural Development and Co-operatives	National Policy for Water Supply and Sanitation, 1998
M32	Population	Population, Poverty, Indigenous people	-	Y	Bangladesh Bureau of Statistics (BBS)	
M33	Poverty	Poverty reduction	Monitoring report 2014	Y	Food Planning and Monitoring Unit (FPMU), Ministry of Food	
M34	Land	Land use	-	N	Center for Natural Resource Studies (CNRS)	
M35	Land	Land owner	Mouza map	N	Land Record and Survey Department	
M36	Crop	-	Crop Estimation, Analysis & Monitoring System (CEAMONS)	N	Agriculture Division, SPARRSO	SPARRSO Act 1991
M37	Crop	Crop suitability, Crop Zoning, Agriculture	Land Resources Information and Maps	Y	Bangladesh Agricultural Research Council (BARC) Bangladesh Agricultural Extension (BAE)	BARC Act, 2012
M38	Crops	Crops	Agricultural Research Management Information System (ARMIS)	Y	Bangladesh Agricultural Research Council (BARC)	BARC Act, 2012
M39	Fishery	-	-	N	Bangladesh Fisheries Research Institute	
M40	Disaster	-	-	N	Disaster Management	

ID	Category	Item	System/ map	GIS (y/n)	Authority	Ordinance, Law, Act, Rule
					Directorate	
M40-2	Disaster	Earthquake	Earthquake (Epi center)	Y	USGS	-
M41	Road	Road and Bridge (main)	Road and Bridge Asset Management System (RAMS)	Y	Roads and Highways Department	
M42	Road	Road (local)	Road digital map	Y	Local Government Engineering Department (LGED)	
M43	Transport	Transportation volume	-	N		
M44	Railway	-	-	N		
M44-2	Waterway	Port and fairway	Port and fairway map	N	Bangladesh Inland Water Transport Authority (BIWTA)	?
M45	Water supply	Water supply	WASA map SCADA	Y	Dhaka Water Supply & Sewerage Authority (DWASA)	
M46	Electrification	Electrification	Grid and S/S (Existing, plan), 33 kV source line	Y	Directorate of GIS,Bangladesh Rural Electrification Board	
M47	Security	-	Unknown	N		

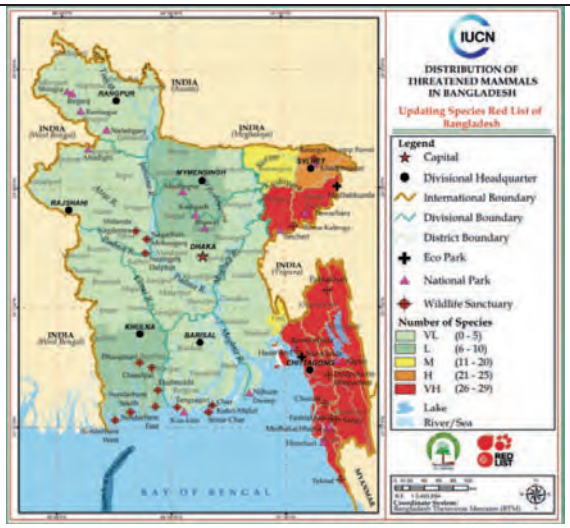
Source: Prepared by JST

Maps that can be used for base maps for environmental study are as shown in the figure below.

Asian Elephant
(Source: IUCN)

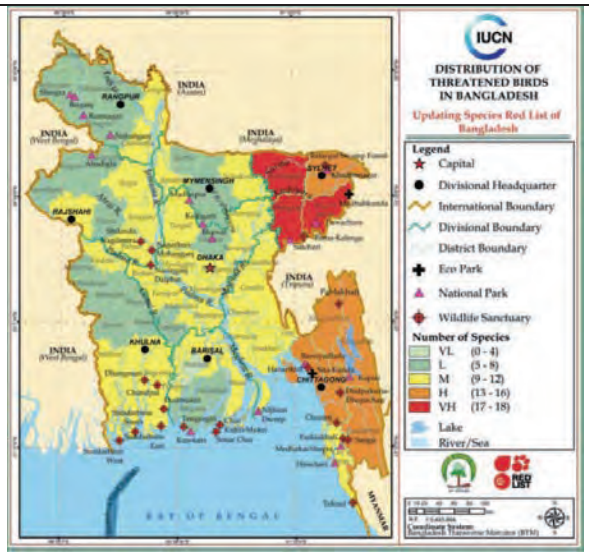


South Asian river dolphin
(Source: IUCN)



Distribution of Threatened Mammals in Bangladesh

(Source: IUCN)

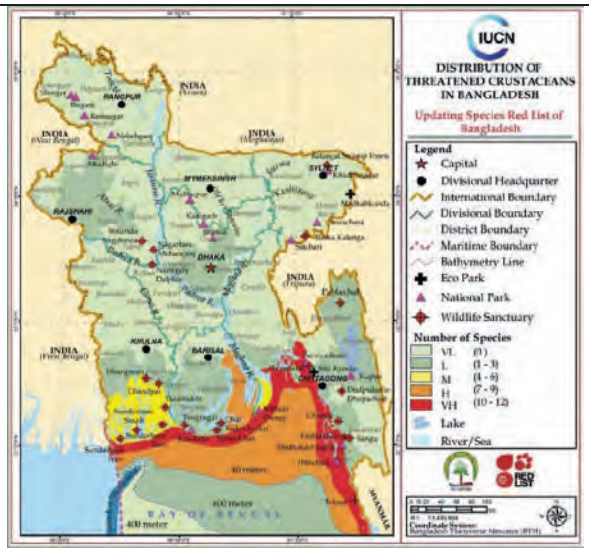


Distribution of Threatened Birds in Bangladesh

(Source: IUCN)

Distribution of Threatened Reptiles in Bangladesh

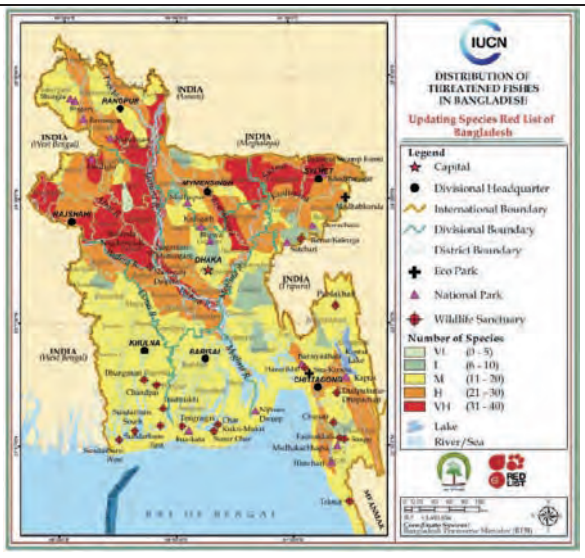
(Source: Red List of Bangladesh, IUCN, 2015)



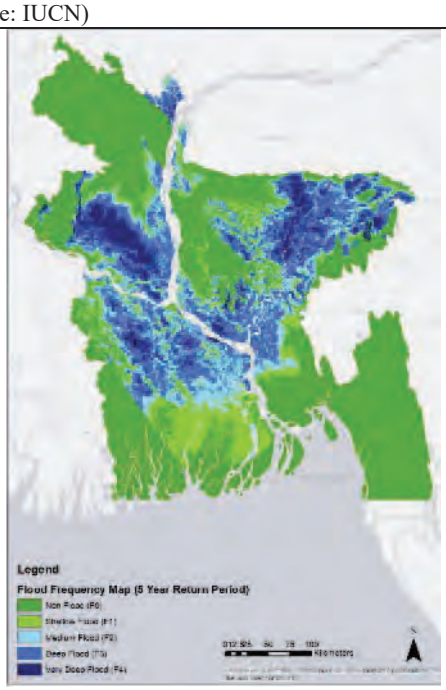
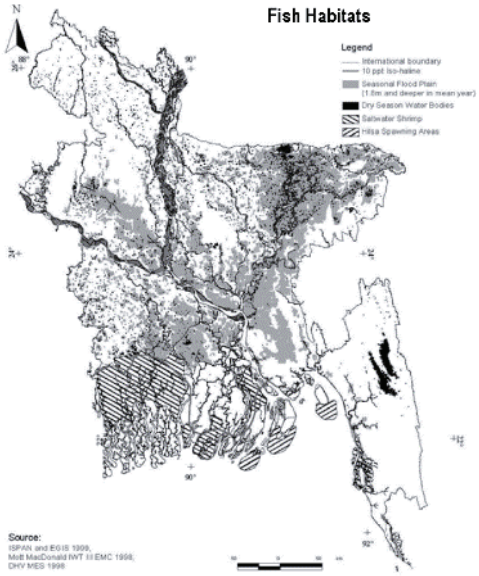
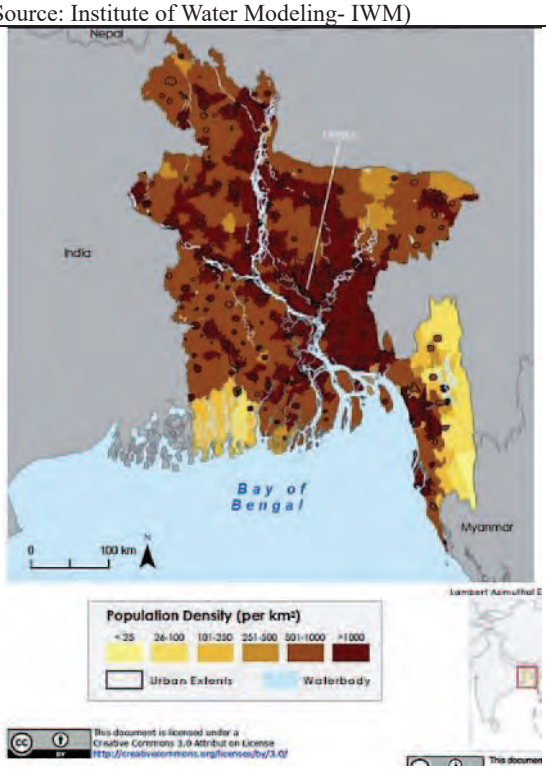
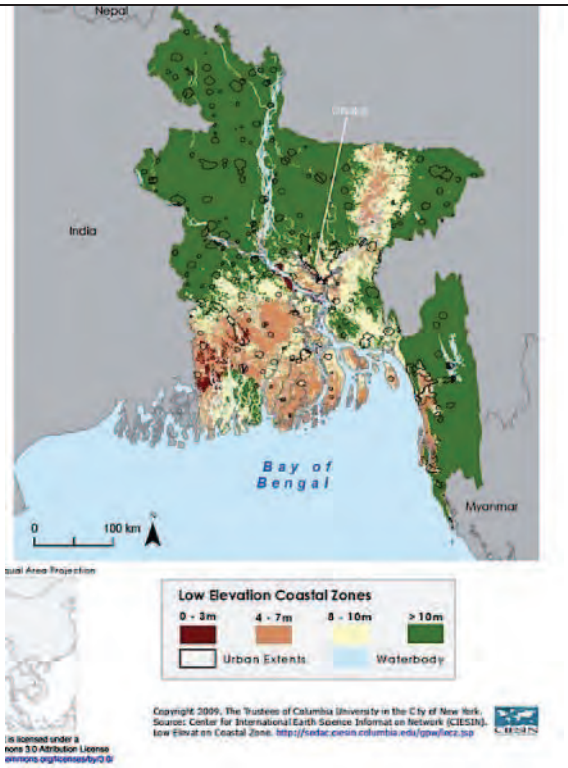
Distribution of threatened Crustaceans in Bangladesh

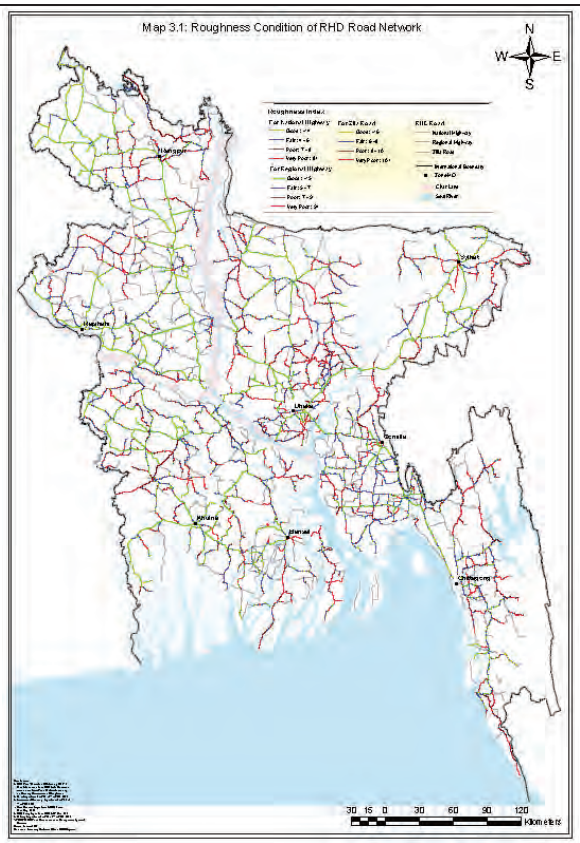
(Source: Red List of Bangladesh, IUCN, 2015)

Distribution of Threatened Amphibians in

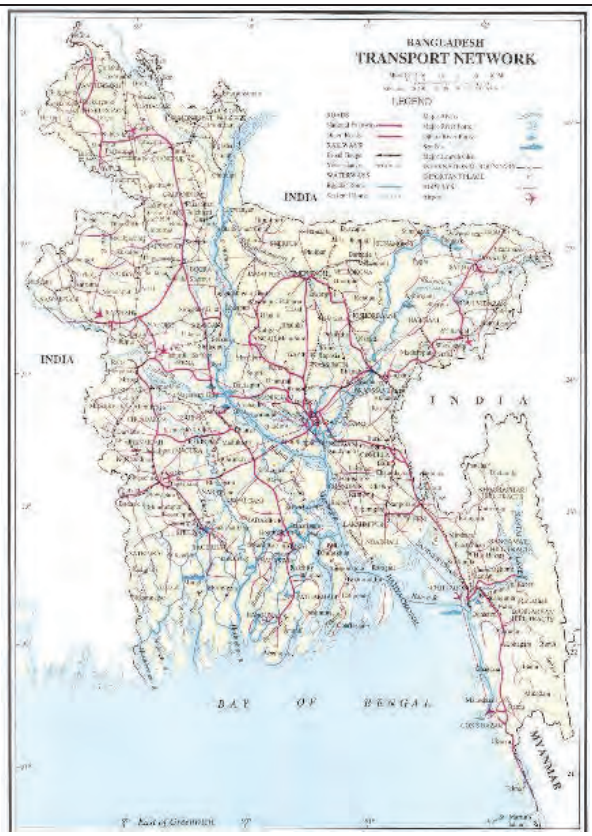


Local Distribution Ranges of Threatened Freshwater

Bangladesh (Source: IUCN)	Fishes of Bangladesh (Source: Red List of Bangladesh, IUCN, 2015)
 Flood Frequency Map- 05 Year Return Period (Source: Institute of Water Modeling- IWM)	 Fish Habitat (Source: NWMP 2001)
 Population Density (Source: BBS)	 Low Elevation Area (Source: SOB)



Roughness Condition of RHD Road Network (Road Master Plan)
(Source: Roads and Highways Department)



Transport Network
(Source: Ministry of Road Transport and Bridges)

Figure 4.1.3 Examples of Baseline Data

4.2 Institutional Set up by Environmental and Social Issues

Regulated areas, planned areas and baseline special data listed above are prepared and managed by various Ministries, Authorities, and other organizations. Ideally one organization covers one item for Regulation, Baseline and Planning. The following table shows organizations and covered issues.

Table 4.2.1 Organizations Managing Special Data by Items

Item	Ministry	Commission, Board, Department, Authority	Council, Unit, Cell	Regula-tion	Baseline	Plan
Ambient Air	Ministry of Environment and Forest (MOEF)	Department of Environment (DOE)	Dhaka South City Corporation (DSCC), Dhaka North City Corporation (DNCC), Dhaka Transport Coordination Authority (DTCA)	R1	M1	P1
Emission	Ministry of Environment and Forest (MOEF)	Department of Environment (DOE)	DoE collect the emission information of 8 major cities (Dhaka, Narayangonj, Gazipur, Chittagong, rajshahi, Khulna, Barisal and Sylhet)	R2, R3	-	P2

Item	Ministry	Commission, Board, Department, Authority	Council, Unit, Cell	Regula-tion	Baseline	Plan
Water quality	Ministry of Environment and Forest (MOEF)	Department of Environment (DOE)	Monitoring cell of Department of Environment	R4	M7	-
Protected areas	Ministry of Environment and Forest (MOEF)	Forest Department (FD)	District level Forest Office	R10, R11, R12	-	P9, P10
Coastal and Wetland Biodiversity	Ministry of Environment and Forest (MOEF)	Department of Environment (DOE)	District level Department of Environment	-	-	P11
Biodiversity and Wildlife	Ministry of Environment and Forest (MOEF)	Forest Department (FD)	District level Forest Office	-	(M28)	P12, P13, P14, P15
Forest	Ministry of Environment and Forest (MOEF)	Forest Department (FD)	District level Forest Office	-	M27	-
Climate change	Ministry of Defense (MOD)	Bangladesh Meteorological Department (BMD)	Cell for Climate Change Research and Impact Study (CRAIST)	-	M22	-
Topography, land use	Ministry of Defense (MOD)	Survey of Bangladesh	Land Record and Survey Department (DLRS)	-	M25	-
River morphology and sediment transportation, Ocean and Coast Drought	Ministry of Defense (MOD)	-	Water Resources Division of SPARRSO	-	M13, M14, M15, M16	-
Crop	Ministry of Defense (MOD)	-	Water Resources Division of SPARRSO	-	M36	-
Flood	Ministry of Defense (MOD)	-	INSTITUTE OF WATER MODELLING (IWM)	-	M23	-
Flood	Ministry of Disaster Management and Relief	Disaster Management Directorate	Flood Forecasting and warning Center (FFWC) Disaster Management Bureau (DMB)	-	M23	-
Flood	Ministry of Water Resources	Bangladesh Water Development Board (BWDB) Joint Rivers Commission, Bangladesh	Flood Forecasting & Warning Centre (FFWC) INSTITUTE OF WATER MODELLING (IWM)	-	M11	P16
Disaster	Ministry of Disaster Management and Relief	Disaster Management Directorate	Disaster Management Bureau (DMB)	-	(M40)	P4
Irrigation	Ministry of Agriculture	Department of Agricultural	Bangladesh Agricultural Research	R7, R8	M19	P6

Item	Ministry	Commission, Board, Department, Authority	Council, Unit, Cell	Regula-tion	Baseline	Plan
		Extension (DAE)	Council (BARC) Bangladesh Agricultural Development Corporation (BADC) Barind Multipurpose Development Authority			
Climate change	Ministry of Agriculture	Department of Agricultural Extension (DAE)	Bangladesh Agricultural Research Council (BARC)	-	M24	-
Salinity	Ministry of Agriculture	Department of Agricultural Extension (DAE)	Bangladesh Agricultural Research Council (BARC)	-	M10	-
Soil	Ministry of Agriculture	Department of Agricultural Extension (DAE)	Bangladesh Agricultural Research Council (BARC)	-	M26	-
Crop	Ministry of Agriculture	Department of Agricultural Extension (DAE)	Bangladesh Agricultural Research Council (BARC)		M37, M38	-
Poverty	Ministry of Food	Food Directorate	Food Planning and Monitoring Unit (FPMU),	-	M33	P20
Indigenous people	Ministry of Chittagong Hill Tracts Affairs	-	-	-	-	-
Culture	Ministry of Cultural Affairs	-	-	R18	-	-
Industry	Ministry of Industries (Bangladesh)	Bangladesh Export Processing Zones Authority (BEPZA)	-	R17	-	P23
Fisheries	Ministry of Fisheries and Livestock	Department of Fisheries	Bangladesh Fisheries Research Institute	-	(M39)	P8
Gas, Coal, other Minerals	Ministry of Power, Energy and Mineral Resources	Energy and Mineral Resources Division	-	-	-	P18
Electricity	Ministry of Power, Energy and Mineral Resources	Power Division	-	-	M46	P19
Road, bridges	Ministry of Road Transport and Bridges	Road Transport and Highways Division Bridges Division Roads and Highways Department Bangladesh Road Transport Authority (BRTA)	-	-	M41, M42	P17
Railways	Ministry of	-	-	-	(M44)	-

Item	Ministry	Commission, Board, Department, Authority	Council, Unit, Cell	Regula-tion	Baseline	Plan
	Railways					
Population, Poverty, Indigenous people	Ministry of Planning	Planning Division, Statistics and Informatics Division, Implementation Monitoring & Evaluation Division	Bangladesh Bureau of Statistics	-	M32	-
Telecommunication	Ministry of Posts, Telecommunications and Information Technology	Bangladesh Telecommunication Regulatory Commission (BTRC) Information and Communication Technology Division	-	-	-	-
Water transport	Ministry of Shipping	Bangladesh Inland Water Transport Authority (BIWTA)	-	R8, R15	-	-
River Bank Coastal Zone	Ministry of Shipping	Bangladesh Inland Water Transport Authority (BIWTA)	-	R16	-	P24
Sea water environment	Ministry of Shipping	-	National Oceanographic & Maritime Institute (NOAMI)	-	M21	-
Water rights, surface water quality, underground water quality	Ministry of Water Resources	Department of Bangladesh Haor and Wetland Development Bangladesh Water Development Board (BWDB)	Water Resource Planning Organization (WARPO) National Water Resources Council (NWRC) Center for Environment and Geographic Information Services	R5	M8, M9	P3
Water supply	Ministry of Water Resources	Department of Public Health Engineering Dhaka Water Supply & Sewerage Authority (DWASA)	Paurashavas and Municipalities	R6	M45	P5, P7
Waste	Ministry of Local Government, Rural Development and Co-operatives	Local Government Division	Local Government Engineering Department Paurashavas and Municipalities	-	-	(P21)
Land use	Ministry of Local Government, Rural Development and Co-operatives	Local Government Division	RAJUK and UDD	R13, R14	-	-
Land registration	Ministry of Land	Land Record and Survey Department	-	-	M35	-

Source: Prepared by JST

4.3 EIA and SEA System

4.3.1 EIA System

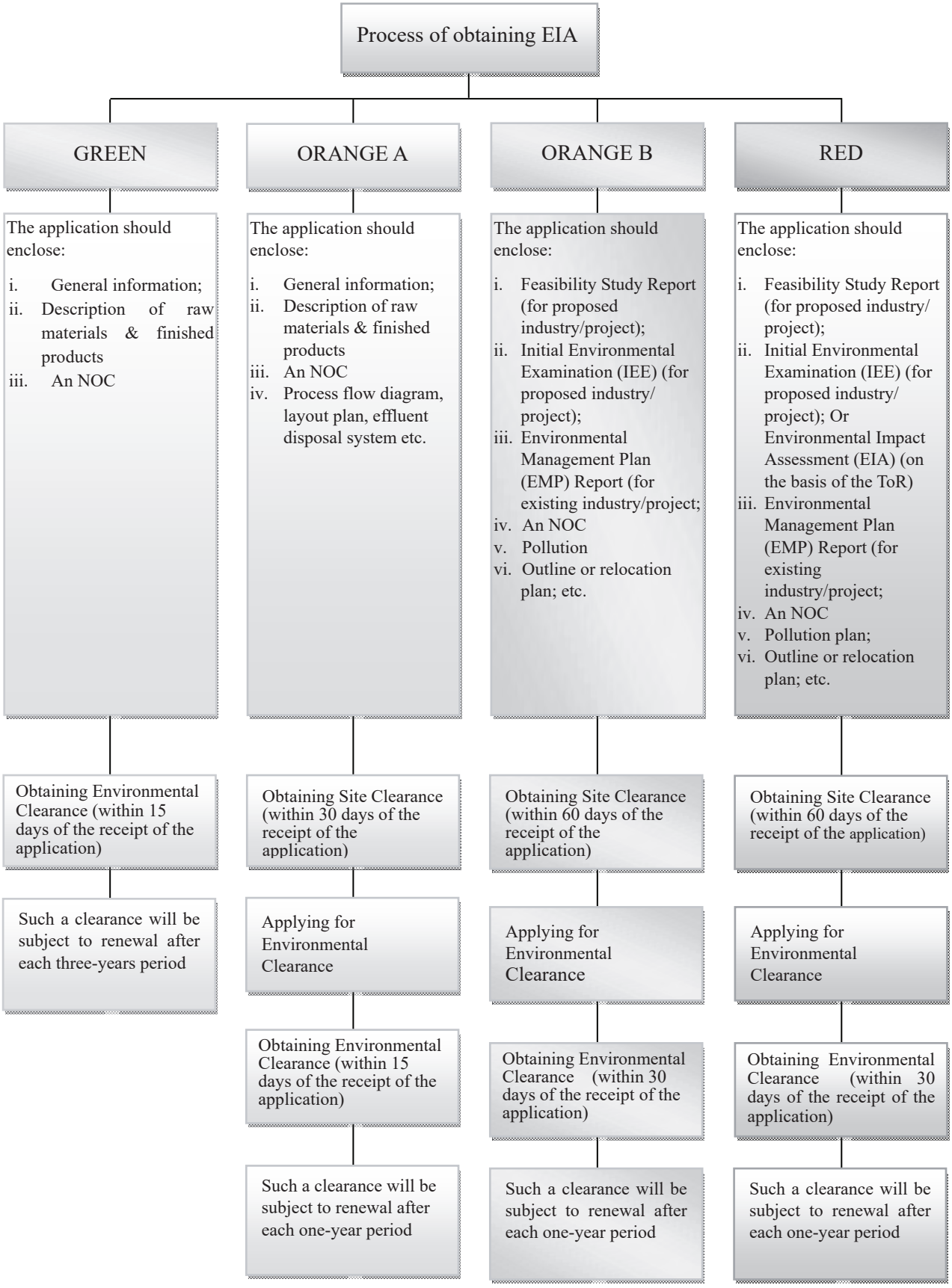
According to the ECA 1995, the proponent of a proposed development project must need to obtain an Environmental Clearance Certificate from the Director General of the Department of Environment (DoE) in the manner prescribed by the Rules. DoE under the Ministry of Environment and Forest (MoEF) is the agency responsible for environmental planning, management and monitoring. The DoE has prepared EIA guidelines for industries on the requirement of the legislation.

Environmental clearance has to be obtained in two steps: first site clearance and thereafter environmental clearance. Environmental Clearance Certificate is issued to all existing and proposed industrial units and projects falling in the Green category, but it is required to obtain a Site Clearance Certificate for industrial units and projects falling in the Orange – A, Orange – B and Red categories, and then the Environmental Clearance Certificate will be issued. According to the categorization, projects fall under the 'Red' category necessitates a full-scale EIA.

The Environmental Clearance Certificate requires submission of the following documents along with the application:

- Feasibility Report for the Project (where applicable)
- Environmental Impact Assessment (EIA) Report
- Environmental Management Plan (EMP)
- No Objection Certificate from relevant Local Authority (where applicable)
- Other necessary information, (where applicable)

Process to be followed for obtaining Environmental Clearance Certificate (ECC) from DOE is outlined in the following Figure.



Source: DOE

Figure 4.3.1 Procedure of Environmental Clearance Certificate (ECC)

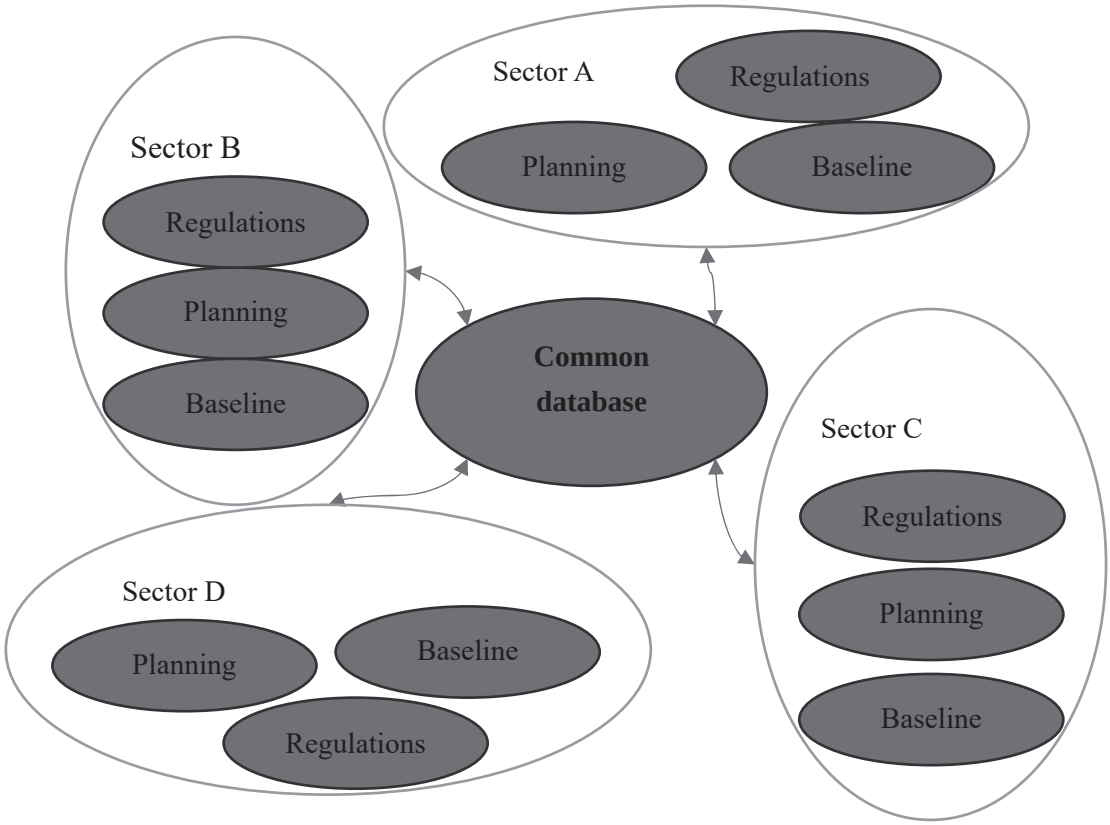
4.3.2 SEA System

There is no SEA system stipulated in Bangladesh.

4.4 Opportunities of Spatial Database for Environment

There are various special data in Bangladesh described in Figure 4.4.1. If these spatial data are stored in one common database and shared mutually among organizations, various benefit would be expected for sustainable development. Image of the common database would be:

- Data control centre and organization should be identified,
- Data format should be common type,
- Uploading and downloading procedures and rules should be prepared,
- Backup and safety system should be established,
- Access security levels should be set by data,
- Interface and access should be simple and easily designed,
- Maintenance cost should be lowered,
- Feasible for IT innovation,
- General data should be opened to public,
- Checking system of data reliability is required, and
- The organization only manage exact data and should not add any intentions.



Source: Prepared by JST

Figure 4.4.1 Image of the Common Database

The benefit of integrated common database would be:

- Data management cost would be lowered,
- Development can avoid some conflicts with other sectors,
- Data security is easily controlled,
- Data reliability will be secured,
- Nation-wide cross sector analysis will be easier,
- Foundation of spatial trend analysis can be prepared, and
- Future development simulation by various scenarios could be possible.

In addition to that if integrated decision-making system is established based on the common database, the policy of Strategic Environmental Assessment or Sustainable Assessment could be naturally combined and no need to establish new system. Off-set mitigation can be combined for planning approval and environmental actions could be accelerated by development planning.

4.5 Environmental Issues about the Proposed Sub-sea Gas Pipeline

For the future gas pipeline network to accommodate LNG injection, JST proposes 1,700 mmcfd capacity Sub-sea Pipeline from Moheshkari to West Padoma, as explained in later Chapter 6. Environmental scoping is conducted for the sub-sea pipeline

It is not cleared that the exact planned route but some kinds of environmental and social matters should be considered in some project stages.

(1) Scoping

Scoping is conducted following the items of JICA guideline. Items should be concerned during route selection stage are examined ferreting Possibility, Time, Area, Intensity and Recoverability. Selected items area Biota and ecosystems, Accidents, Involuntary resettlement, Local economies, Land use and utilization of local resources, Social institutions, Existing social infrastructures and services, Poor, indigenous, or ethnic people, and Cultural heritage.

Table 4.5.1 Scoping Table

Items	Impact	Possibility	Time	Area	Intensity	Recoverability	Considering in route selection
Air pollution	Emission from construction	High	Temporary (Construction)	Along the line	Low	Difficult	No
Water pollution	Chemical additives of hydrostatic Testing (corrosion inhibitors, oxygen scavengers, biocides, and dyes) may cause water	Middle	When failure (Operation)	Along the line	High	Difficult	No

Items	Impact	Possibility	Time	Area	Intensity	Recoverability	Considering in route selection
	pollution.						
	Spills by leaks, equipment failure, accidents, or human error	Low-Middle	When failure (Operation)	Along the line	Middle to Very high	Difficult	No
Soil pollution	Spills by leaks, equipment failure, accidents, or human error	Middle	When failure (Operation)	Line of on sure part	Middle to Very high	Difficult	No
Waste	Construction waste	High	Temporary (Construction)	Land part and terminal	Low	Easy	No
Noise/ vibrations	Construction machine, vehicle, blasting	High	Temporary (Construction)	Along the line	High	Difficult	No
Ground subsidence	-	-	-	-	-	-	-
Offensive odors	-	-	-	-	-	-	-
Geographical features	Deformation of coastal geomorphology	High	Long term (Operation)	Near the landing points	Low	Easy	No
	Flooding risk	Low	Long term (Operation)	Line of on sure part	Low	Easy	No
Biota and ecosystems	Project might impact on ECA, KBA, and UNESCO Marine Reserve directly and indirectly	High	Long term (Operation)	Around landing point and access roads	High	Difficult	Yes
	Ganges River Dolphin (Platanista gangetica) and other fishes might be affected.	High	Long term (Construction - Operation)	River crossing points	Middle	Easy	Yes
Water usage	Water use by Hydrostatic Testing	High	On and off for Long term (Construction - Operation)	Pigging stations	Low	Easy	No
Accidents	Contact or hit by fish net, anchoring, or dropped objects by ships may damage the pipe.	Low	Long term (Operation)	Along the line	High	Middle	Yes
Global warming	Spills by leaks, equipment failure, accidents, or human error	Low	Long term (Operation)	Along the line	High	Difficult	No
Involuntary resettlement	Houses in the ROW must be resettled	High	Permanently	Along the line of on sure part	High	Easy	Yes
Local economies, such as employment,	Pipeline construction might prevent fishery	High	Long term (Construction - Operation)	Along the line of off shore part	High	Easy	Yes

Items	Impact	Possibility	Time	Area	Intensity	Recoverability	Considering in route selection
livelihood, etc.	activities.						
Land use and utilization of local resources	Forestry and Agricultural activities will be affected in the ROW.	High	Long term (Construction - Operation)	Along the line of on sure part	High	Easy	Yes
	Land in the pipeline corridor will be acquired.	High	Permanently	ROW of on sure part	High	Easy	Yes
Social institutions such as social infrastructure and local decision-making institutions	Village forest, village community might be divided.	High	Long term (Construction - Operation)	ROW of on sure part	Low to middle	Difficult	Yes
Existing social infrastructures and services	Maritime traffic might be constrained during construction.	High	Long term (Construction - Operation)	Along the line of off shore part	High	Difficult	Yes
	Community road might be divided.	High	Long term (Construction - Operation)	Along the line of on shore part	High	Difficult	Yes
Poor, indigenous, or ethnic people	Poor people might be affected	High	Long term (Construction - Operation)	Along the line of on shore part	High	Easy	Yes
Misdistribution of benefits and damages	Affected people might not get enough direct benefit	High	Long term (Construction - Operation)	Along the line of on shore part	Middle-High	Easy	No
Local conflicts of interest	It might happen depend on the compensation.	Middle	Long term (Construction - Operation)	Along the line of on shore part	Low - Middle	Easy	No
Limitation of accessibility to information, meetings, etc. on a specific person or group	It might happen depend on the ways of communication.	Middle	Temporary (Construction)	Along the line of on shore part	Low - Middle	Easy	No
Gender	It might happen depend on the compensation.	Middle	Temporary (Construction)	Along the line of on shore part	Low - Middle	Easy	No
Children's rights	It might happen during construction.	Low	Temporary (Construction)	Along the line of on shore part	Low - Middle	Easy	No
Cultural heritage	Cultural heritage might be damaged.	Low	Permanently	Along the line of on shore part	High	Difficult	Yes
Infectious diseases such as HIV/AIDS	It might happen during construction.	Low	Temporary (Construction)	Along the line of on shore part	Low - Middle	Easy	No
Other	unknown	-	-	-	-	-	-

Source: Prepared by JST

(2) Basic examination in route selection stage

All the relevant regulations, policies and baselines described above should be reviewed in detail during route selection stage. Planned have to visit all the relevant authorities and confirm the updated information.

(3) Scoped items and survey plan in route selection stage

In order to avoid natural or social conflicts or troubles, careful designing based on brief site survey is recommended. The items shown in the following table are selected by preliminary scoping in above. In terms of the protected areas, one ECA locates in the project site. The project is also in the KBA areas. The IUCN red list species should be considered are some fishes and river dolphin.

Table 4.5.2 Recommended Survey Items on Route Selection Stage

Scoped items	Survey methods	Expected output	Consideration to design/plan
Biota and ecosystems	Hearing survey and literature survey: Identify the boundary of the ECA, Hearing survey and site survey: Identify the important terrestrial and subsea vegetation including coral reef and mangrove Site survey: Identify the habitat of the river dolphin	ECA boundary map (scale 1: 5,000) Vegetation map Detail dolphin habitat and distribution map	Select the design which will not impact on ecosystem and protected species
Accidents, existing social infrastructures and services	Hearing survey: identify the river boat route and sea channels	Boat and ship route map	Avoid the main boat or ship route.
Involuntary resettlement	Site survey and satellite image examination	Housing maps	Select the minimum resettlement route.
Local economies	Hearing survey: Identify the major economic activities on shore and off shore	Economic activity map	Select the plan of less impact route and design.
Land use and utilization of local resources	Satellite image examination and site survey	Land use map	Select the plan of less impact route and design.
Social institutions	Literature survey and site survey: Identify the village boundaries and center of the villages	Village center and boundary map	Select the plan of less dividing villages.
Poor, indigenous, or ethnic people	Site survey: Identify whether poverty communities or refugee camps exists or not.	Poverty village, refugee camps location map	Select the plan of less impact one.
Cultural heritage	Site survey and literature survey: Identify the locations of the cultural assets including local worship places.	Cultural asset and heritage map	Select the design which will not impact on cultural assets

Source: Prepared by JST

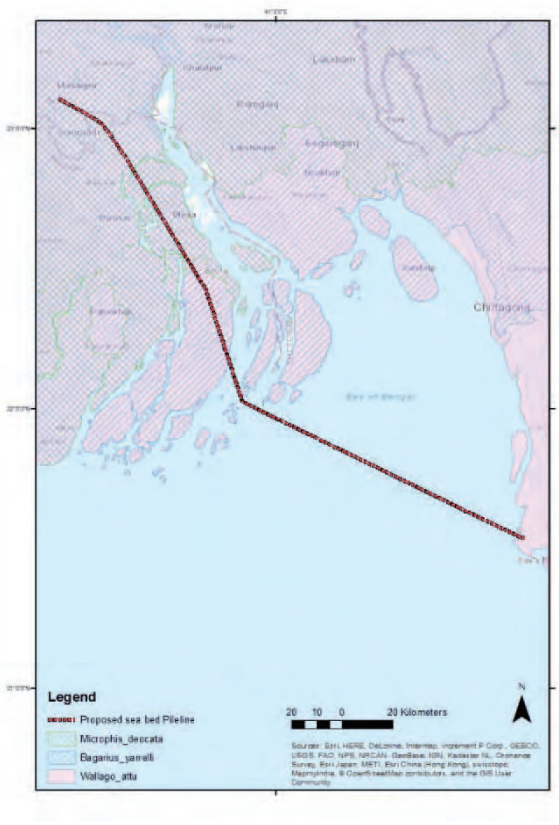
Preliminary pipeline routes are shown on maps with social and environmental information, such as domestic protected areas, international protected areas, habitat of protected fish and river dolphin, school locations, poverty areas, tourism resource locations, and land use, as in the figures below.

Domestic Protected Areas

(Source: DOF)

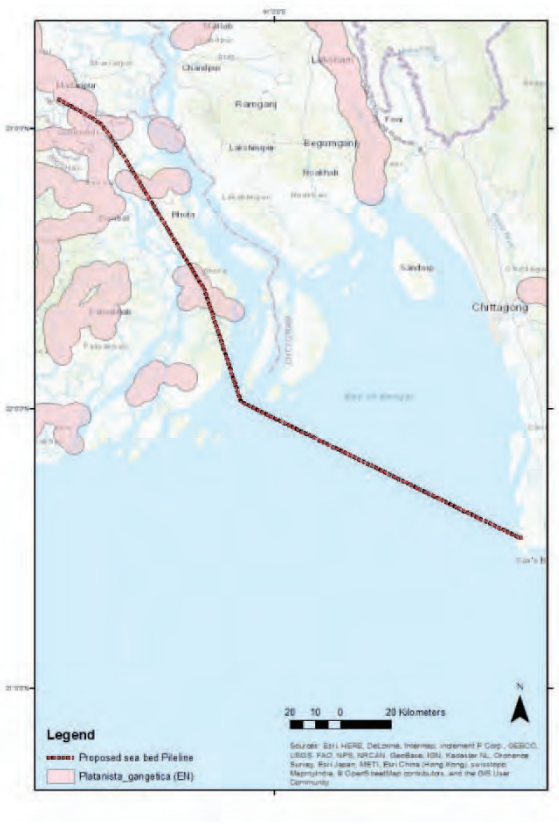
International Protected Areas

(Source: WDPA)



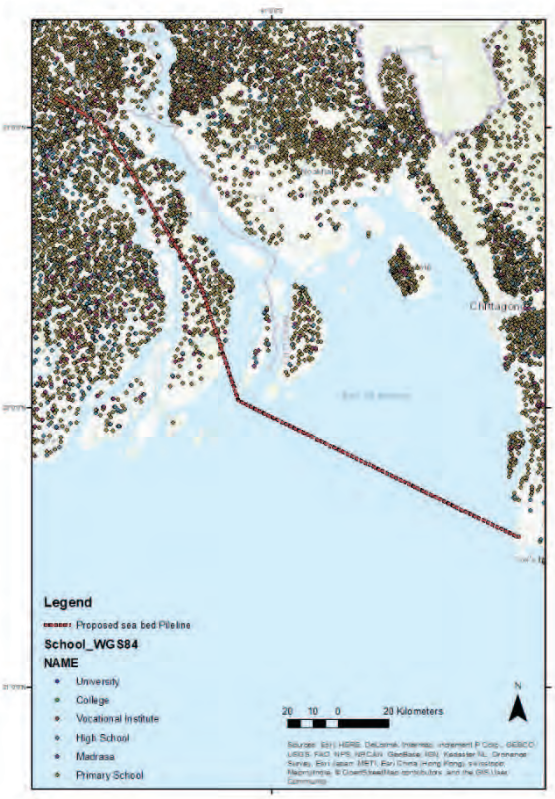
Habitat of Protected Fish

(Source: IUCN)



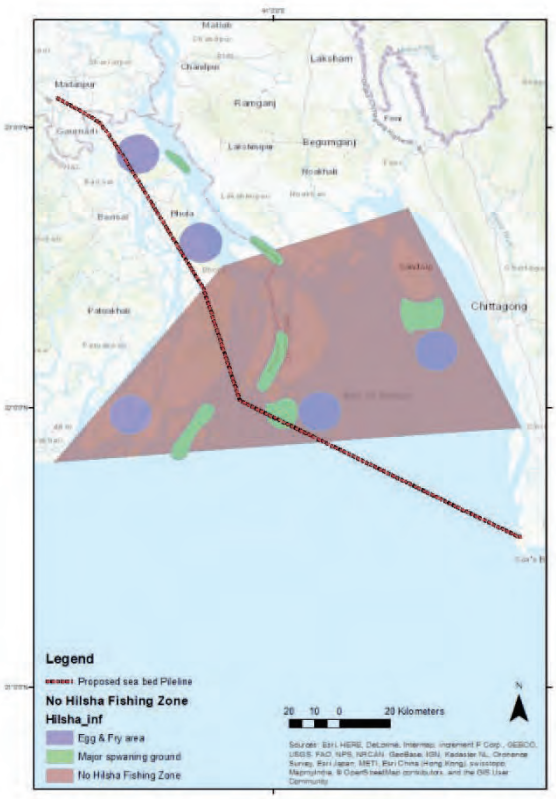
Habitat of River Dolphin

(Source: IUCN)



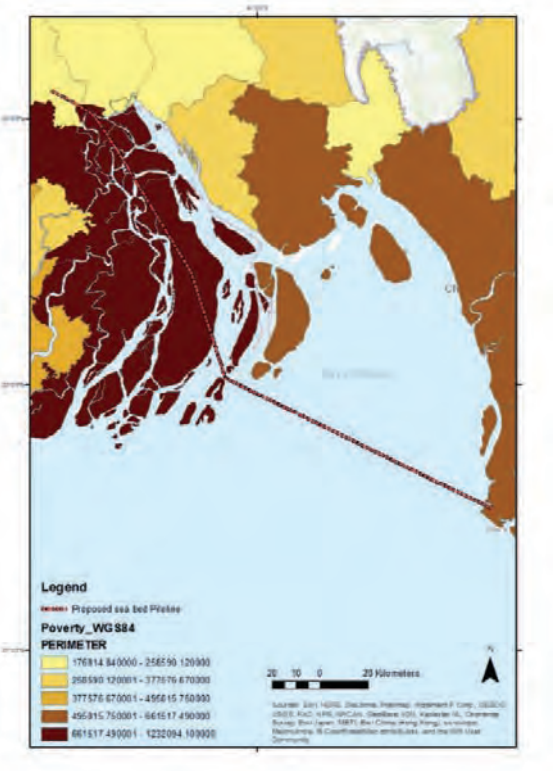
Location of Schools

(Source: SOB)



No Hilsha Fishing Zones

(Source: Ministry of Fisheries and Livestock)

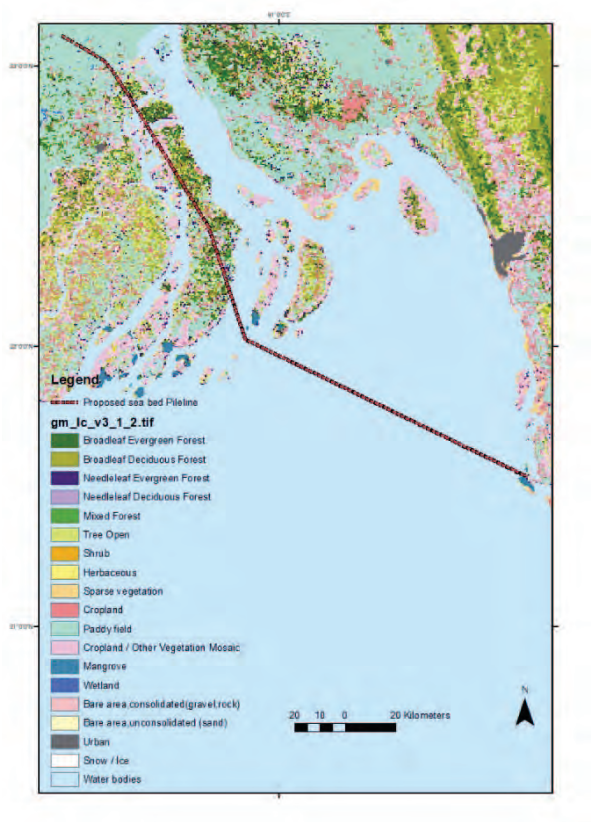


Poverty Map

(Source: Bangladesh Bureau of Statistics)

Tourism Resource Map

(Source: SOB)



Land Use Map
(Source: Globcover 2009)

Figure 4.5.1 Environment Maps and Proposed Sub-sea Pipeline

(4) Project design stage

During the design stage, the following issues should be considered.

- Minimize the acoustic impact on the underwater wildlife such as dolphins
- Minimize the destruction of the coastal vegetation
- Off-set the coastal vegetation
- Early discussion with the local residence and revise the design
- Early discussion with the fishermen and revise the design
- Simulate the worst case including disaster and accidents and estimate the damage

(5) EIA process of gas pipeline project

Project types of EIA categories are listed in the Annex-I of Industrial Categories under Environmental Conservation Rules, 1997. Although gas pipeline is not listed in Annex-I, it will be fallen in red category, since “Water, power and gas distribution line laying/ relaying/ extension” is listed in red category.

According to the “A Guide to Environmental Clearance Procedure (DOE, 2010), the documents should be submitted to DOE are as follows.

i. Report on the feasibility study of the project
ii. Following report (1) or (2)
(1) Report on the Initial Environmental Examination (IEE) relating to the project, and the terms of reference (ToR) for the Environmental Impact Assessment (EIA) of the project and its Process Flow Diagram;
(2) Environmental Impact Assessment (EIA) report prepared on the basis of ToR previously approved by the Department of Environment, along with the Layout Plan (showing location of pipeline facility), Process Flow Diagram, design and time schedule of the pipeline facility of the project
iii. Report on the Environmental Management Plan (EMP) for the industrial unit or project, and also the Process Flow Diagram, Layout Plan (showing location of the pipeline facility).
iv. No objection certificate (Prescribed Form) of the local authority
v. Emergency plan relating adverse environmental impact and plan for mitigation of the effect of pollution
vi. Other necessary information

The steps for Environmental Clearance are as follows.

Step 1 : Submit application with supporting documents.

Step 2 : Verification of application and supporting documents by DOE

Step 3 : Inspection by the authorized officer after verification of all report and documents.

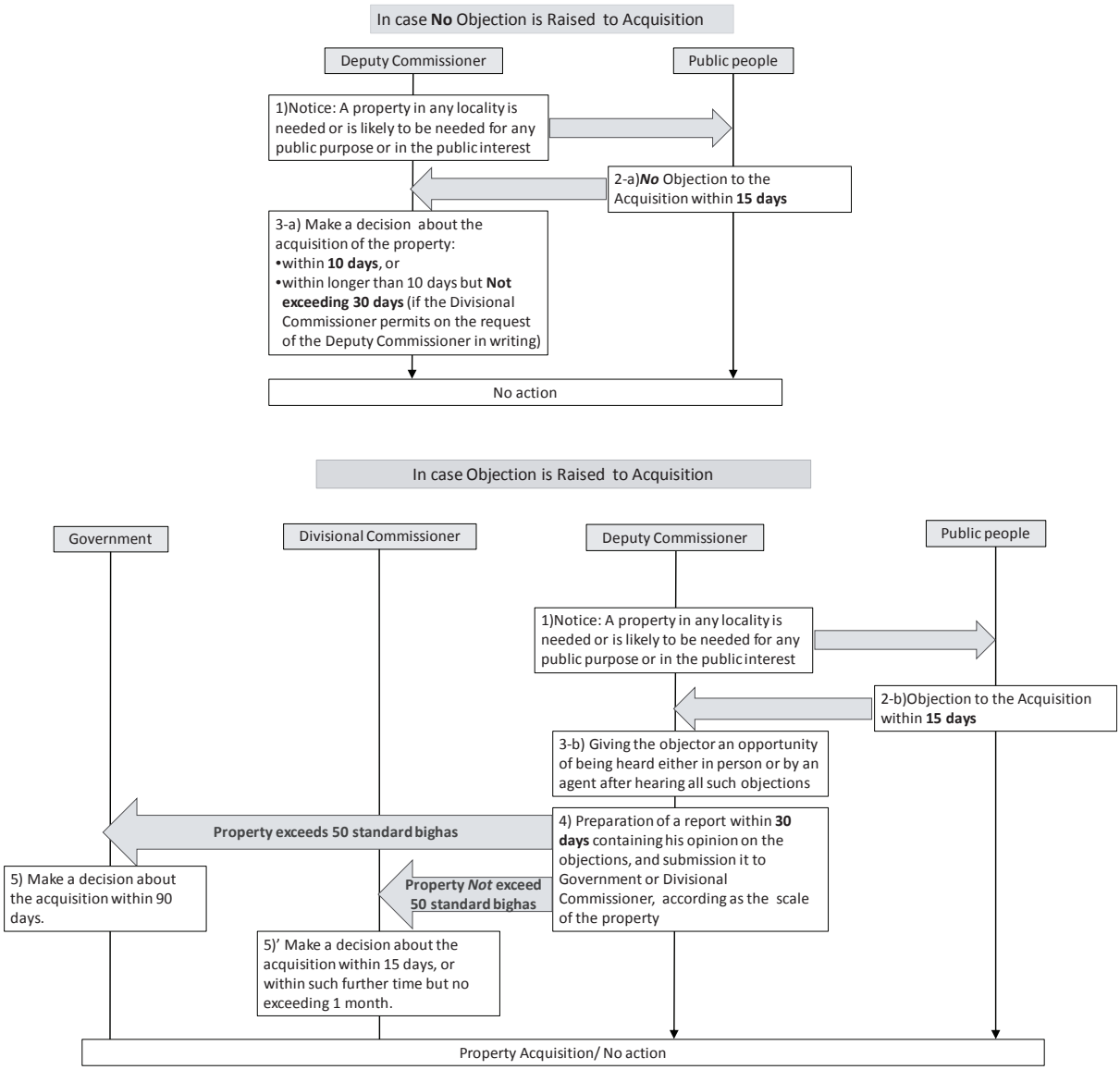
Step 4 : Meeting of Environmental Clearance Committee

Step 5 : Decision

After submission all the required documents, 60 days are required for obtaining Site Clearance. After that, 30 days are required for obtaining Environmental Clearance.

(6) Land acquisition

The land acquisition process in Bangladesh could be referred from the Acquisition and Requisition of Immovable Property Ordinance, 1982. To decide whether the acquisition of the property would be conducted or not, the following process is initially conducted.

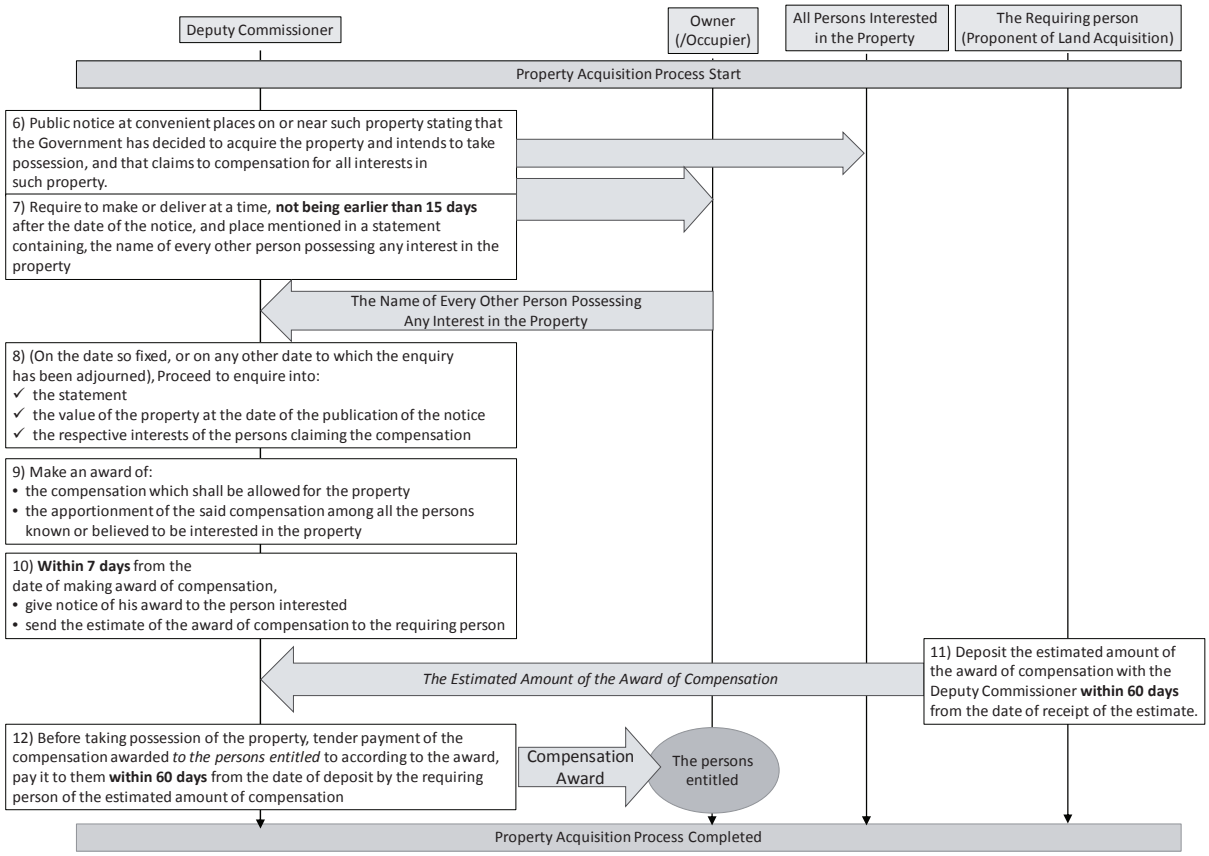


* Bighas (Bigha) is a traditional unit of measurement of area of land. In Bangladesh, it is converted to International System of Units, traditionaly; 1 bigha= 1,337.8 m^2(in British custom, 1 bigha= 14,400 square feet).

Source: Prepared by JST, referring to The Acquisition and Requisition of Immovable Property Ordinance, 1982

Figure 4.5.2 Process before the Acquisition of the Property

In case the government, the Divisional commissioner or the Deputy Commissioner makes the decision to start the acquisition of the concerned property, the following process is started.



Source: Prepared by JST, referring to The Acquisition and Requisition of Immovable Property Ordinance, 1982

Figure 4.5.3 The Acquisition Process of the Property

To determine the award of compensation, matters in the following table are considered.

Table 4.5.3 Matters to be considered/ not to be considered in Determining Stage

Matters to be considered in determining compensation
• the market value of the property at the date of publication of the notice (In determining such market value, the Deputy Commissioner shall take into account the average value of the properties of similar description and with similar advantages in the vicinity during the twelve months preceding the date of publication of the notice) • the damage that may be sustained by the person interested, by reason of the taking of any standing crops or trees which may be on the property at the time of taking possession thereof by the Deputy Commissioner • the damage that may be sustained by the person interested, at the time of taking possession of the property by the Deputy Commissioner, by reason of severing such property from his other property • the damage that may be sustained by the person interested, at the time of taking possession of the property by the Deputy Commissioner, by reason of the acquisition injuriously affecting his other properties, movable or immovable, in any other manner, or his earnings • if in consequence of the acquisition of the property, the person interested is likely to be compelled to change his residence or place of business, the reasonable expenses, if any, incidental to such change • the damage that may be resulting from diminution of the profits of the property between the date of service of notice and the date of taking possession of the property by the Deputy Commissioner
Matters *NOT* to be considered in determining compensation
• the degree of urgency which has led to the acquisition • any disinclination of the person interested to part with the property to be acquired • any damage that may be sustained by him which, if caused by a private person, would not render such person liable to a suit • any damage which is likely to be caused to the property to be acquired, after the date of service of notice to person interested or in consequence of the use to which it will be put

- any increase to the value of the property to be acquired likely to accrue from the use to which it will be put when acquired
- any alteration or improvement in, or disposal of, the property to be acquired, made or effected without the sanction of the Deputy Commissioner after the date of publication of the notice

Source: Prepared by JST, referring to The Acquisition and Requisition of Immovable Property Ordinance, 1982

The draft of Immovable Property Lease and Acquisition Act 2017, the update of this ordinance, had been approved in April 2017. The updated law has proposed an increase in the compensation, and expected to enter in force soon.

CHAPTER 5 DEMONSTRATION OF INTEGRATED GAS AND POWER STRATEGIC PLAN

This chapter presents the demonstration of Network Infrastructure Management System with gas and power data in Bangladesh, using "Smallworld" software. It illustrates the feature of Smallworld and data model. The chapter visualizes the pilot area modeling in Smallworld with asset data and mapping of gas pipeline and power transmission line network. Preliminary integrated gas and power network system was incorporated in the demonstration. Utilization of other systems such as GIS was also illustrated. Then, the recommendation for improvement in the next stage was made.

5.1 Software Features

5.1.1 The Features of Smallworld

Smallworld is an asset management system with GIS function. The advantages of Smallworld compared with other general GIS or database management systems are summarized as follows:

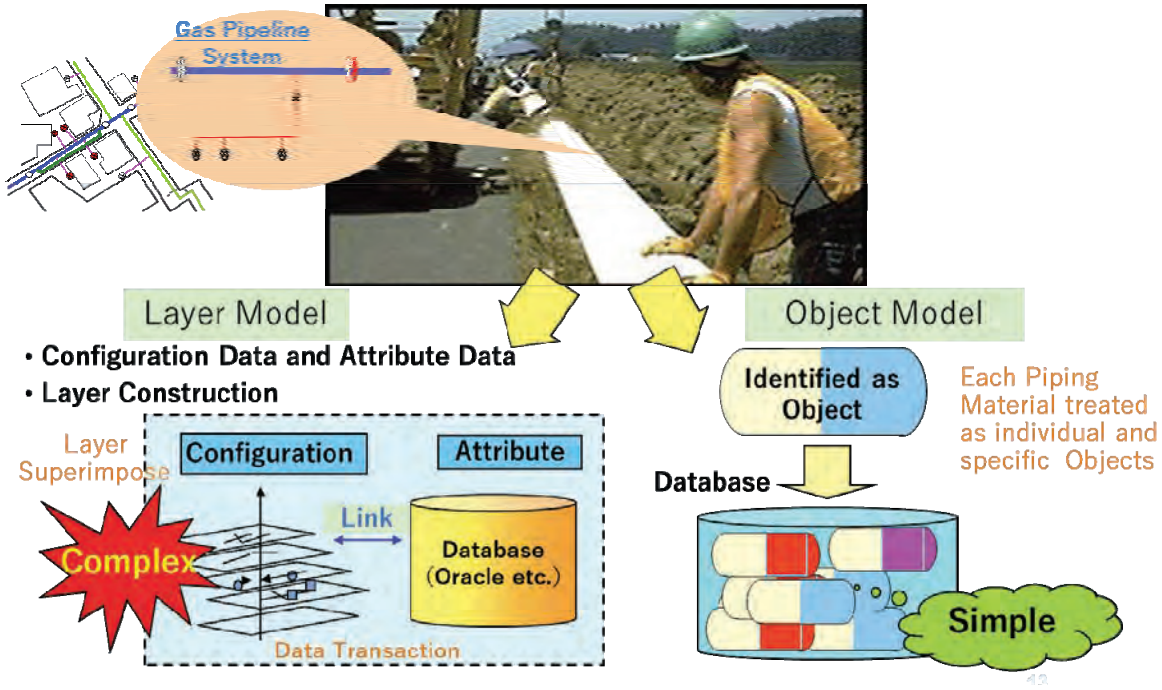
- "Object Model" oriented system
- Large scale and high-accuracy specialized database
- Utilization as an information platform

(1) The advantage of the Object Model in Smallworld

Smallworld adopts "Object Model". The Object Model has a specific structure which is different from general GIS which adopts a layer model.

In a layer model applied in general GIS, annotation information and location information are placed in different layers. Text information may be stored in different database. Information related to one "thing" is dispersed differently in a system. As a result, the system and data structure tends to be complicated.

Meanwhile, Smallworld encapsulates text attributes and geometric attributes such as annotation or location information into one object. A "thing" in the real world is related one-to-one to an Object in the Smallworld system. As a result, the system and data structure is simplified.



Source: Prepared by JST

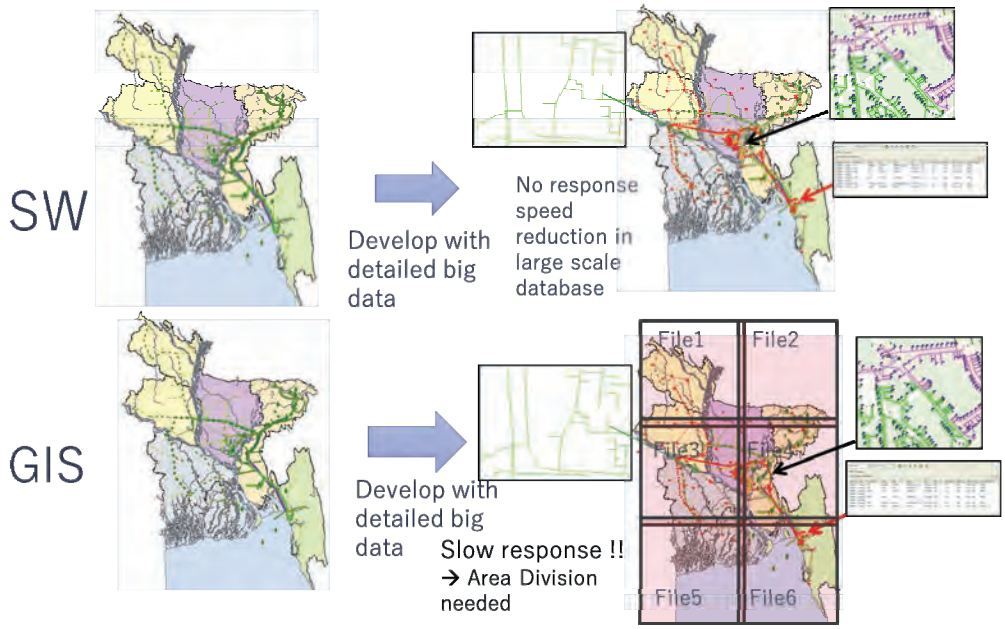
Figure 5.1.1 Layer Model and Object Model

(2) Large scale, high-accuracy specialized database

In general GIS, a significant performance reduction tends to occur when large scale data is handled in one file. Accordingly, it should divide the database into several files, for example, region-wise, and it needs to switch among the different files as necessary. In addition, a performance problem easily occurs under the environment in which many concurrent users access to one data at the same time.

In contrast to above, Smallworld specialized database system can store very large number of facility data, more than a million number of data, in one unified database file. Furthermore, Smallworld can keep high performance without speed reduction under the environment that many concurrent users access to one database at the same time.

Smallworld provides large scale coordinates in the virtual area with 40,000 km width (virtual distance that can be managed in Smallworld system) with 1cm accuracy. It can place objects with various levels of location information, from gas pipelines to each customer's meter, on the coordinate space. Even if the number of each object exceeds over a million, speed or performance problems will not occur. It can manage all assets information of whole Bangladesh network infrastructure in one unified system.

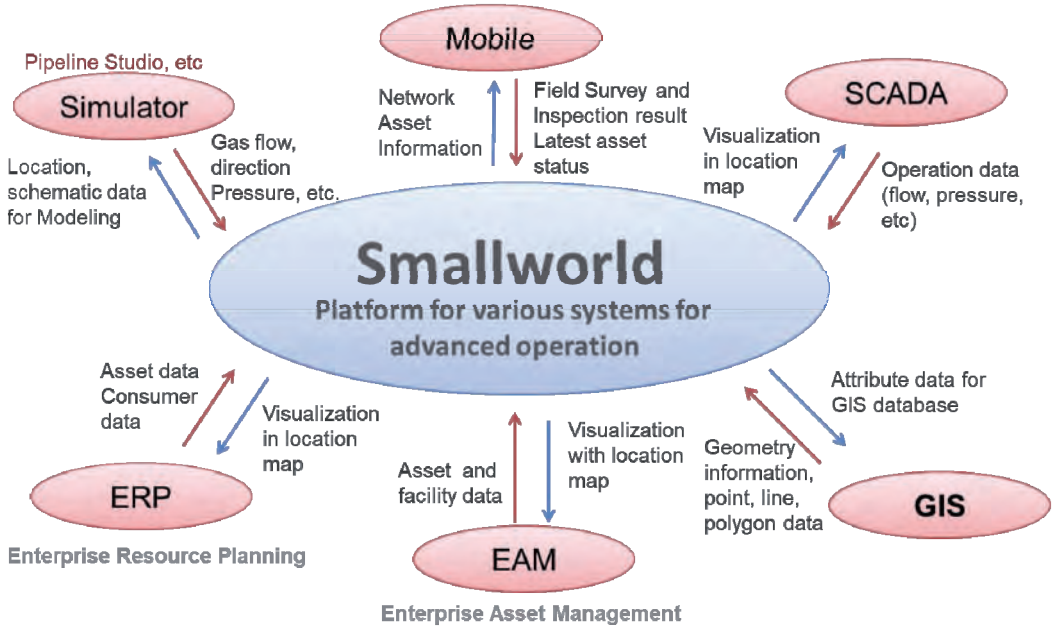


Source: Prepared by JST

Figure 5.1.2 Smallworld Database Performance

(3) Smallworld's role as the information platform

Smallworld has a highly flexible specialized development programming language (Magik) and a developing API (Application Programming Interface). By them, it can easily customize the system to meet requirements for collaboration with other systems. Accordingly, Smallworld can act as an information platform which exchanges and shares data between various systems such as SCADA, simulators, etc.



Source: Prepared by JST

Figure 5.1.3 Smallworld as the Information Platform

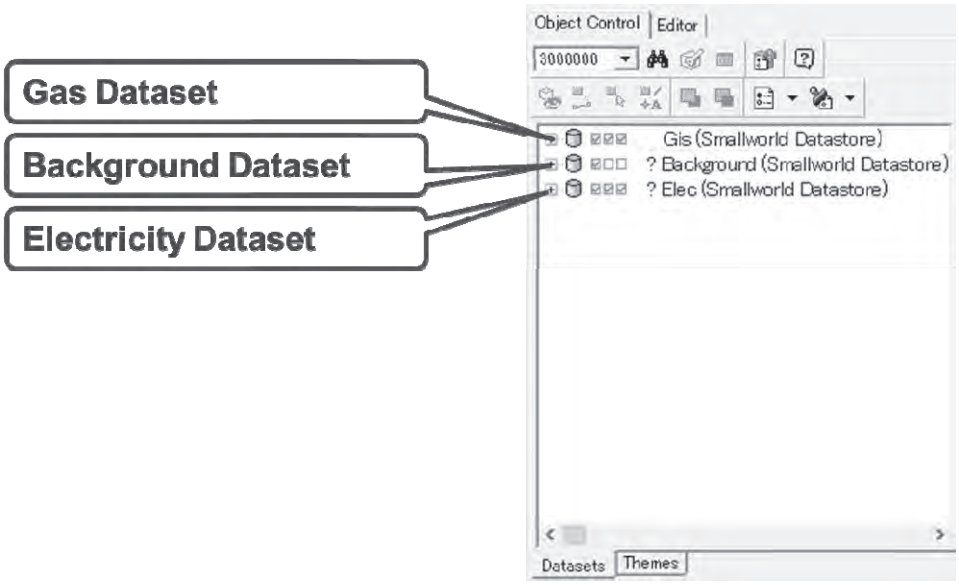
As the example with the demo system structure of this Project, the features of Smallworld function is explained as follows:

- Dataset and version management,
- Object, physical fields and geometry fields,
- Geometry and manifold,
- Network trace,
- Geometry and world,
- Data model definition, and
- Configuration of display and style.

The terminology of Smallworld is shown in Section 5.1.9.

5.1.2 Dataset and Version Management of Smallworld

When several and large-scale infrastructures are handled compositely on Smallworld, we usually create physically separated databases for each infrastructure. Such database is called "Dataset". The demo system in this Project has three datasets, namely, gas, electricity, and background.



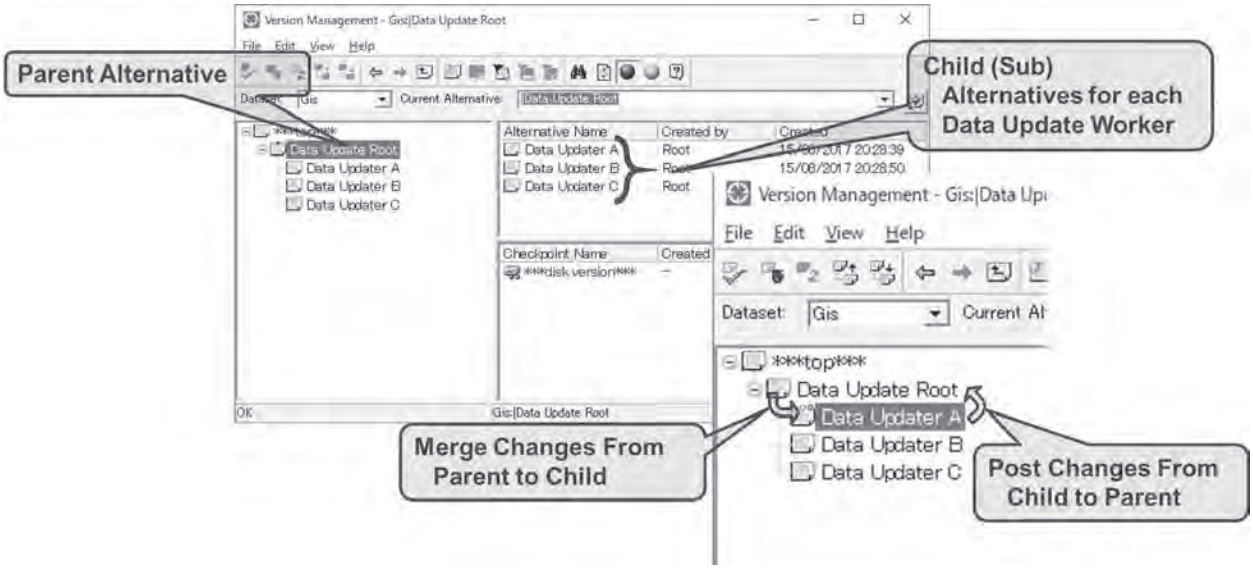
Source: Prepared by JST using Smallworld GUI (graphical user interface)

Figure 5.1.4 Example of Datasets

Smallworld uses "Version Management" function for each dataset. Version Management is the function of updating with maintaining revised record and edited items at each step.

Editors can create several versions concurrently in each dataset. We call such versions "Alternatives". Alternative has a parent-child relationship. It can do a “Merge” operation, which reflects changes from

Parent Alternative to Child Alternative. It can also do a "Post" operation which reflects changes from Child Alternative to Parent Alternative.



Source: Prepared by JST using Smallworld GUI

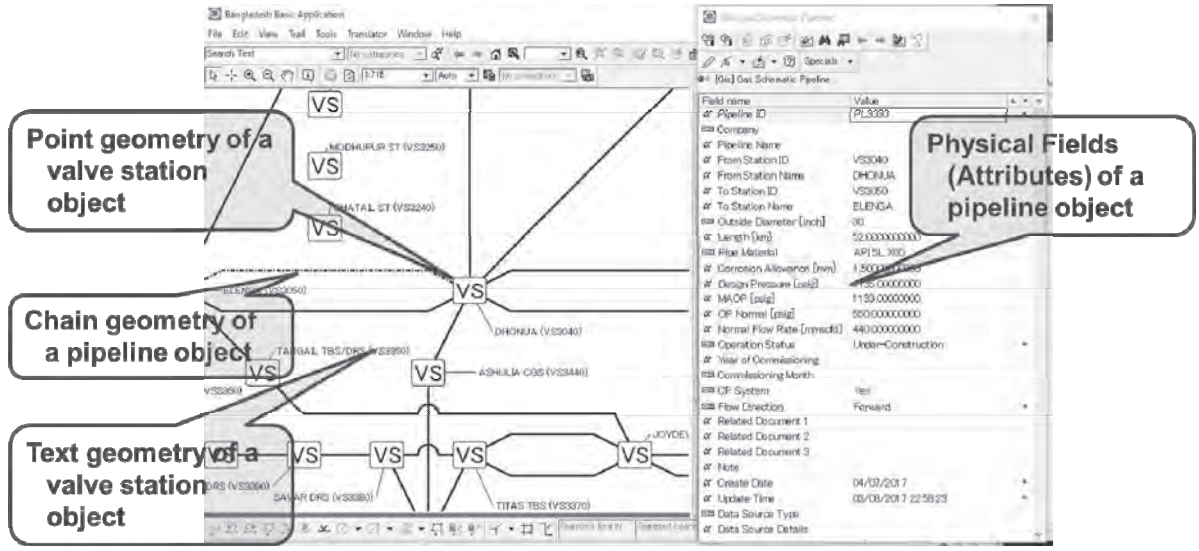
Figure 5.1.5 Version Management on a Dataset

5.1.3 Object, Physical Fields and Geometry Fields

Smallworld manages a "thing" (asset, equipment, machinery etc.) in the real world by a unit called "Object". An Object has physical fields and geometry fields.

Physical fields have a "Type". A Type defines what the data it is. "Type" identifies data if it is string, integer, real number, or date and time, etc. It represents type of features and specifications of each object. The details of physical fields is described in Section 5.3.1.

"Geometry" is the information represents location and shape of each object on the map. They have the Type of area, chain, point, and text (annotation) etc.



Source: Prepared by JST

Figure 5.1.6 Object, Physical Fields and Geometries

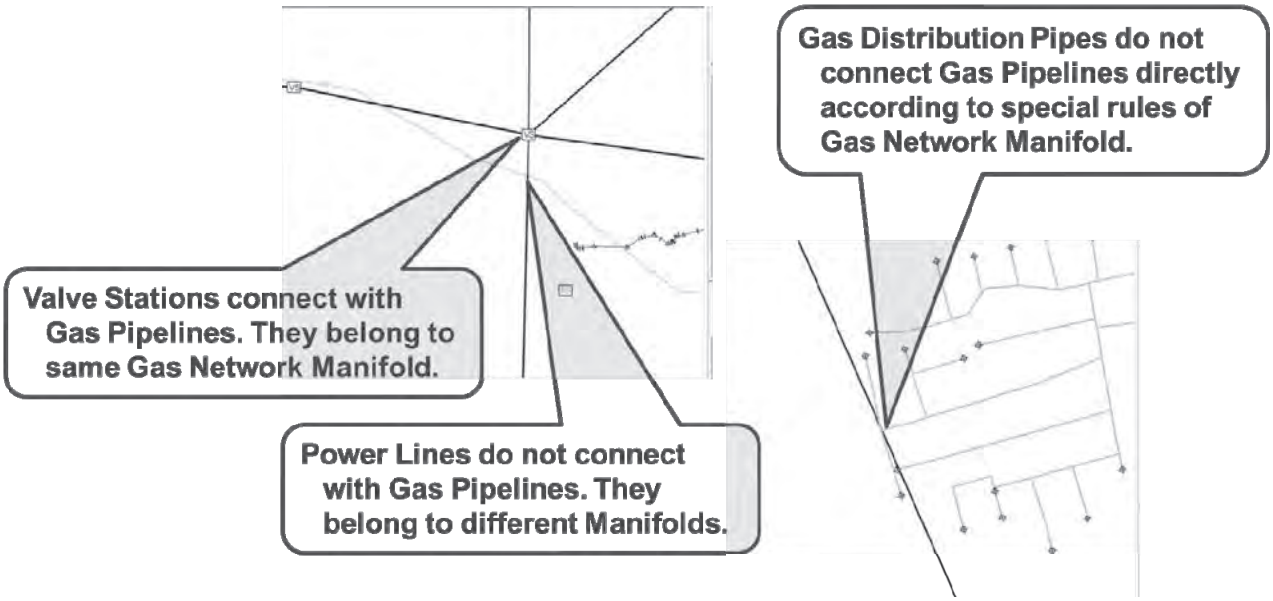
5.1.4 Geometry and Manifold

"Manifold" means a network group to which a geometry belongs. A geometry (information of location and shape) belongs to a group called "Manifold".

Geometries belonging to the same manifold are connected each other automatically if their coordinates are exactly at the same location. (For example, end of gas pipe segments connect each other etc.)

Geometries belonging to different manifolds are not connected even if their coordinates are same. (For example, a gas pipe and a power line don't connect each other.)

We can designate exceptional rules explicitly even if they belong to the same manifold, for example, (i) an abandoned pipeline does not connect to other existing pipelines, and (ii) a service pipe does not connect to pipelines directly, etc.



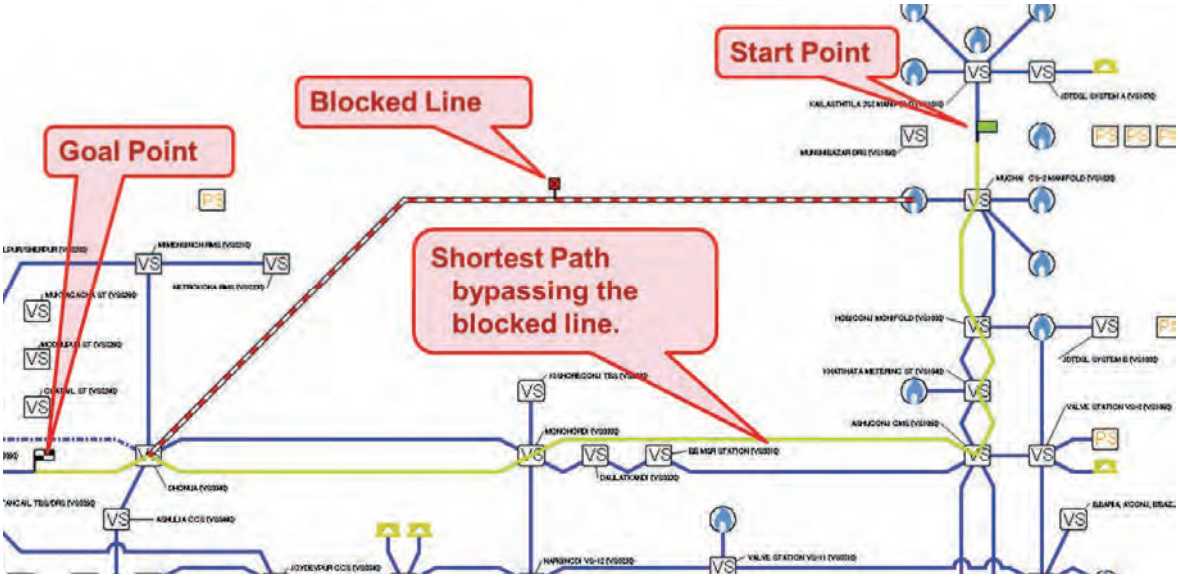
Source: Prepared by JST

Figure 5.1.7 Geometries and Manifold Rules

5.1.5 Network Trace

"Network trace" is a function that chases facilities connected each other. Smallworld has the network trace function. We can blockade a facility at which a failure occurs, and we can also find a detour route bypassing the blockaded facility. The following figure shows a simplest example of a shortest path search.

When connections between facilities are constructed in the demo system, the network trace will be enabled from the most upstream to the most downstream (i.e., from gas field to each customer's meter).



Source: Prepared by JST

Figure 5.1.8 Network Trace Functionality

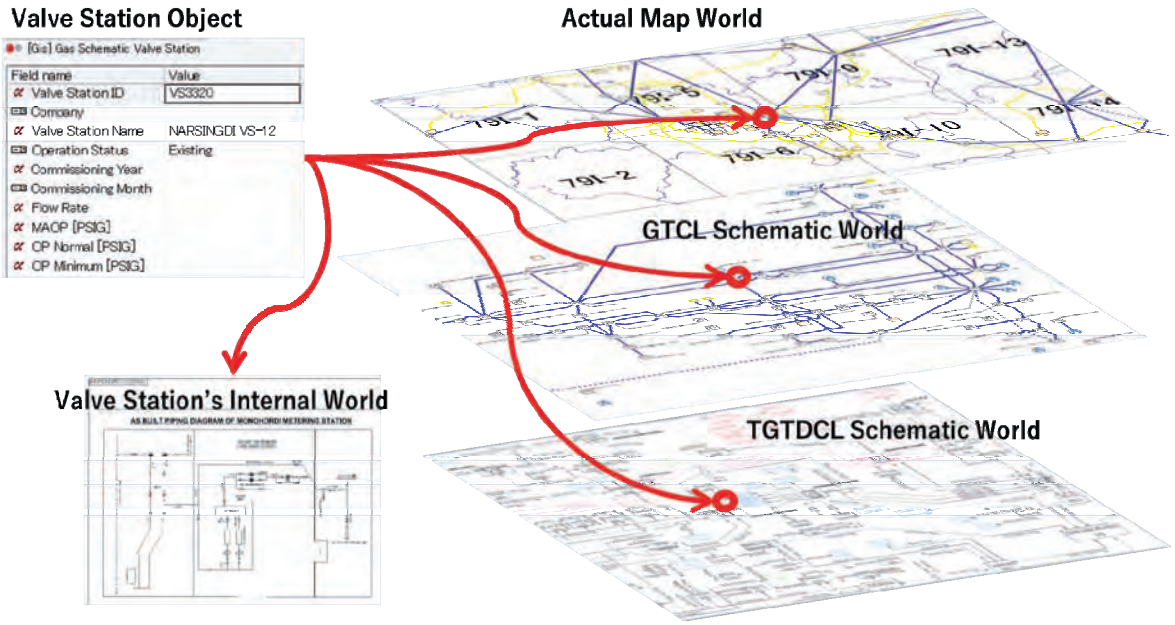
5.1.6 Geometry and "World"

A "World" means a coordinate space in Smallworld system. Smallworld can have several Words with different coordinate space. Smallworld can define a coordinate system, a minimum unit of length, and an area that geometries can be allocated, in each "World" separately.

All geometries belong to a "World". An object can exist across several different "Worlds" by having several geometries belonging to different "Worlds".

For example, gas valve station objects can have two different geometries, (i) a geometry represents an actual coordinate on a map and (ii) a geometry represents a location on a schematic diagram of the gas network. As a result, we can relate locations of the same gas valve station, which exists in different two "Worlds": logical schematic space and an actual map space.

A gas valve station can also have another detailed coordinate space called an "Internal world". This represents an internal structure of facility inside its own building.



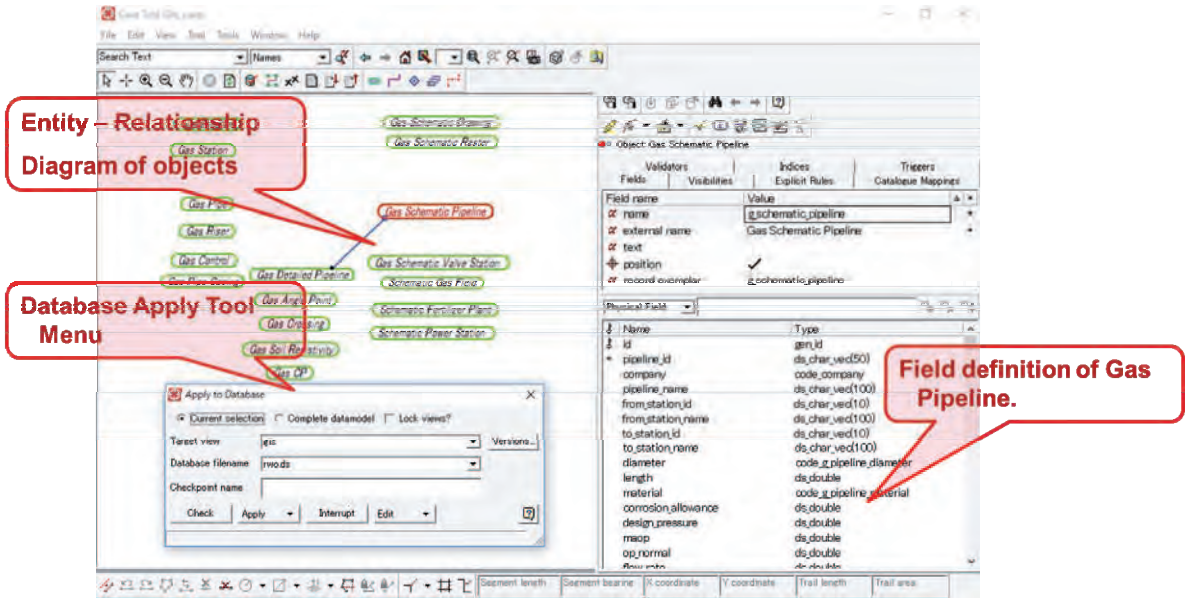
Source: Prepared by JST

Figure 5.1.9 Single Object with multiple Geometries and different "Worlds"

5.1.7 Data model definition

"Case Tool" is a specific tool by which a system developer creates and stores data models. By using Case tool, we define objects such as a gas valve stations and a gas pipelines, and also define each object's physical fields and geometry fields.

By conducting "Apply" the data model definitions to a dataset, defined contents are reflected to the dataset.

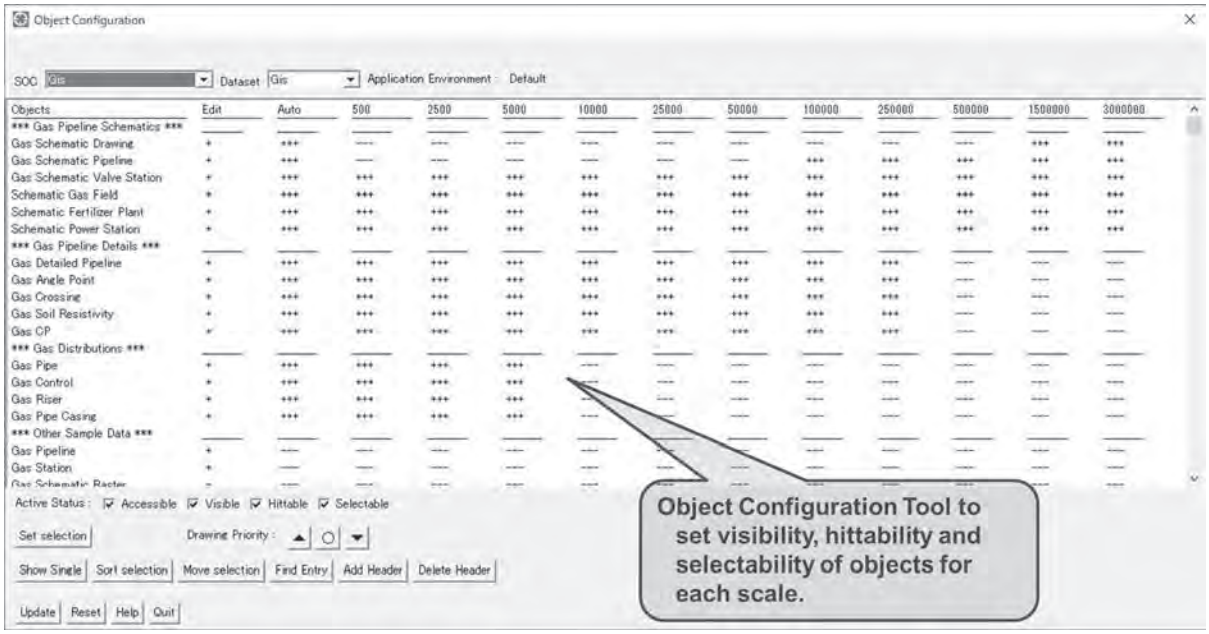


Source: Prepared by JST using Smallworld GUI

Figure 5.1.10 Case Tool for Data Model Definition

5.1.8 Configuration of Visibilities and Styles

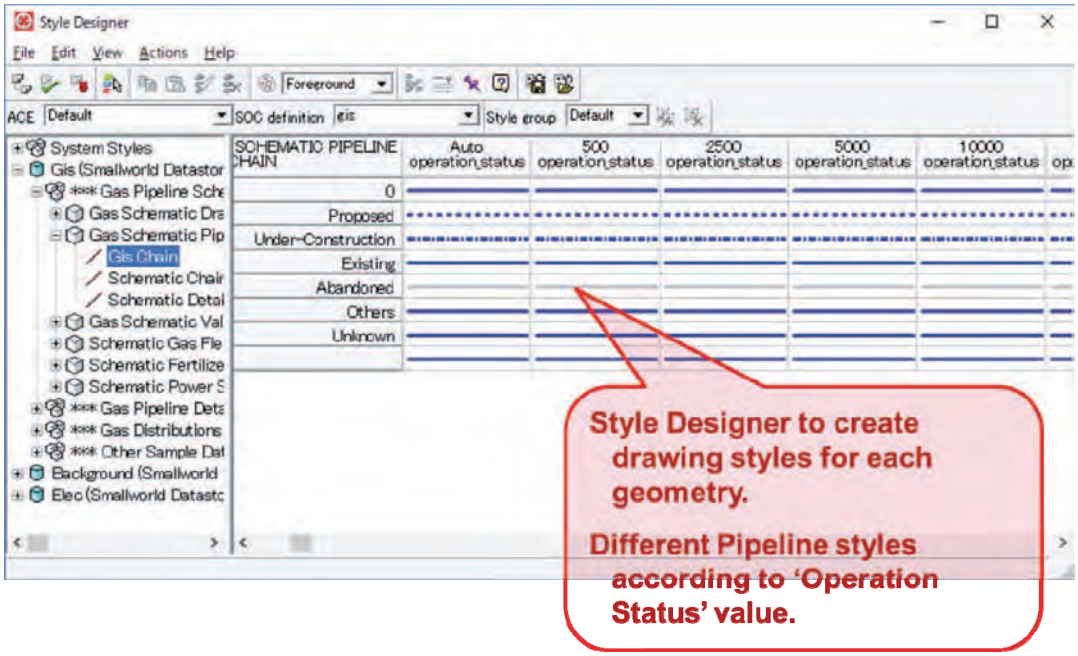
"Object Configuration Tool" is the specific tools that configures each object visible or not, and selectable or not, at various range of scales.



Source: Prepared by JST using Smallworld GUI

Figure 5.1.11 Object Configuration Tool

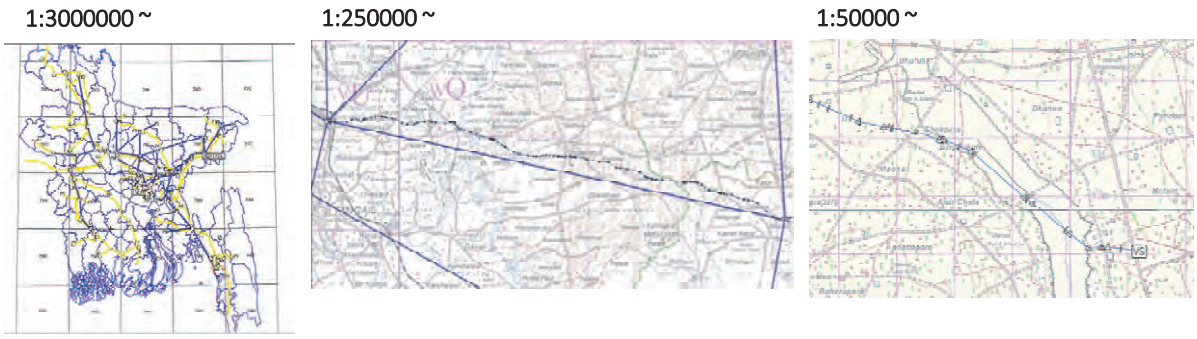
Smallworld also has a specific tool called "Style Designer". This configures shapes and colors of geometries in each scale. By using the tool, we can show geometries in different styles according to their attribute values. (For example, existing pipelines are shown with solid line, and planned pipelines are shown by dash lines)



Source: Prepared by JST using Smallworld GUI

Figure 5.1.12 Style Designer

Smallworld can configure different setting. In a large scale Bangladesh whole country map, only main pipeline geometries are shown which connects between gas valve stations by a straight line. As we zoom in to a larger-scale map, detailed pipeline geometries are shown which have more accurate coordinates, in place of former summarized geometries.



Source: Prepared by JST using survey map of SoB

Figure 5.1.13 Visible Geometries changed from Large Scale to Details According to View Scale

5.1.9 Terminology of Smallworld

There are various specific technical words used in Smallworld. The following table shows the terminology typically used in Smallworld.

Table 5.1.1 Glossary of Smallworld

Term	Description
ACE	ACE is the abbreviation of "Application Configuration Environment". The following various ACE information is stored in the Dataset "ace.ds". - Selecting visible and selectable objects and geometry by each scale - Bookmark information - Database connection information, etc.
Alternative	"Alternative" is a version of a dataset. Alternative has a parent-child relationship. The parent alternative at the top of the hierarchic structure is called a "top alternative". An alternative can have multiple sub (child) alternatives. Only one user can be writable at one certain alternative simultaneously. Meanwhile, other users can access the same alternative only by read-only mode.
Apply	"Apply" of the data model definitions stored in "Case.ds" dataset (refer Case Tool) is conducted to an actual dataset. Then, operation of objects represented by defined data model is enabled. "Apply" also can be conducted to existing objects. In that case, we can add new attributes, update, or delete current existing attributes.
Case Tool	"Case Tool" is a specific tool for defining and storing data models including the following information. Data model definitions are stored in Case.ds dataset. It defines: - What kind of objects exist. - What type of attributes each object has.
Checkpoint	When we make a "Checkpoint" on Alternative, the dataset status becomes "committed". Then, the current status of the dataset is named with a label. After operation, we can recover the status of the dataset to the saved status with the checkpoint name, which is called "Rollback".
Collection	An area where the same kind of objects are stored in dataset is called "Collection" or "Table". Attributes of objects are stored in the Table.
Commit	Saving edited contents in a dataset is called "Commit". When we access a current Alternative with writable mode and when we have "uncommitted" edited information, we can do "Commit".
Conflict	When the same object is edited in both parent and child Alternatives, "Conflict" will occur when "Merge" is performed. At that time, a specific menu window for resolving "Conflict" is shown. Then, we can determine which change on Child Alternative or Parent Alternative is prioritized, or we can discard both changes and recover the status before the edit of each object.
Dataset	Smallworld can manage different infrastructures in one system. It physically builds different databases for each kind of infrastructure (such as gas, power, water, etc.). The respective database is called "Datasets". The "Gis" Dataset is the default dataset and is the most basic dataset. Usually, we store most important infrastructure data in Gis dataset. In our demo system we store the gas infrastructure data in Gis

Term	Description
	dataset. Each “Dataset” is stored in a sub folder of which name is started with “ds_” conventionally. For example, Gis dataset is stored in “ds_gis” sub folder. The databases for administration such as “ace.ds” and “style.ds” are also a kind of datasets. Such datasets are stored in “ds_admin” sub folder conventionally.
Geometry Field	“Geometry Field” is the attributes of shapes of each object. There are several kinds of shapes. For example, “Area” (a polygon shape), “Chain” (a line shape), “Point “(one location) and “text” (annotation), etc.
Image	“Image” is a saved status of a system execution environment with datasets connection that includes Magik source code. By reloading an previous built image, we can recover an execution environment on which we can operate Smallworld.
Magik	“Magik” is a specific programming language for development of Smallword. It has a feature of object oriented programming language which has a concept of class and instance, multiple inheritace etc.
Mandatory Field	“Mandatory Field” is the Attributes which are necessary (cannot be neglected) when creating or updating an object.
Manifold	“Manifold” is a group of network that Geometries belongs to. Geometries belonging to same manifold are connected each other automatically if their coordinates are in the same location. Geometries belonging to different manifolds are not connected even if their coordinates are same. We can also define non-connected Geometries by setting exception rules explicitly, even if they belong to the same manifold.
Merge	“Merge” is an operation which reflects changes from Parent Alternative to Child Alternative. If the same object is changed both in Parent Alternative and Child Alternative, a conflict may be occurred when “Merge” is performed.
Object	“Object” is the information management unit in Smallworld. It corresponds to a thing in the real world (asset, equipment, machinery etc.) one by one. We can operate things as objects by encapsulating text attributes and location information on a map. It may be called “Real World Object” or “RWO” (by taking initial characters of each word) or simply “Record”.
Physical Field	“Physical Field” is a text or numerical attributes of each object. We can allocate different types of Physical Field for each attribute.
Post	“Post” is an operation which reflects changes from Child Alternative to Parent Alternative. A “Merge” is necessary before a post. Accordingly, a conflict does not occur at the timing of “Post”.
Real World Object	Refer to Object.
Record	Refer to Object.
Rollback	“Rollback” is an operation which recovers the Dataset to the last committed status or a specified status by a Checkpoint. The updates of a Dataset may be lost and it may not be possible to recover the latest Dataset status after doing “Rollback”.
Rollforward	“Rollforward” is an operation which updates a Dataset to the latest committed status

Term	Description
	by a user who is accessing to the Alternative with read only mode.
RWO	Refer to Object.
Style	"Style" is the information for representing geometries with various color and shape at various scale view. The information of "Style" is stored in the dataset "Style.ds" .
Table	Refer to "Collection."
Version Management	Each Dataset can have parallel different status of data contents ("Version") at the same time. The management of "Version" of a Dataset is called "Version Management". A dataset concerning version managed is called VMDS ("Version Managed Dataset")
World	"World" is defined to be a coordinate space that Geometries belong to. In Smallworld, we can define multiple different coordinate spaces ("World") in datasets. Geometries belonging to different worlds cannot be shown simultaneously. In addition to the Geographic "World" showing an actual map, Smallworld can define a virtual "World" that represents schematic diagram. In addition, World with details in a building with internal structure of facility is called "Internal World". A different coordinate systems and length units are applicable to each "World".

Source: Prepared by JST

5.2 Pilot Area for Asset Management

5.2.1 Outline Map of Gas Pipeline

The following figure shows approximate pipeline locations and connection information of main gas valve stations and gas fields in Bangladesh country.

Term	Description
	by a user who is accessing to the Alternative with read only mode.
RWO	Refer to Object.
Style	"Style" is the information for representing geometries with various color and shape at various scale view. The information of "Style" is stored in the dataset "Style.ds" .
Table	Refer to "Collection."
Version Management	Each Dataset can have parallel different status of data contents ("Version") at the same time. The management of "Version" of a Dataset is called "Version Management". A dataset concerning version managed is called VMDS ("Version Managed Dataset")
World	"World" is defined to be a coordinate space that Geometries belong to. In Smallworld, we can define multiple different coordinate spaces ("World") in datasets. Geometries belonging to different worlds cannot be shown simultaneously. In addition to the Geographic "World" showing an actual map, Smallworld can define a virtual "World" that represents schematic diagram. In addition, World with details in a building with internal structure of facility is called "Internal World". A different coordinate systems and length units are applicable to each "World".

Source: Prepared by JST

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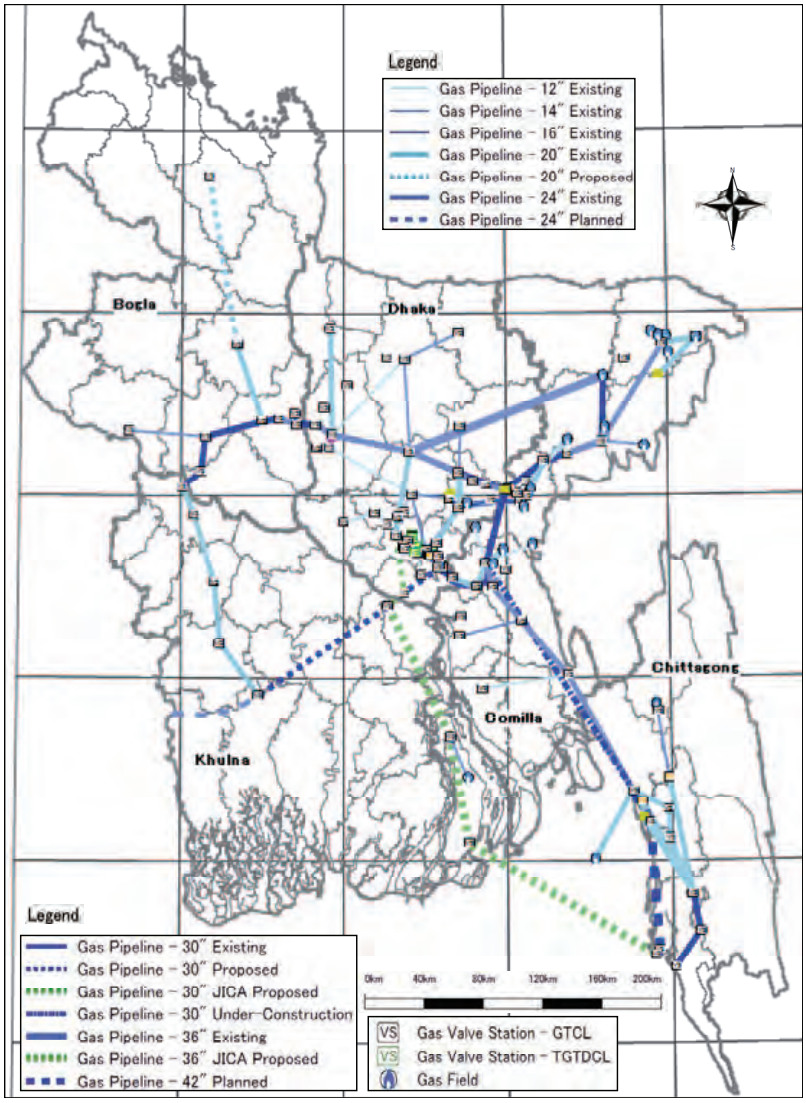


Source: Prepared by JST

Figure 5.2.1 Gas Pipeline Outline Map

The national gas pipeline map with power transmission line prepared in Smallworld is included in Appendix B-2.

(1) The method of data import

We have identified locations of gas valve stations and gas fields in Bangladesh of GTCL and Google Earth in Internet. In addition, we have imported existing GIS Shapefile[12] data to Smallworld by the Shapefile data loading tool, which was developed by Geoplan.

(2) Contents of data

- Gas fields Objects (Approximate locations on the map)
- Gas Valve Station Objects (Approximate locations on the map)

[12] A Shapefile is a file type used in GIS, a geographic information, attribute data, and coordinate system information.

- Summarized Gas Pipeline Objects (Pipeline routes connected between gas valve stations by a straight line)

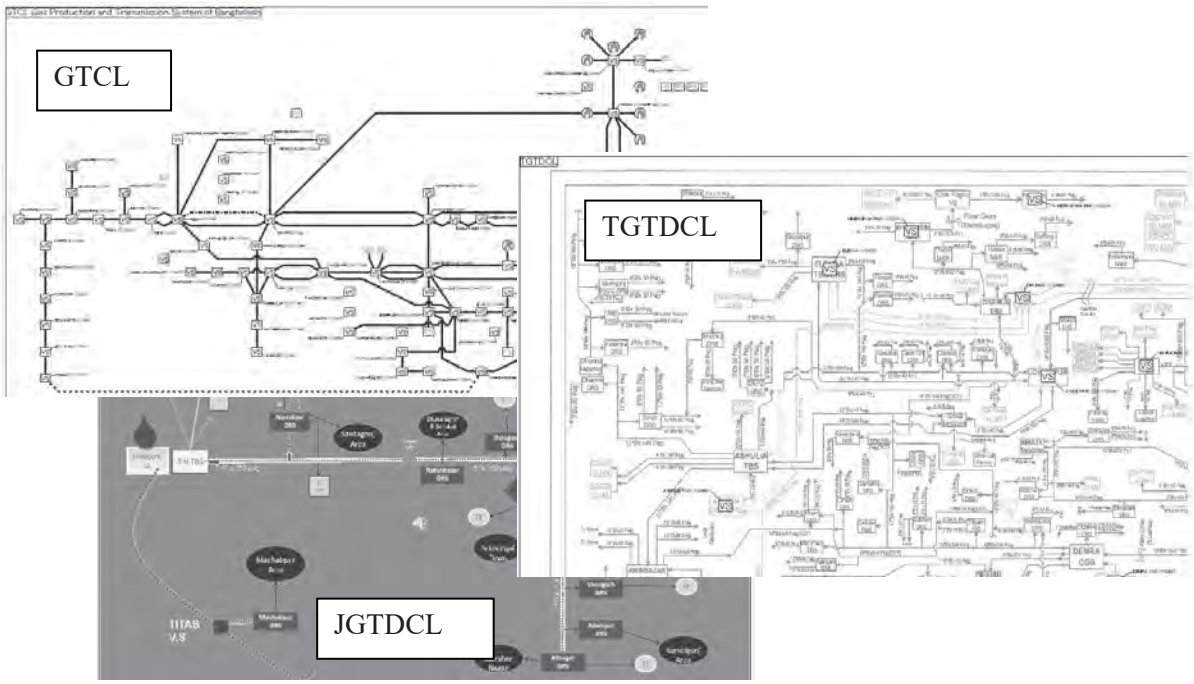
(3) Necessary works in the next stage

At present, most of locations of gas valve stations and pipelines are not accurate. It should identify accurate position data by GPS survey or other method. It needs to modify locations of gas fields and valve stations in the system when detailed locations of facilities are identified.

5.2.2 Schematic Diagram of Gas Pipelines

The project has compiled schematic diagrams of gas pipelines owned by the following gas transmission/distribution companies in Smallworld system.

- ✓ GTCL: The schematic diagram of gas pipelines, which includes gas valve stations, large power plants, large scale fertilizer plants and gas fields in whole Bangladesh country.
- ✓ TGTDCL: The schematic diagram of gas pipelines, which includes gas valve stations, large scale fertilizer plants and gas fields in their service area.
- ✓ JGTDSL: The schematic diagram of gas pipelines, which includes gas valve stations and gas fields in their service area.



Source: Prepared by JST using Schematic Diagram of TGTDCL, GTCL, and JGTDCL

Figure 5.2.2 Gas Pipeline Schematic Diagram

(1) The method of data capture

Firstly, gas schematic diagram of each company is pasted as an image data (a raster data) in the system. Secondly, point geometries are created at the corresponding locations of the valve stations on the raster. It is also possible to input geometries by hand with looking original drawings without raster pasting.

Thirdly, geometries of valve stations are connected each other with pipeline geometries automatically or by hand according to connection information.

(2) Data structure of Objects

- Gas Valve Station (at expedient locations on the schematic diagram)
- Gas Field (at expedient locations on the schematic diagram)
- Fertilizer Plants (at expedient location on the schematic diagram)
- Outline of Gas Pipeline (Pipeline routes connected between gas valve stations by a line)

(3) Necessary work in the next stage

The following works will be required in the next stage

- To add schematic diagrams of remaining gas distribution companies.
- To modify existing schematic diagrams according to newly found valve stations and connection data.

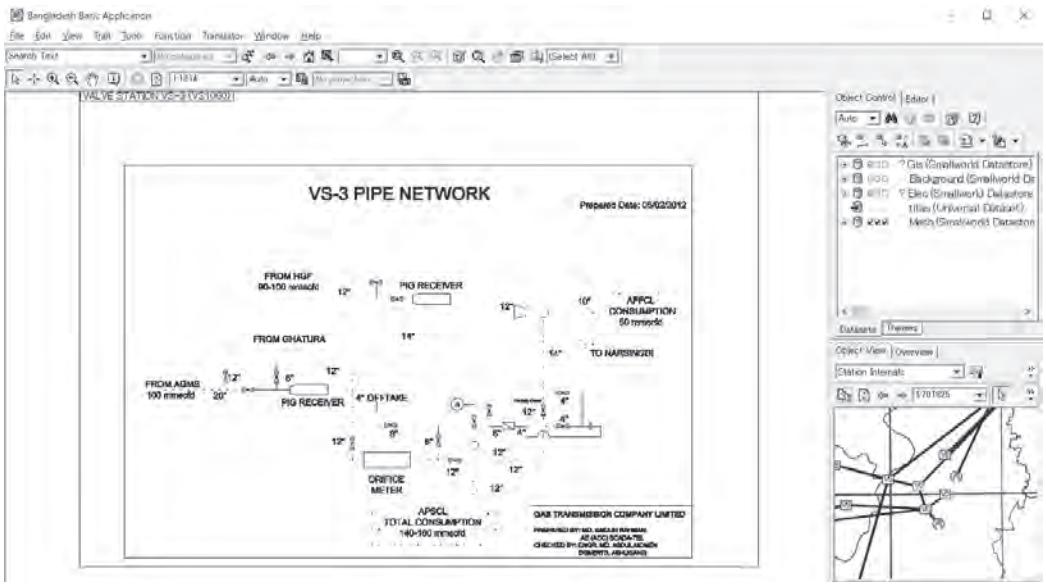
5.2.3 Internal Drawing of Gas Valve Station Building

The internal drawings of buildings in the following table are input to Smallworld system. They are a part of one hundred and several tens of gas valve stations. In the next stage, it is necessary to gather remaining building internal drawings and to input them into Smallworld.

Table 5.2.1 List of Valve Stations input to Internal Worlds

Station ID	Station Name
VS1010	KAILASTHTILA 2&3 MANIFOLD
VS1020	MUCHAI CS-2 MANIFOLD
VS1030	HOBIGONJ MONIFOLD
VS1040	KHATIHATA METERING ST
VS1050	ASHUGONJ GMS
VS2010	BAKHRABAD HUB
VS1060	VALVE STATION VS-3
VS3030	MONOHORDI
VS3440	ASHULIA CGS

Source: Prepared by JST



Source: Prepared by JST

Figure 5.2.3 Example of Gas Valve Station's internal drawing

(1) The method of data capture

First, the internal drawing of valve station building is pasted in an area of the Internal World allocated for each gas valve station. Then, point data of valves and vector data of piping in the building is input according to the drawing.

(2) Data Structure

- Internal Worlds allocated for each valve station.
- Raster data of piping drawing in the building
- Vector data of piping drawing in the building

(3) Necessary work in the next step

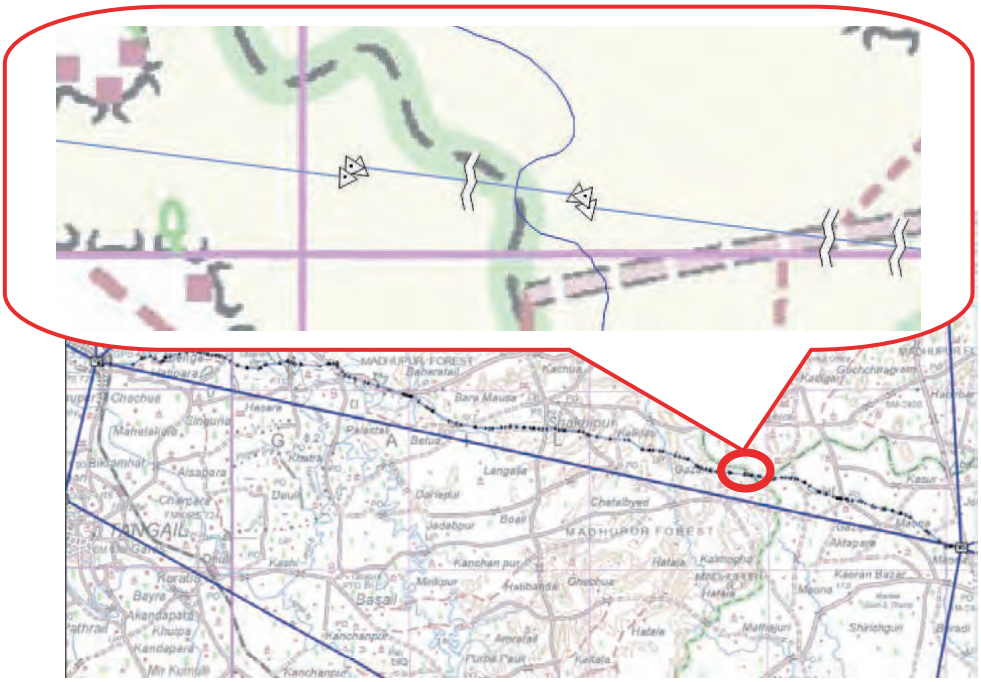
It is necessary to collect piping drawings of the building of remaining gas valve station and preparation of point and vector data.

5.2.4 Detailed Drawings of Main Gas Pipelines

Detailed locations of gas pipelines and associated information (such as Angle Point, Crossing, CP, and Soil Resistivity) collected from concerning drawings of the following projects have been incorporated to Smallworld as demo contents.

- Dhanua-Elenga and West Bank of Bangabandhu Bridge-Nalka Gas Transmission Pipeline Project (prepared by PENSPEN)
- Bakhrabad-Siddhirganj Gas Transmission Pipeline Project (Prepared by Dorsch International Consultants GmbH)

An example of detailed drawing and related objects incorporated into Smallworld system is shown in the figure below. While the blue straight line indicates the approximate transmission pipe alignment in a wide area map, the detailed pipeline alignment is shown in the zoomed map with accurate positioning. The location of objects such as Angle Point and River Crossing are shown on the map when the scale is zoomed up. The locations of such objects overlap accurately on the topographic map issued from Survey of Bangladesh (SOB).



Source: Prepared by JST

Figure 5.2.4 Detailed Gas Pipeline and related objects

(1) The method of data import

We digitized the data according to the drawings such as pipeline alignment sheet in which coordinates of pipelines are given in the drawings. Such drawings were rasterized in Shapefile format and imported into Smallworld system by the Shapefile data import tool.

(2) Data structure

- Gas pipeline objects with accurate coordinates
- Objects which represent associated information of pipelines (Angle Point, Crossing, CP, Soil Resistivity)

(3) Necessary works in the next stage

It is necessary to digitize and import data in the same way as other collected drawings, in which coordinates of gas pipelines are known.

5.2.5 Gas Distribution Pipeline Data

Gas distribution pipes, risers and valves data in a part of Karnaphuli Upazila in Chittagong District have been imported into Smallworld as a sample. In addition, gas distribution pipes and associated facilities in the city center, one of TGTDCL service, have also been incorporated into Smallworld demo system.

The sample area of Karnaphuli, of which data is from Shapefile prepared by KGDCL using ArcGIS[13] is shown in the figure below.

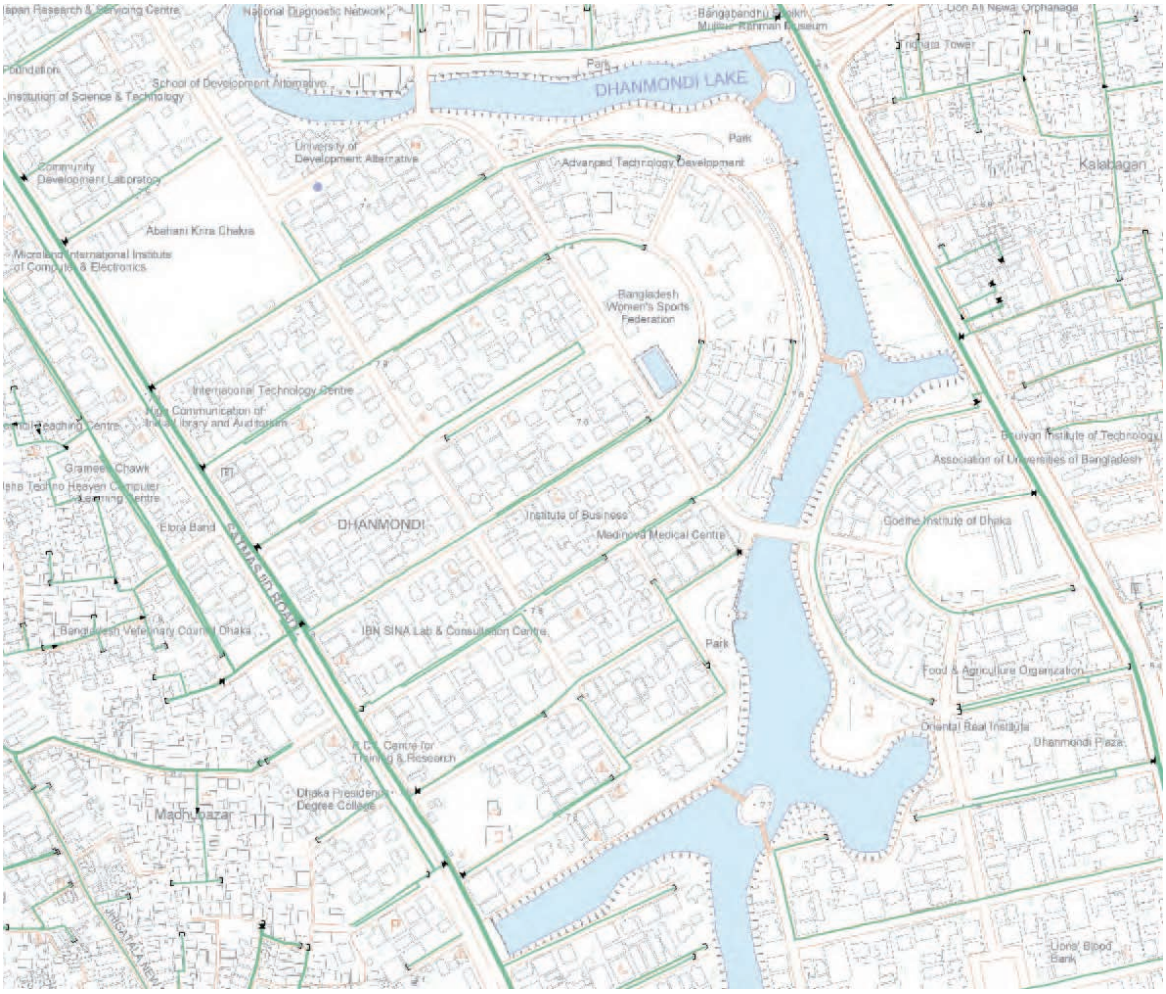
Source: Prepared by JST

Figure 5.2.5 Example of Gas Distribution Data of Karnaphuli

The sample TGTDCL area of which data is incorporated in the demo system is shown in the figure below. The details of the area are as follows:

- Region name: TGTDCL Metro Dhaka Marketing Dept. No.5
- Land name: Dhanmondi, Lalmatia, Jigatala, Kalabagan, Mohammadpur, Shamoly, Agargaon, Farmgate
- Contents of facilities: Gas distribution pipes, gas gate valves, pipe reducers, pipe end caps and pipe casings

[13] ArcGIS is a geographic information system for working with maps and geographic information, produced by ESRI.



Source: Prepared by JST, with base map of SoB 1/5000

Figure 5.2.6 Gas Distribution Data of TGTDCL

(1) The method of data import

(i) Karnaphuli: Shapefile format data prepared by KGDCL using ArcGIS was imported into Smallworld system by the Shapefile data import tool.

(ii) TGTDCL: The paper maps with coordinate grid prepared by TGTDCL was used. The gas distribution pipeline alignment and facilities are drawn on it. Those were once digitized in ArcGIS and Shapefiles. Then, the Shapefile data was imported in Smallworld system with data import tool.

(2) Data Structure

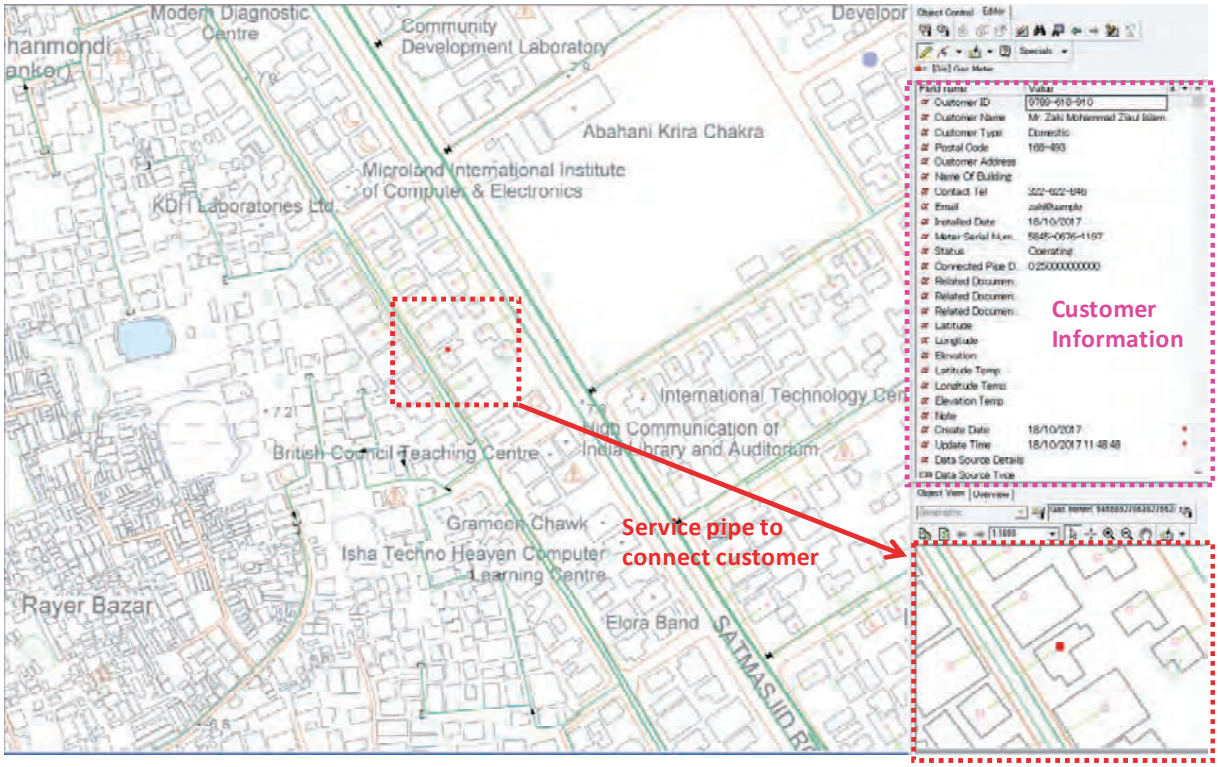
- Gas distribution pipe objects with accurate locations
- Objects related to gas distribution pipes (Gas gate valves, pipe reducers, pipe end caps, and pipe casings)
- Objects for customer service (such as Risers)

(3) Necessary works in the next stage

It is necessary to collect drawings of each gas distribution company and digitize data in the same way.

The drawings with coordinate information is limited, and it is necessary to confirm coordinate for most of the drawings. Conducting GPS survey is necessary for such drawings to incorporate in map system.

In addition, customer data can be incorporated with service pipe when customer information is available from gas distribution companies. The following figure is an example of customer data and connection to customer. The customer information such as Customer ID, Customer Name, Customer Type, Customer Address and Tel, Postal Code, Status, location data, Gas Consumption, etc., can be displayed in the data field.



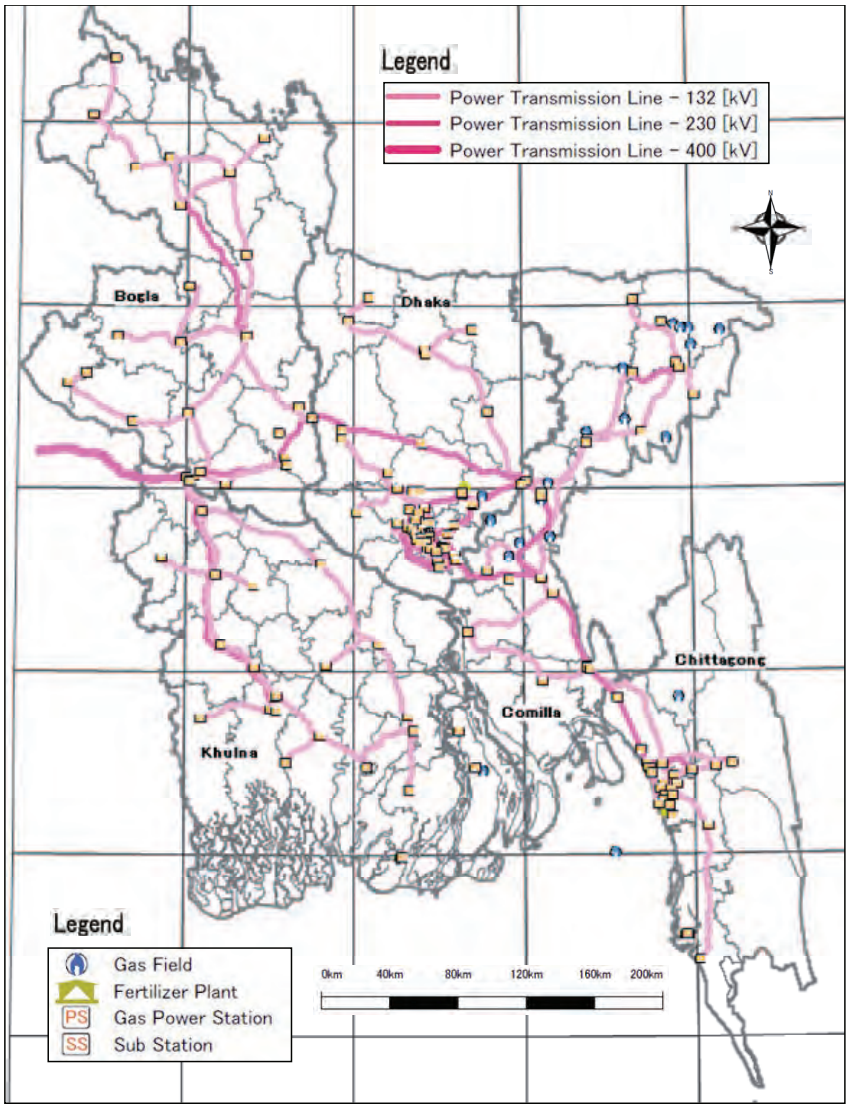
Source: Prepared by JST

Figure 5.2.7 Service Pipe and Customer Information

5.2.6 Power Network

The approximate locations of power stations, substations, and power transmission lines in whole Bangladesh country were collected mainly from Google Earth. The position data and related attribute data of facility was once assembled in Shapefile in ArcGIS, and incorporated into Smallworld System.

The nation-wide power network facilities in Smallworld system is shown in the figure below.



Source: Prepared by JST

Figure 5.2.8 Power Transmission Network

The power transmission line map with the gas transmission pipeline facility is attached in Appendix B-2.

(1) The method of data import

We have processed location information of power stations, substations, and power transmission lines owned by PGCB and BPDB, and created Shapefiles from those data. Then, we have imported the Shapefiles into Smallworld system by the Shapefile data import tool, as well as gas facility data.

(2) Data structure

- Power plant objects
- Substation objects
- Power transmission line objects

(3) Necessary works in the next stage

It is necessary to update the location and facility information of power stations, substations, and power transmission lines planned in future. The as-build drawings of transmission line layout, tower structure, and the layouts of substations are also recommended to be collected and incorporated into Smallworld system for facilitation of overall O&M. In addition, the demo system in Smallworld does not have power distribution lines. It is recommended to incorporate distribution line information in the future to manage overall network connections from power station to consumers as separate project.

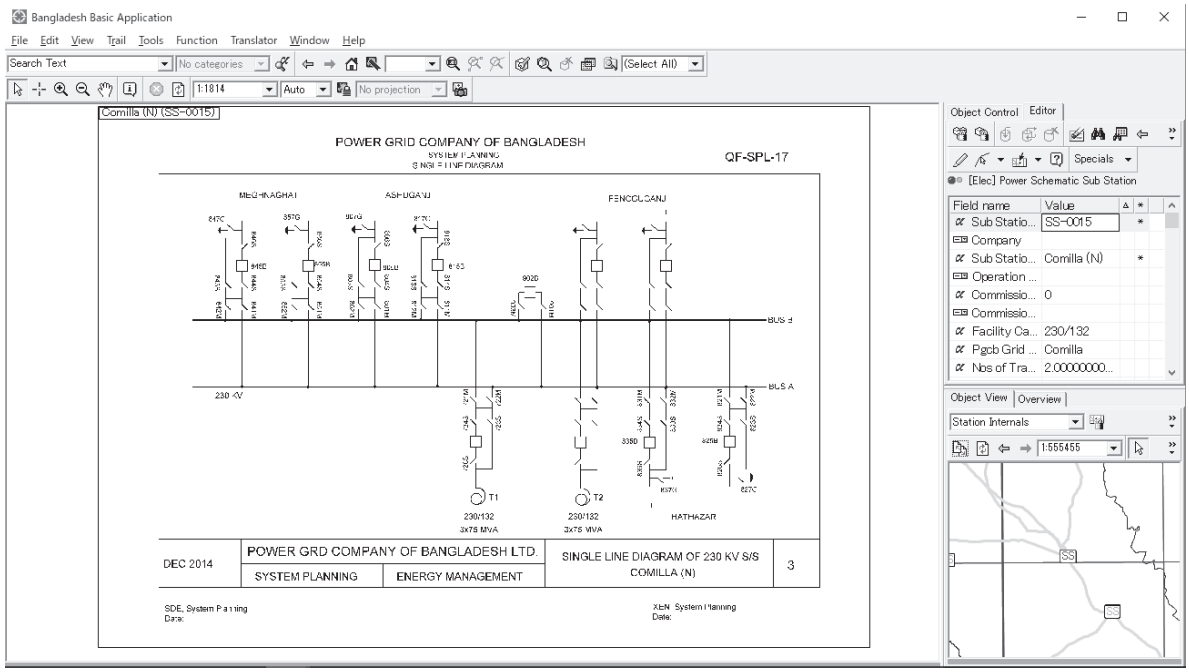
5.2.7 Internal Drawing of Substation

Facilities indicated in single line diagrams of substations were incorporated using Internal World in the Smallworld demo system as sample. The list of five (5) substations already incorporated into Smallworld system is as shown in the table and figure below.

Table 5.2.2 List of Substation incorporated in Internal Worlds in Smallworld

Station ID	Station Name
SS-0015	Comilla (N)
SS-0005	Agargaon
SS-0007	Aminbazar
SS-0021	Ishurdi
SS-0024	Meghnaghat Switching

Source: Prepared by JST



Source: Prepared by JST

Figure 5.2.9 Example of Substation Single Line Diagram incorporated as Internal World

(1) The method of data import

A building internal drawing is pasted in Internal World allocated for each substation. Position data of switches and vector data of power lines vector data in the building internal structure is input along with the drawing.

(2) Data Structure

- Internal Worlds allocated for each substation
- Raster data of a single line diagram in substation buildings
- Vectorised data of a single line diagram and facility position data in substations

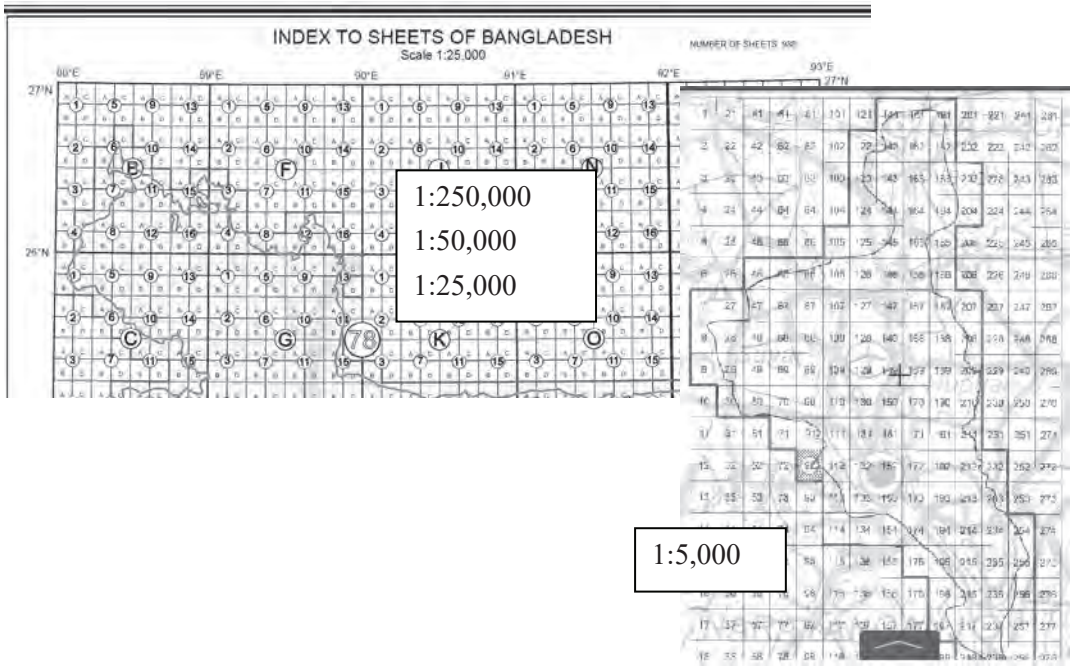
(3) Necessary works in the next stage

It is necessary to collect remaining single line diagrams of the substations, and to prepare position and vector data.

5.2.8 Topographic Maps used for Background Image

(1) Structure of Index Map Mesh

There are four (4) scales (1:250,000, 1:50,000, 1:25,000, and 1:5,000) in Bangladesh topographic map system prepared by Survey of Bangladesh (SoB). Index maps are prepared with mesh for the maps 1:250,000, 1:50,000, 1:25,000 in one sheet by SoB. Other mesh sheet is independently prepared for 1:5000. We have imported these meshes into Smallworld to facilitate background map management to display with network infrastructure information.

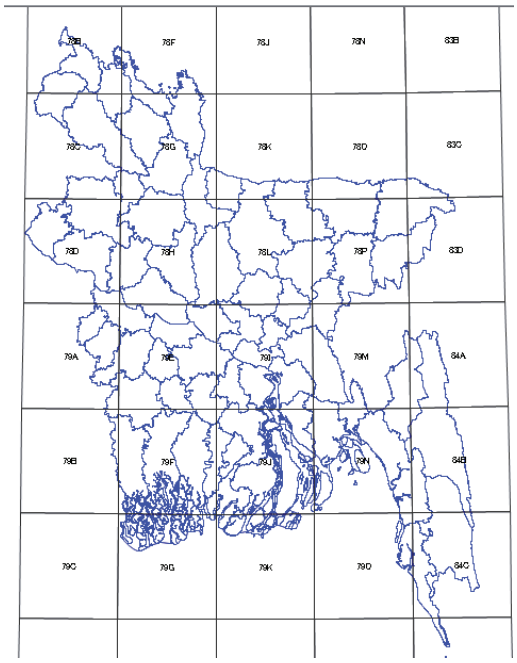


Source: Prepared by JST

Figure 5.2.10 Structure of Index Map Mesh in Bangladesh Background Maps

(2) Administrative boundaries

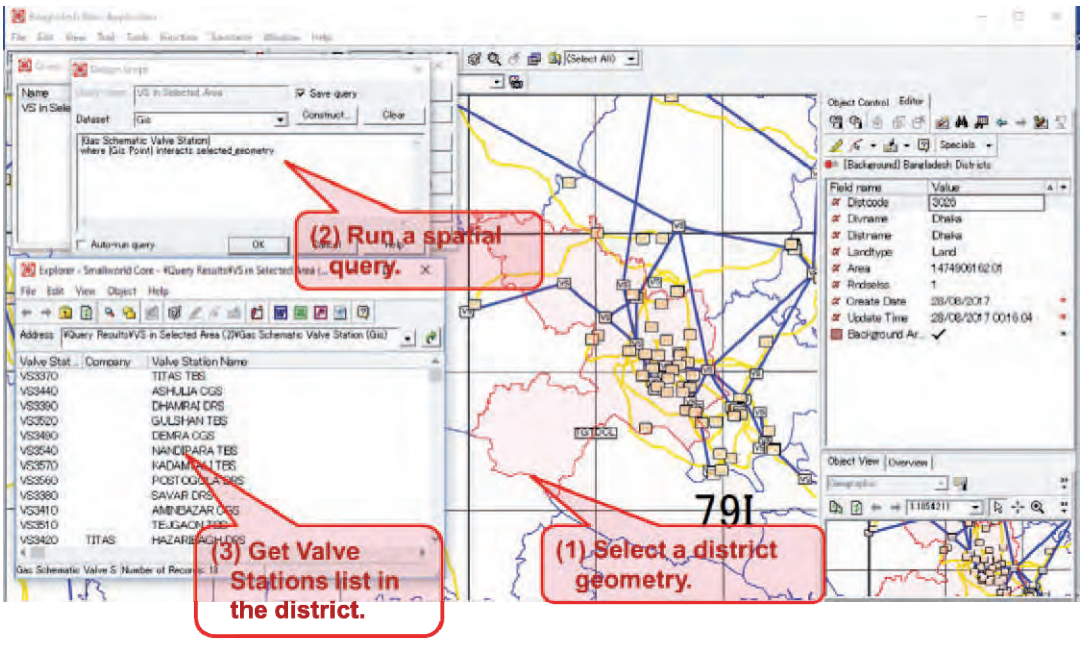
We have imported Bangladesh administrative boundaries into Smallworld using polygon data of Shapefile format, as shown in the figure below.



Source: Prepared by JST

Figure 5.2.11 District Map of Bangladesh

The administrative boundary data can be used for searching facilities by districts or states. For example, we can prepare a list of valve stations in Dhaka district by a spatial query with a polygon data of the district, as illustrated in the figure below.

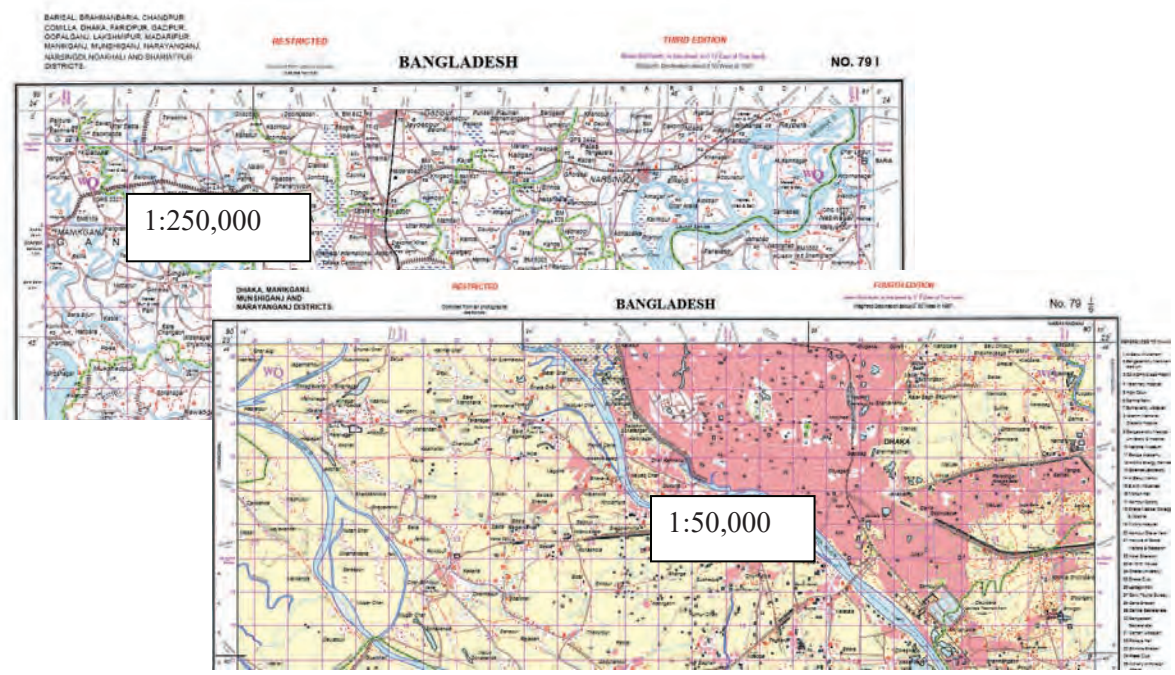


Source: Prepared by JST

Figure 5.2.12 Spatial Query by using Districts Polygon

(3) Topographic maps as background raster images

As mentioned above, topographic maps of Bangladesh were prepared by SoB. In Smallworld demo system, we have incorporated some of the topographic maps to overlay gas and power network infrastructure of demo areas. Those are utilized not only as background image but also to confirm accurate location of infrastructure facility.



Source: Prepared by JST

Figure 5.2.13 Topographic Maps used as Background Image of Network Infrastructure

(4) Background maps obtained from Internet

Background maps can be obtained from Internet such as Google Earth. The advantages of the maps are as follows:

- Maps are automatically and periodically updated to latest ones
- Maps cover whole areas in Bangladesh at every scale
- Objects prepared on the Google Earth maps are compatible with ArcGIS through kml/kmz file types by customization of data exchange facilities

Meanwhile, they have the following disadvantages.

- Connection with Internet is required.
- It takes a certain time until maps are downloaded, and the required time is depending on communication environment.
- Usage fee or license fee is required when it is operated with different system such as Smallworld.

5.2.9 Data Preparation Methods according to Status of Existing Material

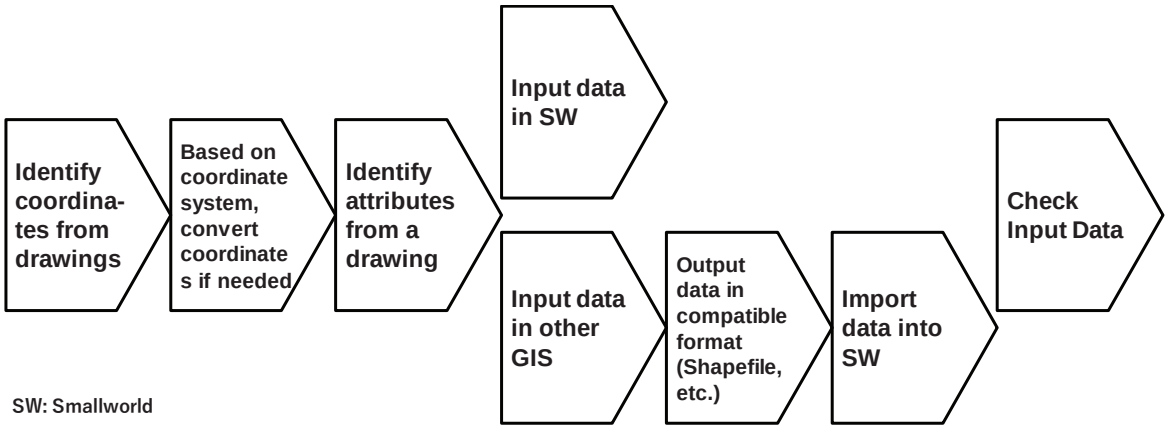
Utility companies and organizations in Bangladesh have been merged or separated several times in the past, and many drawings and relates materials have been dispersed or left unknown. If the drawing is available, many of them are out of date. There are different status of available drawing and other information for network infrastructure as follows:

1) Drawings with coordinate system and position data of facility is available
2) Position data (latitude and longitude) is available at drawing frame or angle point, but coordinate system is unknown.
3) Both the coordinate system and position data are unknown in the drawing, and facilities information such as roads, buildings, and land names are included
4) Locations identification is not possible from drawings
5) No drawings exist, or facility locations in maps are unable to identify

The following are data preparation methods to incorporate in Network Infrastructure Management System according to the availability of drawings and other information.

(1) Drawings with coordinate system and position data of facility is available

The data input procedure in the case (1) is as shown below.

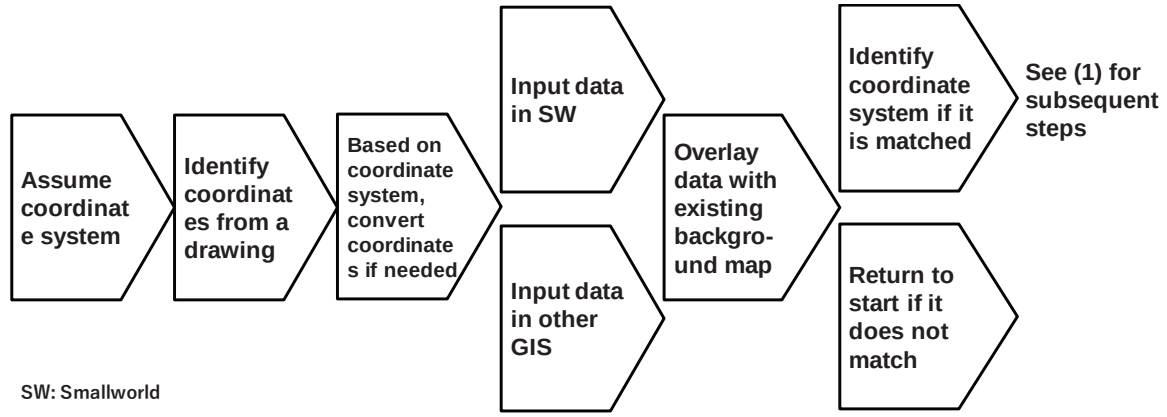


Source: Prepared by JST

Figure 5.2.14 Data Preparation Procedure (1)

(2) Position data (latitude and longitude) is available at drawing frame or angle point, but coordinate system is unknown

The data input procedure in the case (2) is as follows.

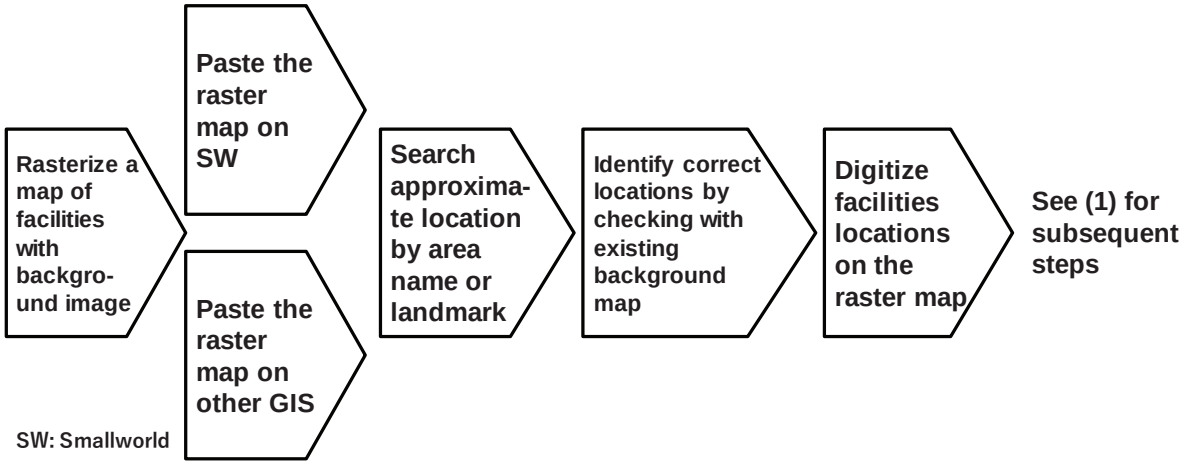


Source: Prepared by JST

Figure 5.2.15 Data Preparation Procedure (2)

(3) Both the coordinate system and position data are unknown in the drawing, and facilities information such as roads, buildings, and land names are included

The data input procedure in the case (3) is as shown below.

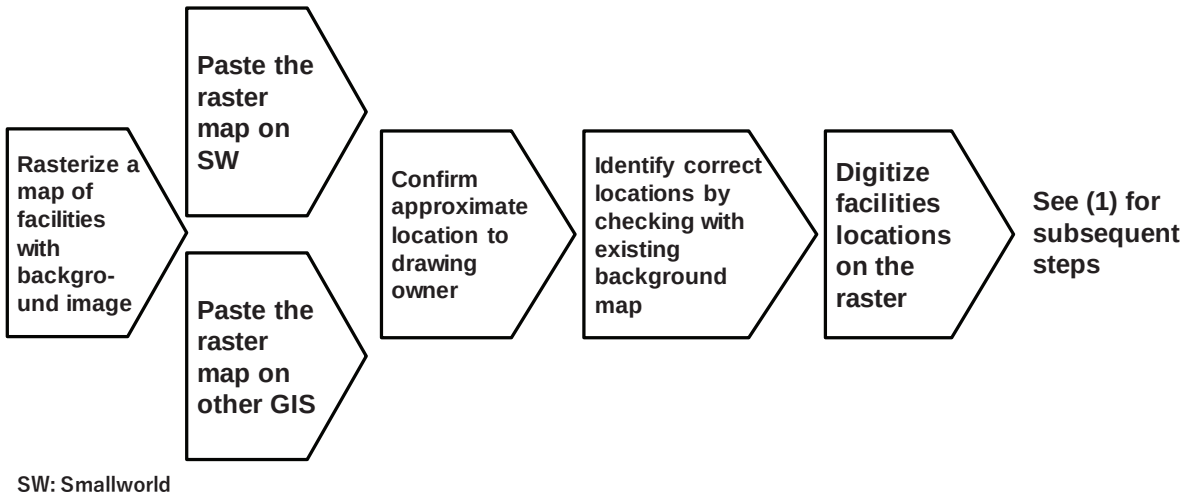


Source: Prepared by JST

Figure 5.2.16 Data Preparation Procedure (3)

(4) Locations identification is not possible from drawings

The data input procedure in the case (4) is as shown in the figure below.

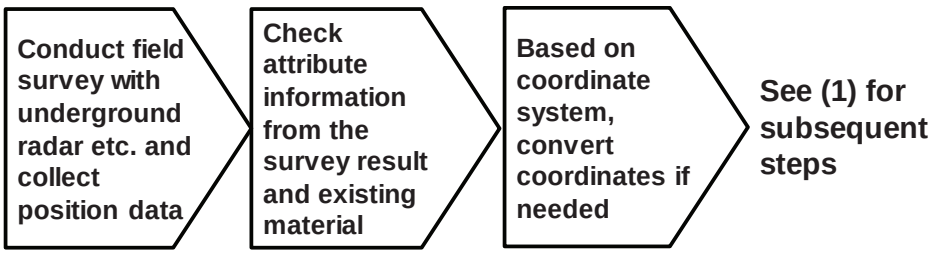


Source: Prepared by JST

Figure 5.2.17 Data Preparation Procedure (4)

(5) No drawings exist, or locations in maps are unable to identify

The data input procedure in the case (5) is as shown below.



Source: Prepared by JST

Figure 5.2.18 Data Preparation Procedure (5)

The drawing preparation, pipe detection survey, and GPS data collection survey is inevitable for base system preparation, which requires large human resources. The organization for fundamental data preparation and management needs to be set up for integrated data management.

5.3 Data Group/Field Definition in Network Infrastructure Management System

5.3.1 Physical Field of Object

Physical Fields of Objects in Network Infrastructure Management System represent specifications and characteristics of each facility. Those items are defined in Object Model. The following are the examples of items to be identified in the Object Model:

- Gas pipe: pipe type, material, diameter, design pressure, etc.
- Gas valve: type of valve, design flow, design pressure, etc.
- Power line: voltage, ampere, conductor type and size, number of circuit, etc.

Similarly, Physical Fields have own features according to facilities. In addition, when a facility has information about operation status (such has Proposed, Under-Construction, Existing, and Abandoned) as the value of Physical Field. Styles of symbol of the facility can be set differently according to the status and values in Physical Field.

Various numerical values obtained from facility operation data can also be included in Physical Fields. For example, a gas valve station has operation data such as gas flow and pressure and a power station has operation data of generated energy and fuel consumption. It is possible to utilize such operation data in the understanding of current issue and in the future planning, after tabulation and statistical analysis of the values in Physical Fields. For example, it is possible to calculate and compare total quantity of gas flow in valve stations and total gas consumption in gas power stations in Dhaka Division easily.

As mentioned above, Physical Fields of Objects provide important information for each phase of planning, construction, operation, and maintenance of asset in network infrastructure.

Details of Physical Fields of each Object are explained in the section below.

5.3.2 Physical Fields

There are data items common to various types of Objects, such as updated time, a file path of an associated document. Such of common type data items in the Physical Fields of objects are listed in the table below.

Table 5.3.1 Common Physical Fields of All Facilities

Name	Type	Description
ID	system id	System unique identifier of object
Name	string	Facility specific name
Operation Status	string	One of : 'Proposed','Planned','Under-Construction','Existing', and'Abandoned'
Commissioning Year	integer	The year of commissioning
Commissioning Month	integer	The month of commissioning
Related Document 1	string	File path of associated document
Related Document 2	string	File path of associated document
Related Document 3	string	File path of associated document
Latitude	float	Latitude value of object's location
Longitude	float	Longitude value of object's location
Elevation	float	Elevation value of object's location
Latitude Temp	float	Temporary latitude value of object's location
Longitude Temp	float	Temporary longitude value of object's location
Elevation Temp	float	Temporary elevation value of object's location
Create Date	date	Object created date
Update Time	time	Object updated time
Data Source Type	string	One of: 'Drawing','Hearing','Field Survey',and'GPS

		Measurement'
Data Source Details	string	Detailed information of data source
Note	string	Free text information, remarks

Source: Prepared by JST

There are data items specific to each type of Physical Field such as gas pipeline, valve station, gas field, etc. Physical Fields need to be prepared for each type of Object. For example, Physical Field of Gas Pipeline is shown in the table below.

Table 5.3.2 Physical Fields of Gas Pipeline

Name	Type	Description
Company	string	Owner company's name
From Station ID	string	Valve Station ID from which the pipeline comes
From Station Name	string	Valve Station name from which the pipeline comes
To Station ID	string	Valve Station ID to which the pipeline goes
To Station Name	string	Valve Station ID to which the pipeline goes
Outside Diameter [inch]	integer	Outside diameter value
Length [km]	float	Length of the pipeline
Pipe Material	string	Material of the pipe
Corrosion Allowance [mm]	float	Allowance of pipe corrosion
Design Pressure [psig]	float	Design pressure
MAOP [psig]	float	Maximum allowable operating pressure
OP Normal [psig]	float	Normal operating pressure
Normal Flow Rate [mmscfd]	float	Normal flow rate
CP System	string	The pipeline has cathodic protection system,or not. (Yes or No)
Flow Direction	string	Flow direction of the pipeline

Source: Prepared by JST

Physical Fields for Objects installed in gas network infrastructure was prepared in Smallworld system, for the items below. This is to indicate the overall layout and asset data of gas transmission infrastructure in large scale maps. The details of Physical Fields are listed in Appendix C.

(1) Gas Pipeline

(2) Gas Valve Station

(3) Gas Field

(4) Fertilizer Plant

(5) Power Station (in gas schematic drawing)

In addition to the above, Physical Field of Objects in the detailed pipeline drawing was prepared separately to indicate actual layout and asset data with precise position data of facilities. The Smallworld system incorporated the following items.

(1) Gas Detailed Pipeline

(2) Angle Point of Gas Pipeline

(3) Gas Crossing Point

(4) Soil Resistivity

(5) Cathodic Protection (CP) of Gas Pipeline

For gas distribution network, Physical Fields were prepared for the following facility objects.

(1) Gas Pipe

(2) Gas Riser

(3) Gas Control

(4) Gas Pipe Casing

(5) Consumer information (Gas Meter)

Physical Fields were also prepared exclusively for Internal World objects that presents equipment and materials installed inside facilities. The Physical Fields of those objects of Internal World include the following.

(1) Gas Pipes

(2) Valves

(3) Meters

(4) Manifolds

(5) Instruments

(6) Filters,

(7) K.O. drum

(8) Heat exchanger

As well as gas network infrastructure, Physical Fields of power network infrastructure were prepared for the following items.

For World maps:

(1) Power Stations

(2) Substations

(3) Transmission Lines

For Internal World Objects:

(1) Power Lines/Cables

(2) Disconnect switches

(3) Circuit breakers

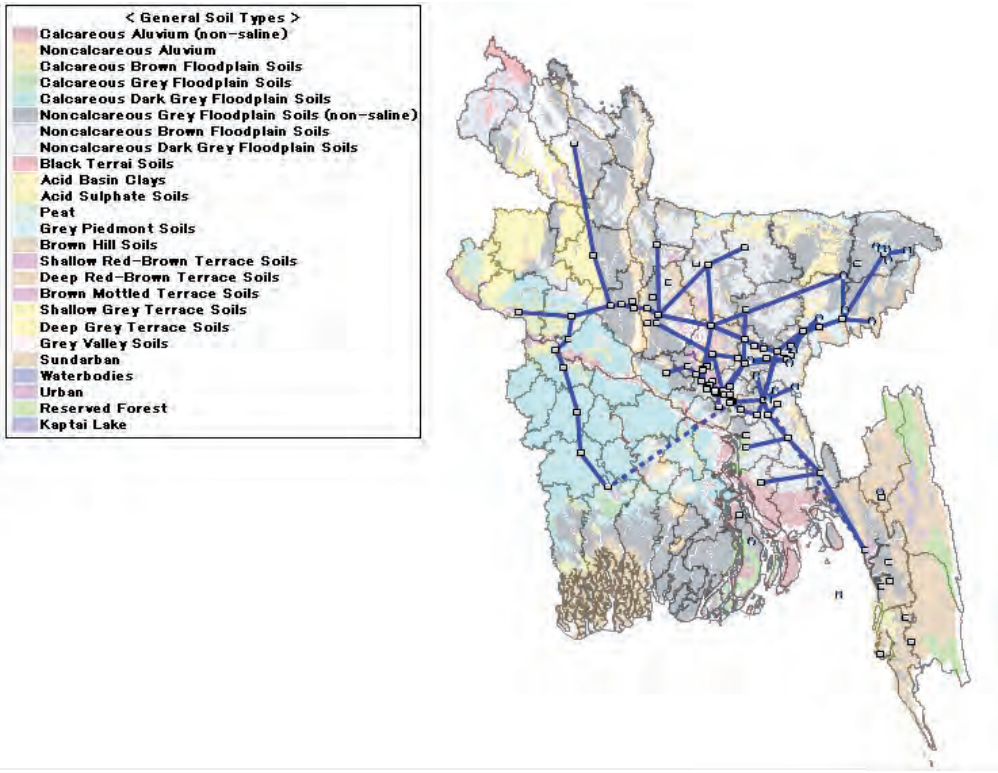
(4) Earth

(5) Generators

5.4 Utilization of GIS Shapefile Data

Network Infrastructure Management System can be utilized for planning of network system with several background maps including environmental and social data. Various types of environmental and social maps are available in GIS Shapefile format. It is possible to utilize shapefile data in Smallworld system together with network infrastructure Object data. Such utilization of various types data enables efficient infrastructure network planning.

For example, soil condition data is necessary to assess electrical conductivity of soils, which is used as a parameter for designing cathodic protection of pipeline. The soil type GIS shapefile map can be utilized and overlaid with pipeline transmission line alignment to support cathodic protection plan, as shown in the figure below.



Source: Prepared by JST using GIS Shapefile data of BARC

Figure 5.4.1 Soil Type Map with Pipeline Alignment in Smallworld

For other example, environmentally constrained area needs to be considered when extension of power transmission line and construction of power station is planned. GIS shapefile data of environmentally constrained area map can be overlapped with power transmission line data and power station data to assess necessary consideration and mitigation plan, as shown in the figure below.

Source: Prepared by JST based on GIS Shapfile data of BARC

Figure 5.4.2 Constrained Area Map with Transmission Line Alignment in Smallworld

Likewise, there are many possibilities for application of environmental and social background map data with Smallworld. The following are other examples of utilization of GIS shapefile together with Smallworld system.

1) Use of population density map for determination of classification of pipe material in terms of safety and protection
2) Planning of power transmission line considering biological corridor of birds specified as rare species
3) Application of land use shapefile data to prepare and estimate land acquisition and compensation planning in environmental impact assessment

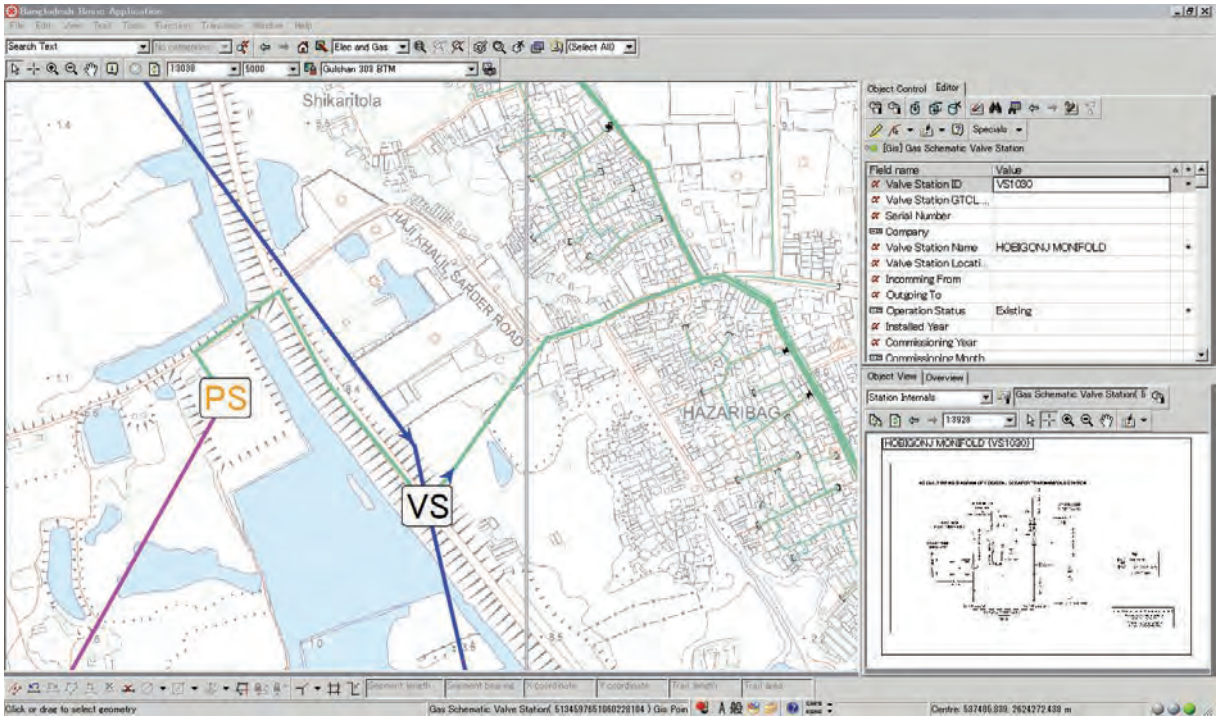
5.5 Integration of Gas and Power Network Data in Network Infrastructure Management System

5.5.1 Gas and Power Network Connection

As described earlier, different type of infrastructure is managed by each dataset. Smallworld system can display different type of networks as necessary with recognizing the connection.

In the following figure, “PS” symbol indicating the Power Station is connected from “VS” symbol indicating the Valve Station through green line indicating distribution pipeline. “VS” is connected

from blue line which indicates as transmission line, and "PS" is connected from pink line which indicates power transmission line. It shows both gas and power network infrastructure is managed in one system with recognizing connection of two different type of infrastructure.

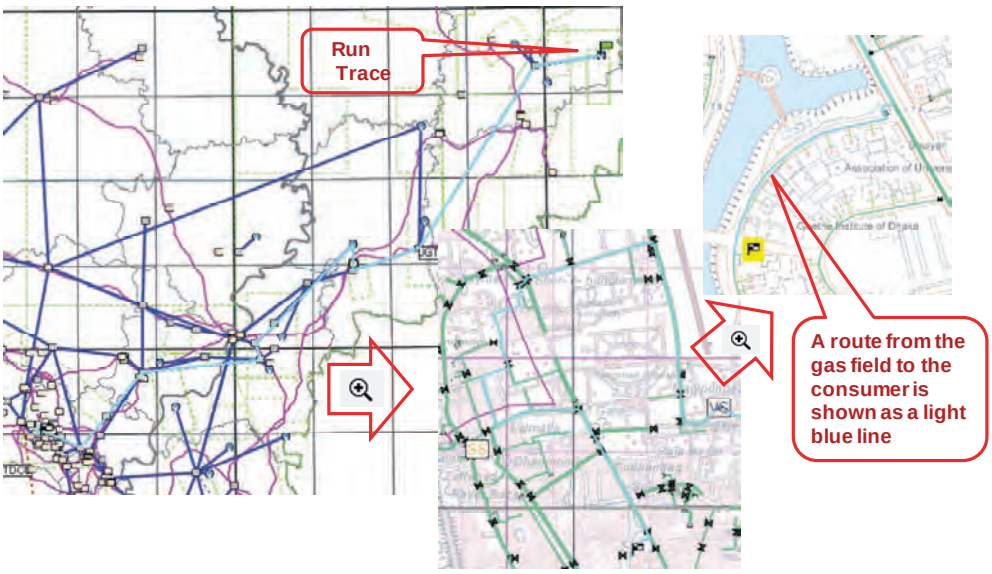


Source: Prepared by JST

Figure 5.5.1 Connection of Gas and Power Network

Recognition of the connection in different dataset is possible through an Object with Key Field. Object with Key Field indicating power station in Gas Dataset (GIS Dataset), for example, can be referred for searching power stations connected from a certain pipeline in Power Dataset.

"Network Trace" function will identify the pipeline network paths from supply source through transmission pipes, distribution pipes, and valve stations to the final consumers. This identifies the accurate connection from gas source to gas power station, and provides necessary geometry data for demand-based operation for respective power station.



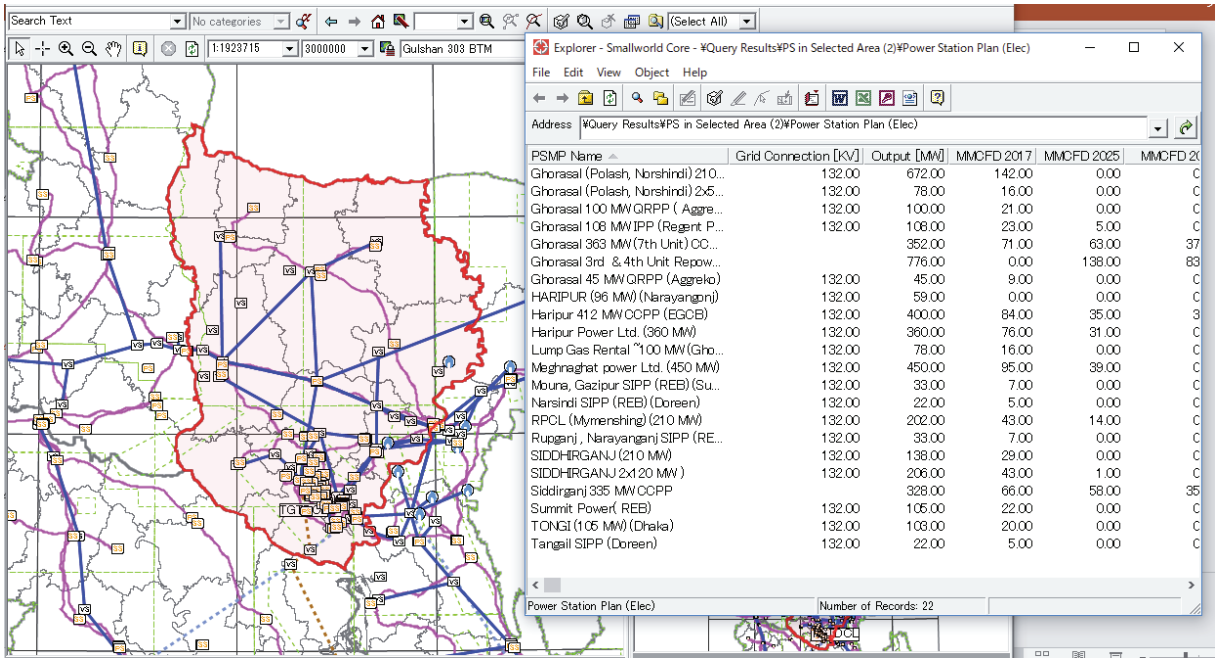
Source: Prepared by JST

Figure 5.5.2 Connection of Gas and Power Network

5.5.2 Power Plant Location and Regional Gas Consumption

Regional gas consumption by power station can be estimated by Spatial Search function, as shown in Figure 5.2.2. Gas power station belonging to a certain region can be searched and selected, and total gas consumption in power stations belonging to a certain region can be calculated. Such function is utilized for regional gas demand estimation and planning of gas pipeline enhancement with gas demand future projections.

The following figure shows an example of query and selection of gas power with present and future gas demand in Dhaka Region in Smallworld.



Source: Prepared by JST

Figure 5.5.3 List of Power Stations with Divisional Gas Consumption Projection

5.6 Recommendation for Improvement in the Next Stage

5.6.1 Collaboration of Smallworld with SCADA

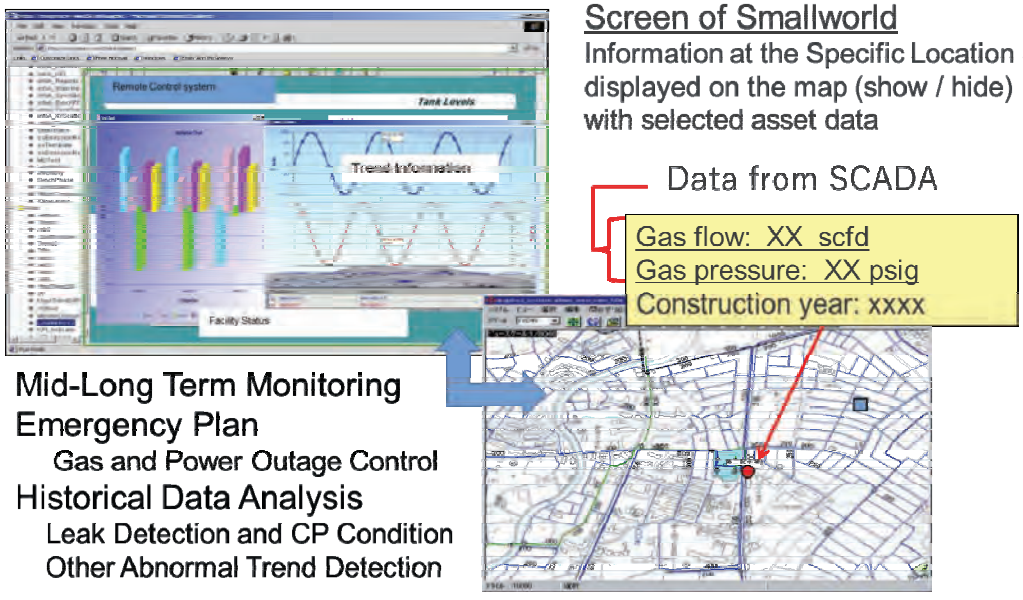
Supervisory control and data acquisition (SCADA) is the system consists of software and hardware for real-time data gathering from various locations to conduct remote control and condition setting. SCADA is used in network infrastructure such as gas, power, telecommunication, water, and road.

When the information of SCADA data is incorporated and monitored in Smallworld, there are several advantages in operation.

Currently only the staffs of the department concerning SCADA can access SCADA information. When SCADA is collaborated with Smallworld, more staffs who need SCADA information can share operation status in both gas and power network. Then, information sharing is facilitated and necessary correspondence such as demand response and countermeasure of failure will be fastened.

In addition, we can check mid term and long term historical trend in gas flow and pressure for each facility with overlaying actual geographical information. Then, it will be utilized for preparation of the maintenance and emergency plan, considering various aspects such as geographic analysis of gas leakage points, condition change of CP, and detection of other abnormal trend values.

From the above point of view, it is recommend collaborating Smallworld and SCADA in the technical cooperation project of the next stage.



Source: Prepared by JST using material of Namtech Inc.

Figure 5.6.1 Collaboration between SCADA and Smallworld

Interface are needed to be examined to develop the method of collaboration of Smallworld and SCADA. The following candidate methods can be considered. In principle any SCADA system can be connected to Smallworld via. JAVA API.

(1) Method via text files

The latest facility operation data is periodically output from SCADA in text formatted file. Smallworld clients import the text file and show latest information of facilities on the map.

(2) Method of direct access to SCADA Database

Smallworld clients directly access to SCADA database via interface such as Open Database Connectivity (ODBC) etc., and collect the latest operation data in SCADA. Using a database view is also available to cope with changes of SCADA database specifications.

(3) Method of specialized server

A new server is prepared to collect data from the server of SCADA system via a protocol for inter-server communication, such as ICCP (Inter Control Center Protocol) etc., and Smallworld clients access to the server to obtain SCADA data.

Advantages and disadvantages of above methods are compared in the table below.

Table 5.6.1 Pros and Cons of SCADA Connection Methods

Methods	Pros	Cons	Evaluation
Via Text File	Coupling between servers is not frequent, accordingly, one system is not affected from failures of others such as system down. Implementation is relatively easy.	A periodical and automatic information output function is necessary at SCADA side. Output information by hand may also be necessary at the initial stage.	A
Direct Access to SCADA DB	Data acquisition is relatively faster than other methods. Implementation is relatively difficult.	A communication path is required for each Smallworld client to access SCADA database directly. There is a risk that SCADA side may be affected by the direct access to SCADA database from Smallworld clients.	B
Specialized Server	Risk of bad influence on SCADA is small since data collection is conducted via the formal protocol.	Cost of the new application server development will be high.	B

Source: Prepared by JST

5.6.2 Documents and Drawings Management System

Current demo system provides function of accommodation of drawings, maximum three (3) drawings of electronic files per each object.

In future, much more concerned electronic drawings and documents will need to be accommodated in the system. In such case, more efficient system for managing and storing large amount of drawings and documents is required, instead of current simple document accommodation system.

From the above point of view, it is recommend to develop and introduce the specialized document management system, namely, Electronic Filing System in the technical cooperation project of the next stage. Electronic Filing System can display large amount of related drawings by using facility ID as the key to collaborate with Smallworld.

5.6.3 Collaboration of Smallworld with Simulators and ERP

As mentioned also in 5.1.1(3), Smallworld can act as an information platform which exchanges data between various systems.

If Smallworld can collaborate with a simulator, Smallworld can overlay simulation results on the geographical location information of input facilities. For example, when there are alternative plans of gas pipeline route, pressure, gas flow, and diameter, the simulation result corresponding to the alternative plans can be displayed with asset information on Smallworld with detailed locations in visual maps.

Furthermore, if Smallworld can collaborate with Enterprise Resource Planning (ERP) system, asset or organization information managed by ERP can be located with facility asset data on the maps.

In this way, useful information for works in network infrastructure, such as planning, design, construction, operation, and maintenance, can be provided from Smallworld system as the information platform, by assembling the facility data distributed in various existing systems.

From the above point of view, it is recommended to implement collaborations of Smallworld and other systems in the technical cooperation project of the next stage.

As well as SCADA, collaborations of Smallworld with other systems need to be conducted by designing and testing the details of data exchange methods and interfaces between the systems.

5.6.4 Collection and Incorporation of Base Maps

Survey of Bangladesh publishes topographic map of Bangladesh of scale of 1:250,000, 1:50,000, 1:25,000, and 1:5,000. They are used as base maps of Network Infrastructure Management System, and a part of maps were incorporated as demonstration in the Network Infrastructure Management System. Currently, SoB is preparing and updating national 1:25,000 topographic maps based on satellite image. They are targeted to be completed in 2018. In addition, 1:5000 maps are being prepared for local cities. As soon as the update topographic maps are prepared, those needs to be procured and incorporated in the Network Infrastructure Management System in the next phase.

The Table below shows the type of SoB maps and number of maps incorporated in the current Network Infrastructure Management System.

Table 5.6.2 Summary of SoB Maps incorporated in the System

Scale	1:250,000	1:50,000	1:25,000	1:5,000
Usage	Whole Map Summary	Mid-Range Map Big River and Broad Road	Detailed Map Land Mark Normal Road	Most Detailed All Road Each Buildings
Example			N/A	
Incorporated / Total	26 / 27	68 / 267	0 / 988	8 / 124
Next Step	Import all area	Import facility existing area	Import urban area mainly	Import all Dhaka area

Source: Prepared by JST

5.7 System Improvement Target

5.7.1 Pre-Paid Meter Introduction and System Integration

Currently, the gas is distributed to domestic consumer at fixed rate according to number of burners, not according to gas flow amount. Demand side saving of gas is hardly conducted and gas leakage is not detected. This has been caused to the loss of gas in distribution network.

In 2014-2015, the demonstration project was conducted for gas pre-paid meter installation with approx..200 consumers. The customer will charge gas tariff in pre-paid card, and gas meter will read the pre-paid card and allows the gas flow according to the charged balance.

Based on the result, installation of gas pre-paid meter is under implementation by Japanese loan. The 1st phase of the pre-paid meter project has been installing 200,000 units of pre-paid meter in TGTDCL franchise area and 60,000 meters in KGDCL, which is targeting to be completed in March 2018. By 2021, approx. three million units of pre-paid meters are planned to be installed in Bangladesh, as shown in the table below.

Table 5.7.1 Pre-paid Meter Installation Plan

Project Target	Number of Pre-paid Meter units	Status
TGTDCL	200,000	1st phase Under implementation
TGTDCL	1,500,000	To be planned
KGDCL	60,000	1st phase Under implementation
KGDCL	460,000	To be planned
BGDCL	220,000	To be planned
JGTDSL	100,000	To be planned
JGTDSL	150,000	To be planned
SGCL	5,000	To be planned
PGCL	209,528	To be planned
TOTAL	2,904,528	

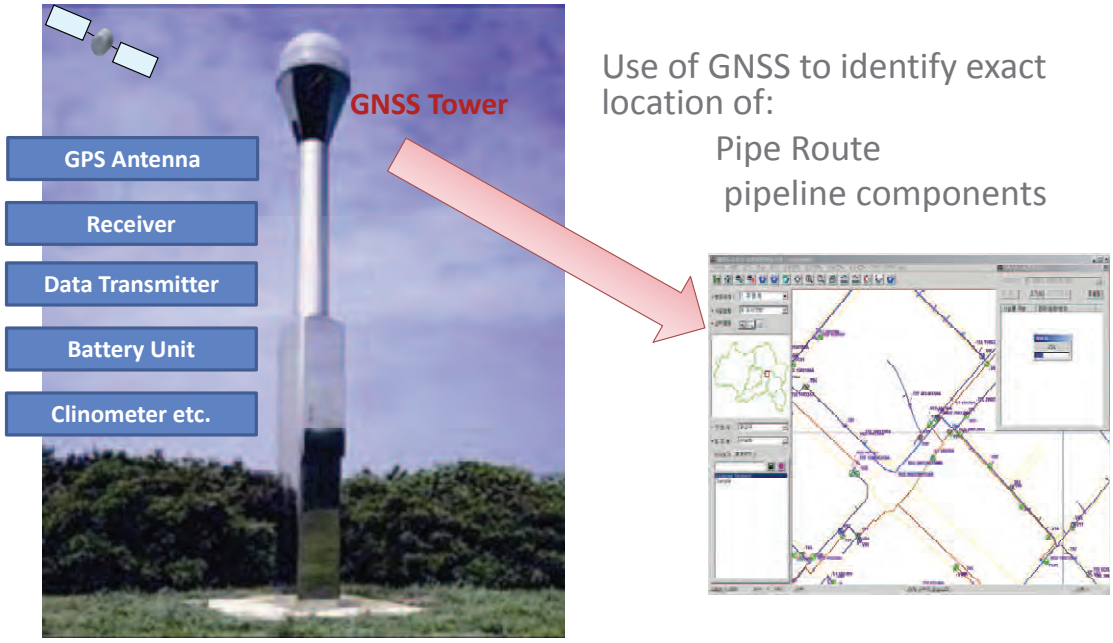
Source: Helios Halding Co., Ltd.

The customer data is sent to the server which will be installed in the head office of each gas distribution company. The customer data collected from server of pre-paid meter system can be sent to Network Infrastructure Management System and managed together with asset data. Demand data can be analysed with pre-paid meter system.

5.7.2 Location Data Accuracy Improvement

For precise positioning using GPS, Global Navigation Satellite System (GNSS) can improve accuracy of GPS survey at the level of within 10 cm. Electrical control point for GNSS has been installed at six locations in Bangladesh, namely, Dhaka, Chittagong, Sylhet, Khulna, Rangpur, and Rajshahi. One control point covers approx. 30 km radius. Thus, only corresponding areas can be covered for precise GPS survey using GNSS. It is planned that the electrical control point is increased to be 70 km, which will cover overall Bangladesh area.

Asset positioning by GPS survey using GNSS and data management with visual mapping will enable minimization of repair hours and optimum O&M works. It is proposed to conduct asset positioning survey using GNSS to incorporate in the Network Infrastructure Management System for important gas facility.



Source: Prepared by JST

Figure 5.7.1 Use of GNSS for Exact Pipeline Facility Positioning

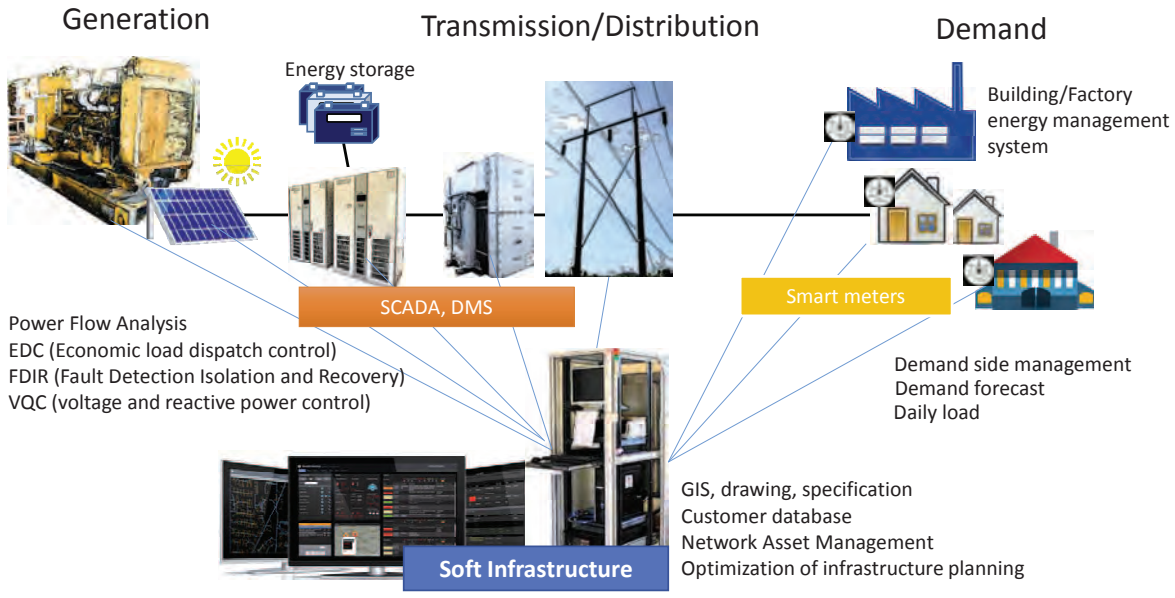
5.7.3 Smart Grid Introduction

Smart Grid is the advanced power grid system with variety of energy generation sources and large number of demand supported by information technology. Monitoring, conditioning, and control of the

production, transmission, and distribution of electricity are important aspects of the smart grid. The components of smart gird are not limited to be:

- Planning and optimization of generation considering efficiency and supply forecast;
- Outage control and minimization of outage;
- Power quality management and frequency adjustment;
- Asset management and real-time monitoring of asset performance
- Demand forecast, demand response and demand side management based on historical demand dataTo enable above, hardware system as well as soft system is necessary to be developed such as:
  - Smart meters supported by communication system to provide demand data;
  - SCADA and wide area monitoring system
  - GIS and mapping system
  - Battery energy storage system
  - Communication system for large volume of information with big data analysis

Network Infrastructure Management System will function as one of the fundamental database to manage above system components with SCADA, distribution management system (DMS), and information system. The concept of smart grid is as shown in the figure below.



Source: Prepared by JST

Figure 5.7.2 Concept of Smart Grid with Network Infrastructure Management System

CHAPTER 6 POLICY AND STRATEGY OF GAS INFRASTRUCTURE

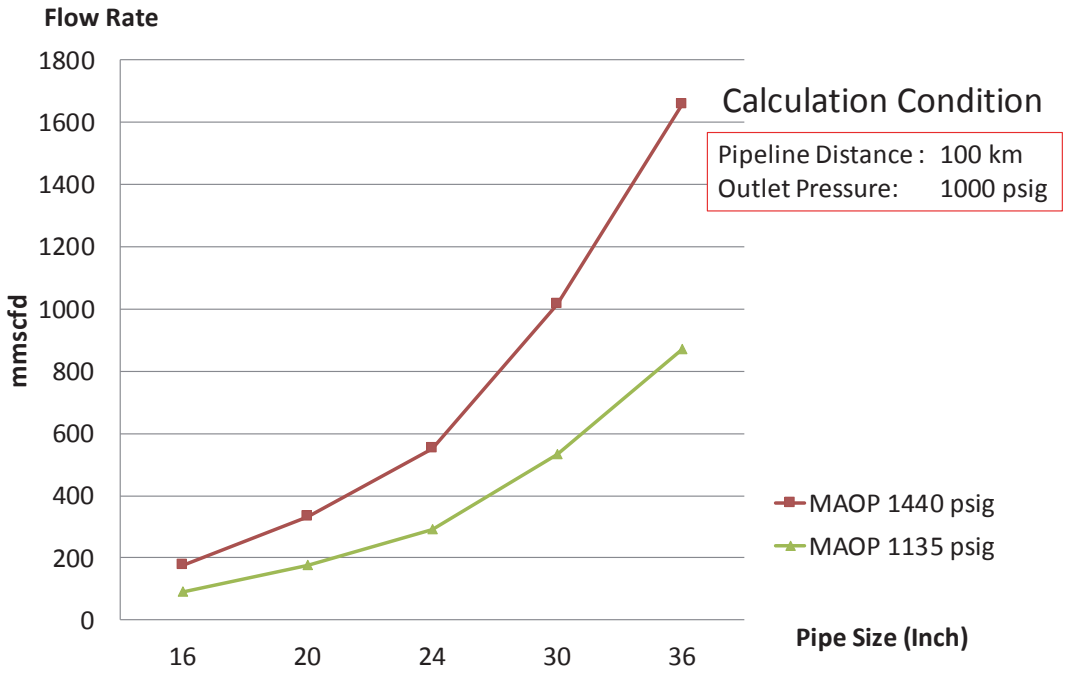
This Chapter summarizes present issues and challenges of energy sector in Bangladesh, and provides proposal for strategic gas network infrastructure plan. Then, gas infrastructure projects conducted by development partners were reviewed and guidelines for development partner projects and draft policy recommendations were presented.

6.1 Overview of Present Issues and Challenges of Gas Infrastructure

6.1.1 Maximum Allowable Operating Pressure (MAOP)

As stated in Section 2.4, current design is not fully benefited from the design limit of valves and fittings in ASME Code. Design Pressure (MAOP) used in Bangladesh appears to be a legacy of #400 rating standard and limit the design pressure at 960 psig. Current design standard uses #600 class which allows to use 1,440 psig, as MAOP. While in Bangladesh, MAOP of #600 ASME Class is 960-1,135 psig. Gas compressor station is necessary to keep gas pressure at required level.

With the use of 1,135 psig, gas transmission capacity will be half the level of 1,440 psig, and more compressor station are required.

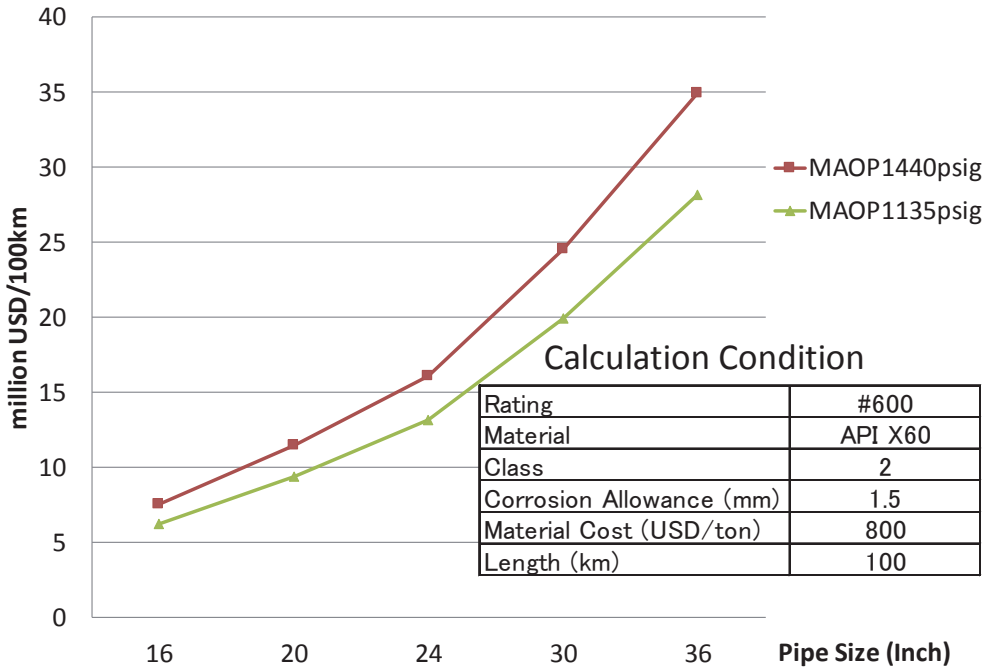


Source: Prepared by JST

Figure 6.1.1 Flow Capacity Comparison of Different Pressure Rating

Currently in Bangladesh, pipeline diameters of 16” to 36” are generally used. Appendix B-2 includes gas transmission pipeline diagram with its sizes.

Higher design pressure requires thicker wall. Material cost impact is calculated as follows:



Source: Prepared by JST

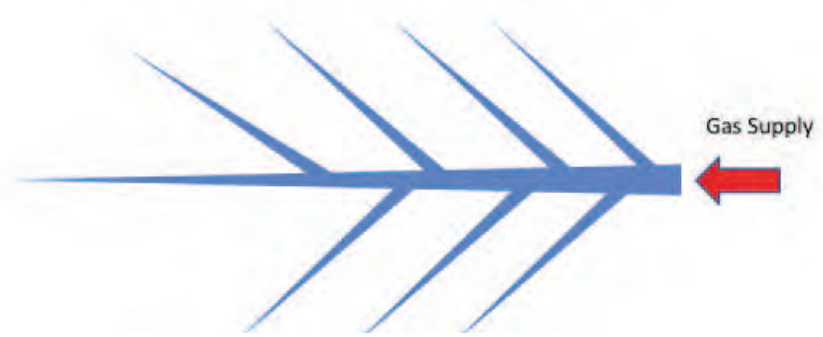
Figure 6.1.2 Pipe Material Cost Comparison

The relationship of pressure and distance is as illustrated in Figure 2.2.5.

Material cost will raise 20% (5% in terms of construction cost) if 1,440 psig of MAOP is used in comparison with the case of 1,135 psig, but allow to increase the capacity by 200% and reduce the numbers of compressor stations and construction cost.

6.1.2 Supply Pipeline Configuration

Current Gas Supply system in Bangladesh is called Fish Bone supply system. This Fish Bone system is typical of initial stage of the gas infrastructure development.



Source: Prepared by JST

Figure 6.1.3 Concept of Fishbone Gas Supply System

Following table is an example of pressure reduction from gas field (Kailashtila) to consumption area (Ashulia) through several as valve stations in Fish Bone gas supply system.

Table 6.1.1 Current Pressure System in Fish Bone Supply System

Valve Station	psig	kg/cm^{2}g	Gas Pressure
Design Pressure	1135	79.8	MAOP (Design Pressure)
Kailashtila A2/3	1133	79.7	MAOP
Target Operating Pressure	1000	70.3	
Ghatura M & R	970	68.2	Minimum Operating Pressure
BB M&R	950	66.8	Minimum Operating Pressure
Monohohordi	740	52.0	Minimum Operating Pressure
Narsingdi	650	45.7	Minimum Operating Pressure
Dhonua	600	42.2	Minimum Operating Pressure
Elenga	550	38.7	Minimum Operating Pressure
Demra/Siddhirgonj/Chittagonj CGS	400	28.1	Minimum Operating Pressure
Joydepur	350	24.6	Minimum Operating Pressure
Ashiulia	218	15.3	Minimum Operating Pressure

Source: GTCL

Highest pressure is at Kailashtilla Gas Field, which is gradually lowered toward the downstream to supply the gas to end users. In principle, higher pressure is required at the inlet of the system to maintain the overall pressure system. The system worked well under gas allocation system, however, it is not necessarily fit in with the gas demand system. To increase the capacity and extend the delivery area, installation of numbers of compressor stations are required and/or gas inlet pressure may need to be raised. Since the supply system relies on a certain level of high pressure, operational flexibility is limited. The system is also vulnerable to disruption in the trunk line. Once part of the trunk line is damaged or closed, all the downstream customers are affected, and also backup capability is limited.

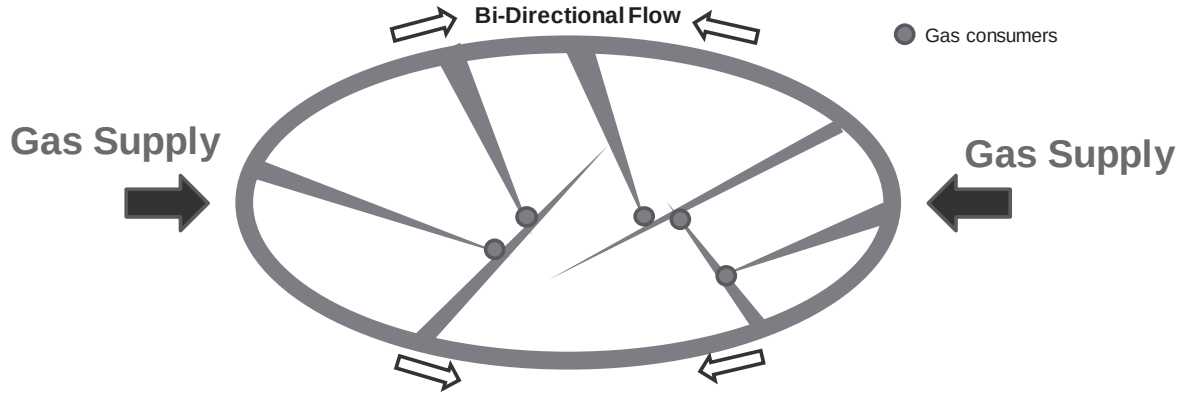
6.2 Proposal for Strategic Gas Network Infrastructure

6.2.1 Loop Pipeline System

In the advanced supply system, gas infrastructure has a looped configuration. Loop system has the following advantages:

- Supply Capacity to customer will be increased because of number of injection points and potential of network construction with in the loop..
- Reliability is higher. Even if one side is blocked, gas is still available, because of bi-directional gas flow.
- Suitable for demand base supply due to a flexibility in gas supply without complex control system, since there are several gas injection points.

- System Operating Pressure can be lowered with in a loop system. Gas flow rate is maintained by supply of gas from several injection points and also potential network configuration.
- No compressor station will be required in the loop system if designed properly.



Source: Prepared by JST

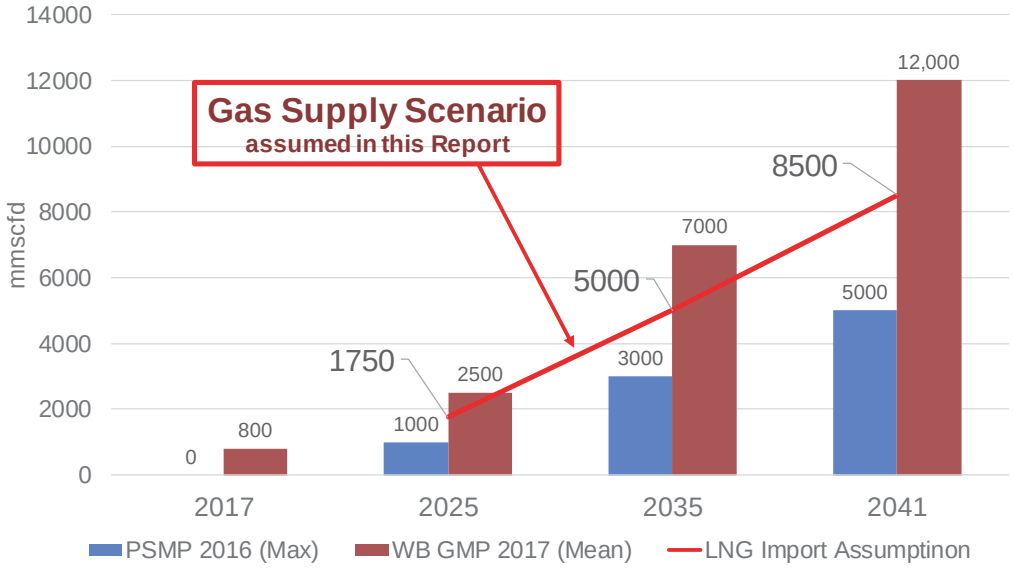
Figure 6.2.1 Concept of Loop Pipeline Supply System

6.2.2 Gas Supply Capacity and Infrastructure Development Plan

Bangladesh will be a gas importer sooner and required gas to be imported will be significant. Two Master Plans [i.e., Power System Master Plan (PSMP 2016) and Gas System Master Plans (GSMP 2017)] have been prepared and submitted to the GoB. Each has its own ground for gas demand forecast. Latent demand is considered significant and counted in GSMP 2017. Significant difference in demand forecast between the Master Plans.

The following is the gas demand forecast assumed by JST, based on PSMP in 2016 and GSMP in 2017. Note that Indigenous gas production which has not yet been confirmed or discovered is counted as gas "import" (i.e., LNG import).

Applying the average gas import assumption of PSMP2016 and GSMP in 2017, 1,750 mmscfd in 2025 and 5,000 mmscfd in 2035 are assumed in this infrastructure development scenario.



Source: PSMP, GSMP, and JST

Figure 6.2.2 Gas Import Forecast and LNG Import Assumption

(1) Gas Supply Infrastructure in 2018

Gas Latent Demand is reportedly 800-1,000 mmscfd as in a journal "Energy and Power" issued in November 2017". This demand and supply gap will be filled out by the LNG import plan as follows:

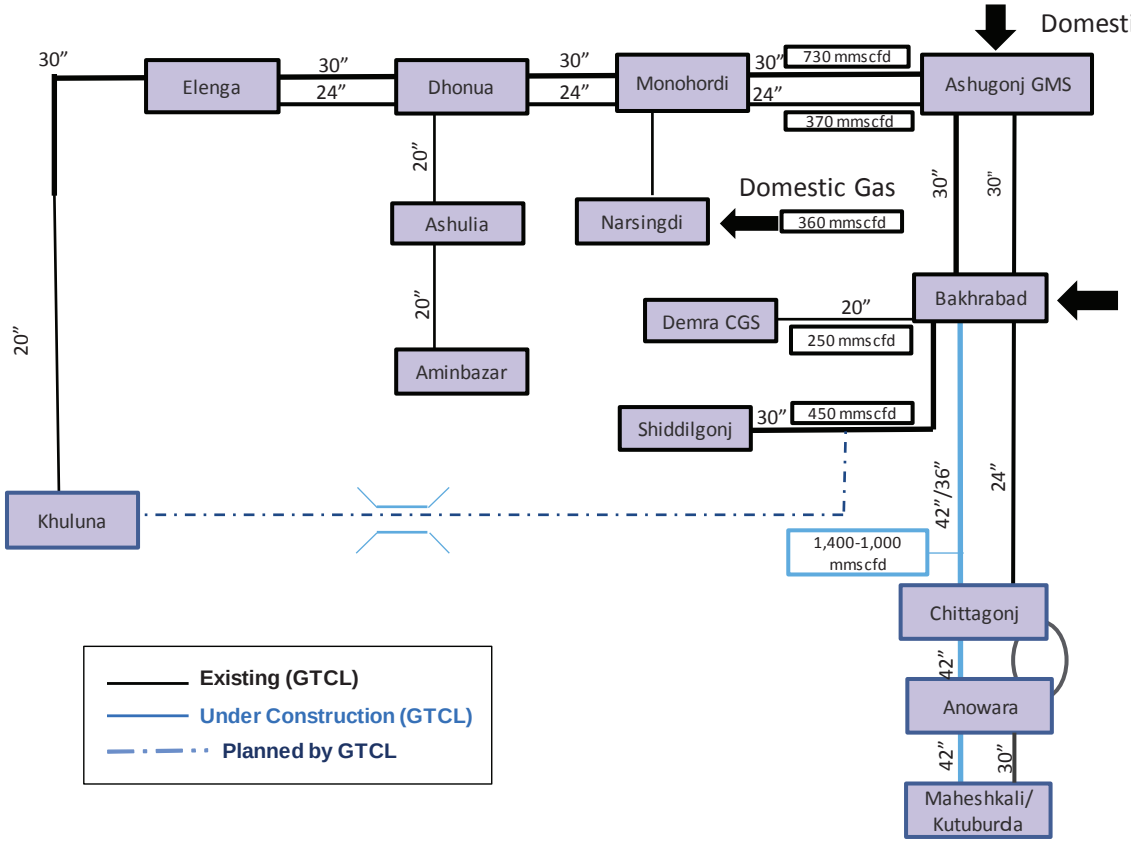
1) 500 mmscfd FSRU at Moheshkali developed by Excelerate Energy
2) 500 mmscfd FSRU at Moheshkali developed by Summit Corp.

Gas supply pipeline infrastructure is under construction as follows:

1) 30" 90 km Pipeline from Moheshkari to Anowa completed (500 mmscfd to Chittagon)
2) 36"/42" 310 km Pipeline from Mohaeshkari to Bakhrabad under construction (1000 mmscfd)

Although the infrastructure is completed, it still requires additional transmission capacity for future increasing demand.

Based on the schematic diagram incorporated in Network Infrastructure Management System, the simulation model with capacity, pressure, and length of transmission pipeline was prepared. The model of pipeline capacity with gas import is illustrated in the figure below.



Source: Prepared by JST

Figure 6.2.3 Pipeline Capacity for Gas Import (LNG) in 2018

(2) Proposed infrastructure for 2025

Gas Import of 1,750 mmscfd is assumed in 2025. To meet the requirement, some more FSRUs and part of land based LNG Terminal at Mohaeshkali/Kutubdia need to be commissioned or Payra LNG terminal to be commissioned. Expected gas supply from Payra LNG Terminal is 500 mmscfd. Import of gas from India (200 mmscfd) to Khuluna started.

Reinforcement of Transmission Pipeline from the LNG terminal to load center in Dhaka and Dhaka Loop System need to be completed to mitigate gas shortage in capital area.

Recommended Infrastructure Construction is as follows:

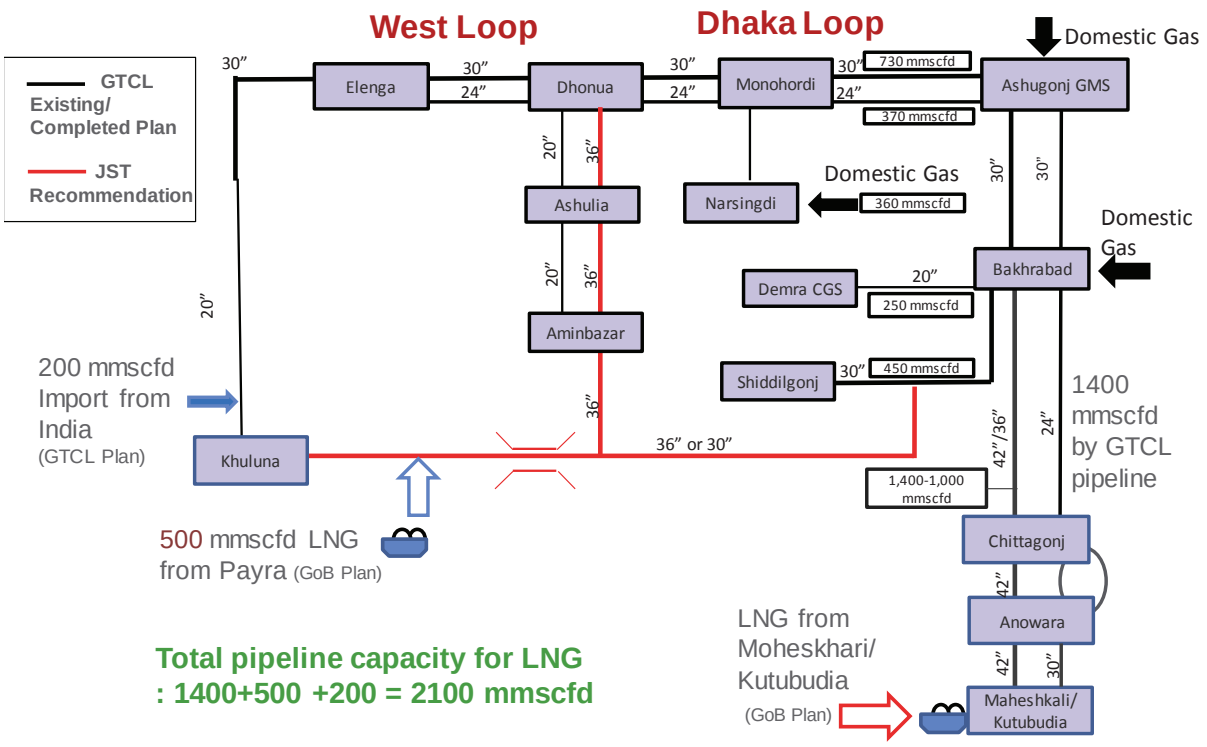
1) Dhaka Pipeline Loop Completed.

   Pipeline from Shiddilgonji to Dhonua via. Aminbazar Loop to be constructed to close the loop. All the valve stations and manifolds located on the loop will need to be reviewed and modified to allow bi-directional flow.

2) West Pipeline Loop to be completed

   Section of the pipeline from Dhaka Loop to Khuluna will be constructed to close the West Loop.

3) To fill in the requirement of gas in Bangladesh by 2035 and after, evacuation plan for 5,000 mmscfd LNG Gas from Mohaeshkali/Kutubdia to be prepared.



Source: Prepared by JST

Figure 6.2.4 Pipeline Capacity for Gas Import (LNG) in 2025

To support Loop system, LNG Import Terminal in Payra and import of gas from India to be materialized, and those contribute to injections from multiple points for Loop system.

(3) Proposed infrastructure for 2035

Gas import of 5,000 mmscfd is assumed by the year 2035. New additional LNG receiving Terminal will be constructed at Mohaeshkali/Kutubdia. Supply capacity from Moheshkali/Kutubudia to Dhaka will need to be increased further. LNG Terminal at Payra will be expanded.

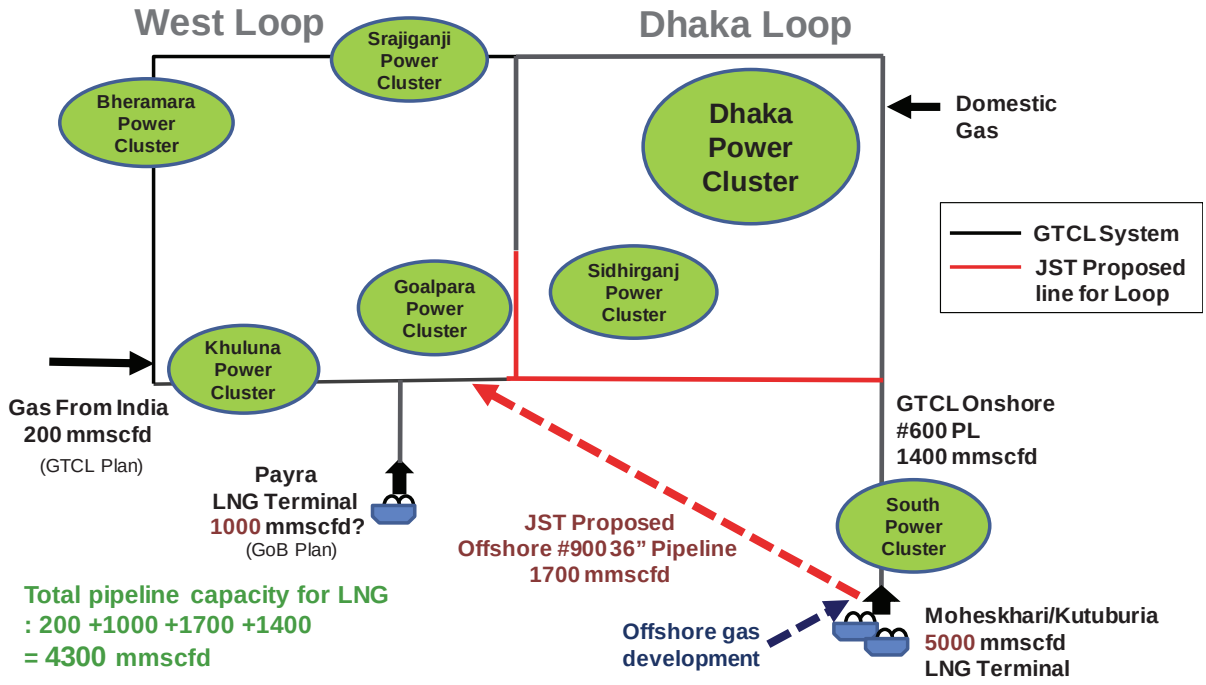
Recommended Gas Infrastructure will be:

- 36" Offshore #900 Class Pipeline (MAOP 2,160 psig) from Moheshkali/Kutubudia to west part of Padoma bridge

The recommended offshore pipeline works to transport the gas from potential offshore gas field at the border of Myanmar, where major gas fields are discovered, to main gas grid.

The gas pipeline loop is connected to power clusters in each region. The power clusters are the areas with a group of planned power stations that provide power for planned industry development in each region.

Image of the infrastructure will be as follows:



Source: Prepared by JST

Figure 6.2.5 Concept of Dhaka Loop and West Loop for 2035 with Off-shore Pipeline

6.2.3 Preliminary Evaluation of Offshore Pipeline

In general, offshore pipeline and long distance pipeline uses higher pressure rating, i.e., #900 system. In case of Bangladesh, it is considered appropriate to use the higher pressure system.

In this paragraph, #900 offshore pipeline is evaluated in a form of comparison with on-going onshore #600 ANSI Class in Bangladesh Standard, under construction:

(1) Offshore Pipeline calculation base is as follows:

1) Design Condition:

Pressure Rating:	ANSI Class #900
Size:	36 inch
Send Out Pressure:	2,160 psig
Pressure at the destination:	1,000 psig
Pipeline Length:	300 km

2) Calculation result

Calculated Flow Rate:	1,700 mmscfd
Calculated velocity at Outlet	42.7 ft/sec
Nos of required compressor station:	Zero

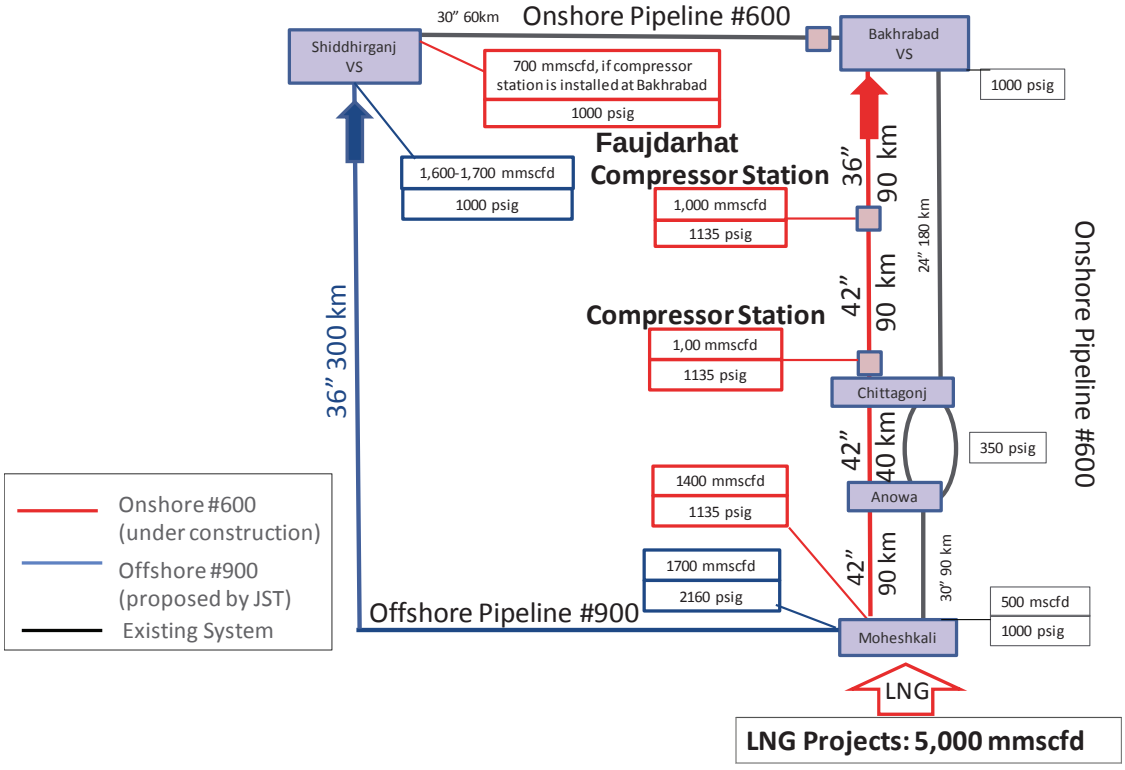
(2) Onshore Pipeline calculation base is as follows:

1) Design Condition:

Pressure Rating:	ANSI Class #600
Size:	42/36 inch
Send Out Pressure:	1,135 psig (Based on Bangladesh Standard)
Pressure at the destination:	1,000 psig
Pipeline Length:	300 km

2) Calculation result

Calculated Flowrate:	700 mmscfd to at Shiddhirganji
	1,000 mmscfd at Bakhrabad
	1,400 mmscfd at Faujarhat
Calculated velocity	24.6 ft/sec at Bakhurabad
Nos of required compressor station:	Two (2) to Bakhrabad, and Three (3) to Shiddirganji



Source: Prepared by JST

Figure 6.2.6 Pipeline Flow Calculation

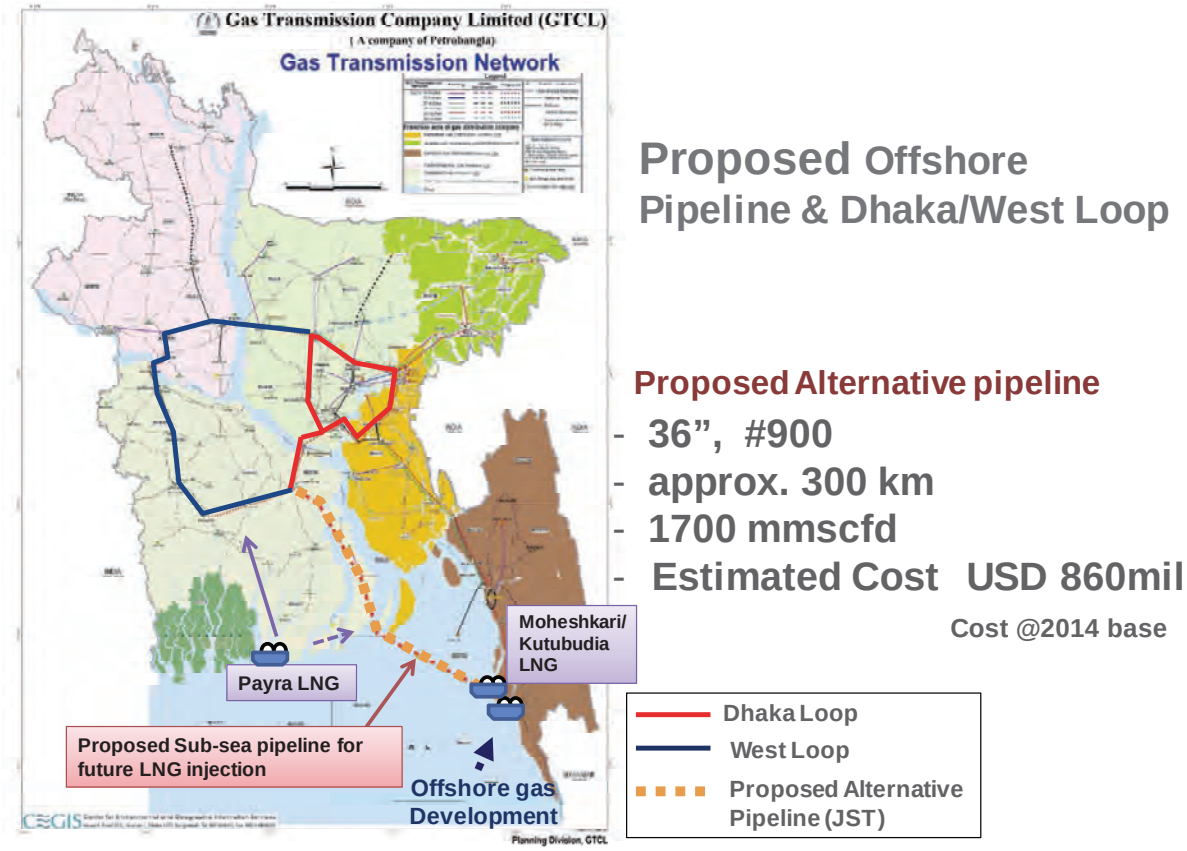
(3) Result of Case Comparison

Calculation result shows that #900 36inch pipeline from Moheshkari to Dhaka area (West Padoma Bridge) will be able to transmit 1,700 mmscfd of gas without any compressor stations.

Onshore #600 42/36-inch pipeline under construction will be able to transmit 1,000 mmscfd of gas with two more compressor stations to Dhaka area (Bakhrabad).

Considering the scale of the gas flow, 5,000 mmscfd by LNG import it is necessary to construct further pipelines in addition to ongoing 42/36" onshore pipeline. In view of the construction cost and schedule for new pipeline, offshore Pipeline will be advantageous since there is no RoW issue. It can be an option to evacuate the gas from Moheshkali/Kutubudia, and injected into Dhaka Loop and West Loop.

The following figure indicate the potential routing of the offshore pipeline. This option will not only serve the gas supply to the west part of the country and reinforce the supply system in Dhaka area but serve the support the offshore gas field development.



Source: Prepared by JST with GTCL Map

Figure 6.2.7 GTCL Gas Transmission Line Network and Proposed Sub-sea Pipeline

Regarding construction cost, offshore portion is assumed 150 km and recent similar project in North Sea is used as a benchmark and adjusted to suit. Onshore portion of 150 km is calculated based on US construction index. Total estimated construction cost will be USD 860 million +/- 30% accuracy.

6.3 Review of Performance of Gas Infrastructure Project by International Development Partners

6.3.1 Outline of Gas Infrastructure Investment Projects

Until now, Asian Development Bank (ADB) is the biggest development partner institution in the gas infrastructure investment projects in Bangladesh. The World Bank group has funded one project in the past and Gas Master Plan (GSMP) is also under preparation thanks to a technical assistance provided by the World Bank. Furthermore, Japan International Cooperation Agency (JICA) funded one project which is currently under implementation.

In the years 1980's and 1990's, ADB promoted directly development of gas fields. However, since most of gas field development projects (gas production projects) are undertaken nowadays by International Oil Companies (IOC), gas infrastructure investment projects funded by international development partners mainly consist of (i) gas transmission pipelines, (ii) gas distribution pipelines, (iii) installation of other auxiliary equipment such as compressors, and (iv) installation of gas meters for end users. Due to the shortage of available funds by Bangladesh governmental agencies, international development partners' involvements are welcomed in order to construct necessary public and common gas infrastructure needed to ensure a smooth operation of gas transmission from gas production field as well as gas distribution to final customers.

6.3.2 Asian Development Bank (ADB)

ADB's involvement in the gas infrastructure investment projects goes back to 1974 with its first technical assistance (TA) on "Energy Policy Study". Gas infrastructure investment project started also with "Greater Dacca Gas Distribution Project" accompanied by a TA in 1975. Until the beginning of year 2000's, as mentioned above, ADB financed not only transmission and distribution pipeline projects but also gas field development projects undertaken by Bangladesh governmental agencies (First, Second and Third Natural Gas Development Projects), together with several TAs aiming at institutional arrangements including promotion of private sector participation in the energy sector.

The Table below shows all gas infrastructure investment projects funded by ADB. It is noted that some projects are co-financed with other development partners ("Natural Gas Infrastructure and Efficiency Project" under implementation is the first co-financing project with Asian Infrastructure Investment Bank (AIIB)), and many of these projects are supplemented by TAs which are provided in parallel with project financing.

Table 6.3.1 List of Recent Energy Projects in Bangladesh Funded by ADB

Project Name	Funding Source	Amount (Million US $)	Date of Approval	Project Description	Current status
Dhaka Clean Fuel Project	Nordic Development Fund (loan) 9.3		Nov. 26, 2002	1. Construction of 60-km, 20-inch pipeline between Dhanua and Aminbazar 2. Construction of 97-km, 16-inch natural gas distribution pipelines in Dhaka 3. Construction of CNG filling stations in Dhaka and outside of Dhaka 4. Purchase of CNG-fueled buses and related facilities	All construction works and purchase of equipments completed
	Ordinary	42.4			
	ADF	30.2			
Gas Transmission and Development Project	Government of Norway (grant) 5		Oct. 27, 2005	1. Improvement and expansion of gas transmission pipelines and distribution network in Western part of Bangladesh (51 km, 30-inch between Monohardi-Dhanua-Elenga and Jumuna Bridge East Bank, 87 km, 30-inch between Hatikumrul-Ishwardi and Bheramara, 53 km, 12-inch between Bonapara and Rajshahi and 165 km, 20-inch between Bheramara and Khulna, and Rajshahi City gas dsitribution network) 2. Appraisal of gas fields to update estimated reserves 3. Gas sector reform to attract private investments	All works completed
	Ordinary	225			
	ADF	5			
Natural Gas Access Improvement Project	Ordinary	261	Mar. 26, 2010	1. Safety and supply efficiency improvement at Titas gas field 2. Construction of 845 km gas distribution pipelines (from 2-inch to 20-inch) in South-West Region	Under Implementation
	ADF	5			
Natural Gas Infrastructure and Efficiency Improvement Project	Ordinary	100	Nov. 18, 2016	1. Construction of 181-km, 36-inch gas transmission pipeline from Chittagong to Bakhrabad in parallel with exisiting pipeline 2. Installation of seven wellhead gas compressors at Titas gas field	Co-finance with AIIB Under Implementation
	ADF	67			
	AIIB	60			

Remarks: "Ordinary" means loans using ordinary capital resources of ADB, "ADF" means concessional ordinary capital resources lending
Development Fund, "AIIB" means Asian Infrastructure Investment Bank
of Asian

6.3.3 World Bank (WB)

WB financed one gas transmission pipeline project until now. The 60-km and 30-inch pipeline was constructed as one of the components of “Siddhirganj Power Project” with a main objective of constructing gas power plant, now modified to 335 MW combiled cycle gas-fired turbines, at Siddhirganj as advised by GTCL, located outside the metro Dhaka area. The gas pipeline was therefore built in order to ensure the availability of gas at Siddhirganj power plant (together with two other power generating sites and an export processing zone), as an extension from Bakhrabad gas processing plant which has been already connected with Ashuganj (Titas gas field).

6.3.4 Japan International Cooperation Agency (JICA)

JICA has approved one gas related project until now with an ODA loan (Yen loan) of 23,598 million Japanese yen, as shown in the Table below. This project has four components; (i) Construction of

53-km, 30-inch gas pipeline between Danua and Elenga and 14-km, 24-inch gas pipeline between West of Jamuna Bridge and Nalka, (ii) Installation of three well-head compressors at Titas gas field C and Narshingonj gas field, and (iii) Installation of prepaid meters (approximately 260,000 units).

The project is currently under implementation.

Table 6.3.2 List of Other Energy Projects in Bangladesh

Project Name	Funding Source	Amount	Date of Approval	Project Description	Remarks
Siddhirganj Peaking Power Project	World Bank (IDA)	300 Million US $	Dec. 14, 2007	1. Construction of 300 MW (two 150 MW simple cycle gas turbines) power plant at Siddhirganj 2. Construction of 60-km, 30-inch gas pipeline between Bakhrabad and Siddhirganj 3. Construction of 11-km, 230 kV power transmission line from Siddhirganj to a grid substation in south Dhaka 4. Related technical assistance and consulting services	Completed
Natural Gas Efficiency (Improvement) Project	JICA (ODA loan)	23.598 Million Yen	June 16, 2014	1. Construction of 53-km, 30-inch gas pipeline between Danua and Elenga and 14-km, 24-inch gas pipeline between West of Jamuna Bridge and Nalka 2. Installation of three welhead compressors at Titas gas field C and Narshingonj gas field 3. Installation of prepaid meters (approximately 260,000 units) 4. Rehabilitation and expansion of SCADA and related consulting services	Under Implementation

Source: Prepared by JST

6.3.5 Government of Bangladesh

The Government of Bangladesh is also financing by its own funds two gas transmission pipeline projects. One is “Capacity Expansion of Ashuganj – Bahkurabad Pipeline” (61-km, 30-inch) and the other is new construction of a gas transmission pipeline between Moheshkali and Anowara (91-km, 30-inch). The latter is intended to secure gas transmission from future Floating Storage Regasification Unit (FSRU) planned to be installed very soon in Moheshkali surrounding area.

In addition, GTCL has constructed 137 km, 36-inch Bibyana-Dohnua pipeline to transport gas from Bibyana to west area.

6.3.6 Consistency with GSMP

During this survey, JST visited a consultant company that prepared GSMP 2017 contacted from World Bank to exchange the view on the demand and supply forecast scenario and economics of LNG terminal between FSRU and Land Terminal.

This was the first attempt for consultants to meet together to improve the quantity of actual commericial data in the report. During the visit, however, issues of the Design Standard and operational issues could not be fully discussed with the consultant.

Issue of Maximum Allowable Operating Pressured (MAOP) as part of Design Standard was discussed at later stage and reached agreement that raised issue is correct and MAOP can be higher in Bangladesh. Advantage of Loop Configuration was also discussed and also reached agreement that Loop configuration is more stable than Fish-Bone Configuration. These may be incorporated in the GSMP 2017 Report.

6.3.7 Gas Transmission Network

Table 6.3.3 shows a list of major gas transmission pipelines project. Substantial part of the network was financed by ADB as well as by other international development partners mentioned above. It is easily understood that the current network of main gas transmission pipelines has been constructed by financial assistance of international development partners.

Numbers of gas projects are contributed by development partners and most of them are used for pipeline expansion.

Table 6.3.3 List of Project Supported by International Donners

Source: Petrobangla Annual Report
Unit: Million BDT

	Name of the Project	Project Period		Executing Agency	Estimated Cost	Development Partner
		From	To			
1	Installation of Compressor Stations at Ashuganj and Elenga	Jan'06	Sep'17	GTCL	14,941	ADB
2	Hatikumrul-Bheramara Gas Transmission Pipeline Project (30" x 98.1 km)	July'06	Dec'16	GTCL	7,269	ADB
3	Bonpara-Rajshahi Gas Transmission Pipeline Project (12"x 53 km)	July'06	Dec'14	GTCL	1,835	ADB
4	Bheramara-Khulna Gas Transmission Pipeline Project (20" x 162.5 km)	July'07	Dec'15	GTCL	9,038	ADB
5	Bakhrabad-Siddhirganj Gas Transmissin Pipeline Project (30"x 60 km)	July'07	June'16	GTCL	8,000	WB/IDA
6	Natural gas Efficiency Project (Welhead Compressor at Titas Gas Field C and Narshingonj gas field)	July'14	June'18	BGFCL	8,686	JICA
7	Natural gas Efficiency Project (Dhanua-Elenga and W of Jamuna Bridge-Nalka Gas Transmission Pipeline 30"x53km, 24"x14 km)	July'14	June'19	GTCL	9791.76	JICA
8	Gas transmission capacity expansion Project (Ashuganj=Bahkurabad (30"x 61 km)	Jan'10	june'16	GTCL	7,434	GoB
9	Moheshkhali-Anowara Gas Transmission Project (30" x 91 km)	Jan'13	June'16	GTCL	9,819	GoB
10	Muchai=Ashuganj Compressor Station Installation Project	Jan'06	June'13	GTCL	304.08 Crores	ADB
11	Monohordi-Danua, Elenga-east Bank of Jamna Bridge (30"x 103 km) and Installation of compressor station at Ashugnji and Elenga	Jan'06	Dec'12	GTCL	834.62 Crores	ADB
12	West Bank jamuna Bridge-Nalka, Halikumrul, Iswardi, Bheramara 30"x 98.1km Gas Transmission Pipeline	July'06	Dec'13	GTCL	628.7 Crores	ADB
13	Rehabilitation and Expansion of Existing SCADA (Supervisory Control and Data Acquisition System)	Jan'13	June'16	GTCL	2940,04	JICA
14	Natural gas Efficiency Project (Prepaid Meter for KGDCL)	July'14	June'19	KGDCL	2,466	JICA
15	Natural gas Efficiency Project (Prepaid Meter for TGTDCL)	July'15	Dec'18	TGTDCL	7,121	JICA
16	South West Region Gas Distribution Network Project	Jan'10	Sep'15	SGFL	6,000	ADB

It was found that specification and standard of pipelines differs project by project, and standard specification and design standard is not commonly applied in the above projects.

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6.4 Draft Policy Recommendation on Gas Supply and Gas Price

6.4.1 Diversification of Gas Supply

It is probable that the supply of natural gas will fall very short in meeting domestic demand in Bangladesh in the coming years, and Bangladesh needs to expand gas supply through diversified sources. LNG import is a realistic solution given the current international spot market price as well as an expected long term contract price, for which terms of supply have become more flexible than before. Thanks to new discoveries of offshore natural gas reserves in Myanmar, import from Myanmar is also worth examining in the long run, as suggested in GSMP, although this solution is not applicable immediately given various geo-political difficulties. It is not also to be forgotten to make efforts in developing domestic gas fields and increasing gas production not only of onshore existing fields bur also of new offshore fields attracting as much as possible international oil companies (IOC) by introducing attractive product sharing contract (PSC).

Construction of LNG receiving terminals is an urgent issue requiring detailed and realistic executing plan as well as necessary funding of projects. If import of natural gas from Myanmar becomes feasible in future, construction of a gas pipeline between two countries will also be necessary.

6.4.2 Gas Price Reform

Table 6.5.1 shows "Current Gas Tariff at consumer level for Gas Distribution Companies" as determined by Bangladesh Energy Regulatory Commission (BERC) on 23 February 2017.

Table 6.4.1 New Gas Tariff at consumer level for Gas Distribution Companies

Memo No.: BERC/Tariff/Gas-12/T&D/Part-1/085 Date: 23 February 2017

Sl. No.	Category of Consumers	Tariff (BDT/cum)	
		with effect from1 March 2017	with effect from 1 June 2017
1	Electricity	2.99	3.16
2	Captive power	8.98	9.62
3	Fertilizer	2.64	2.71
4	Industry	7.24	7.76
5	Tea garden	6.93	7.42
6	Commercial	14.20	17.04
7	CNG	38.00	40.00
8	Domestic		
	Meter based	9.10	11.20
	Single Burner (Fixed per month)	750.00	900.00
	Double Burner (Fixed per month)	800.00	950.00

1) The tariff of CNG in phase-1 and phase-2 included BDT30.00 and BDT32.00 respectively for feed gas and BDT 8.00 for Operator margin in both phases.
2) The other terms and conditions for gas distribution will remain unchanged.

Source: Bangladesh Energy Regulatory Commission (BERC)

There are three LNG Pricing System in Asia, i.e., 1) traditional long term oil linked pricing system, 2) NBP linked pricing system, 3) US henry Hub linked pricing system. CIF or DES in December 2016 in Japan is USD 8.00/MMBTU, and in Europe (UK) USD 5.88/MMBTU. While Henry Hub price is

USD 2.82/MMBTU. This Henry Hub Price is translated to FOB price of USA at USD 7.00/MMBTU, and CIF price in Japan is USD 9.00-10.00/MMBTU.

LNG requirement in Europe is determined by Market, and only the occasion of import is based on price and requirement dictated by the Market on a spot basis. At this stage, this is the cheapest LNG in the world, and mostly provided by Qatar. There is a possibility for Bangladesh to acquire NBP linked LNG from Qatar but may be limited amount. The most realistically LNG CIF price at Bangladesh will be USD 6.00-8.00/MMBTU for the time being.

Other than CNG of which price is linked with international oil price, the domestic gas price is low compared with LNG. From Table 6.5.1, it is estimated that gas price for electricity and fertilizer is about 0.9-1.1 USD/MMBTU and gas price for industry and tea garden is around 2.5-2.7 USD/MMBTU.

Consequently, it is obvious that there is a huge gap between domestic gas sales price in Bangladesh as we see at present and predominant international LNG or natural gas price. If Bangladesh begins to import considerable volume of gas and intends to fill such price gap with subsidies, financial deficit of the Bangladesh government will certainly accumulate to an unaffordable level.

Under such circumstances, if Bangladesh government's financial situation is deteriorated to a level unacceptable by international development partner agencies, they would become reluctant to provide new loans to infrastructure projects in Bangladesh. As a result, development of infrastructure in Bangladesh would be hampered, leading to a possible deceleration of economic growth.

It is therefore unavoidable for the Bangladesh government to raise gas price, taking into consideration of the current and future international gas price and the most appropriate long term scenario for gas price reform, as suggested in the PSMP 2016.

As mentioned in the PSMP 2016, the Bangladesh Energy Regulatory Commission Act 2003 (BERC Act 2003), in its Chapter 6, article 34, paragraph 2(b), stipulates that it is necessary "to harmonize the tariff with the cost of production, transmission, marketing, distribution, supply and storage of energy". This text does not seem to be taken into consideration the coming new situation where the cost will increase tremendously driven by LNG import. If and when Bangladesh revises the BERC Act 2003, the harmonization with international gas market price should also be taken into consideration.

Hence, it is important to consider increasing the natural gas price progressively to reduce the gap with the international market price of natural gas so that the further increase of financial deficit in the national budget is minimized as much as possible.

The gas tariff was increased in February 2017 as in Table 6.5.1. In addition, ERC has increased gas tariff again in June 2017, but Supreme Court cited that laws prohibit the energy regulator from changing tariffs more than once in a fiscal year unless fuel prices change, and second tariff increase is repealed

Determination of gas price based on post-LNG import evidence will be taken after LNG import starts. For the preparation of gas tariff increase scenario, strong governmental leadership is inevitable with

formulation of consensus. Mixing domestic gas with LNG gas supply will take a role for tariff scenario with soft landing.

Since gas price increase affects various sectors and daily life of many vulnerable people in Bangladesh, various transitional scenarios should be examined to mitigate the impact trough the adjustment of tariff for each sector consumers, and use of domestic gas mix as a buffer to mitigate the impact while minimizing the financial risk to GoB.

6.4.3 Recommendations for Investment/Loan Arrangement for Gas Infrastructure

(1) Lessons from Past Projects

As explained in Section 6.1, it is necessary to determine firstly the most suitable and adequate (efficient) specification of gas transmission pipeline in Bangladesh and secondly to introduce and apply such specification in all future related projects either financed by international development partners or by Bangladesh Government own funds. This common and unified specification is also very important in order to secure a smooth operation of gas transmission over all territory of Bangladesh.

(2) Ways to Go

We consider that following steps urgently need to be taken.

(1) Development partners meeting to get a common understanding on the necessity of formulating a unified specification of gas transmission pipeline, including auxiliary equipment, and Basic Infrastructure Development Plan (BIDP), i.e., from Fish Bone Structure to Loop Structure.
(2) Formulation of a technical assistance with an objective of engaging international qualified consultant(s) to elaborate above-mentioned unified specification, higher qualification system need to be in place and make it common among the international development partners.
(3) At each step of elaboration of unified specification and review of BIDP, development partners' meeting is also necessary to secure consensus of all development partners.

When unified standards and specifications are adopted, these design basics are always to be agreed upon when Government of Bangladesh concludes a loan or grant agreement with international development partners. Such updated standard specifications and designs should also be shared among governmental agencies and related companies.

CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1 Challenges facing with Bangladesh Energy Sector

There are challenges facing with Bangladesh energy sector as in the following areas:

(1) Missing system integrity and lack of design standard

Integrity of gas transmission and distribution system has not been reviewed in the past. There is no common design philosophy and standard commonly applied in all organizations in Bangladesh. Applicable standard and design These philosophies are differently selected from project to project.

There is no centralized information management system, and no asset register is maintained, and no system for physical asset verification is in place, and therefore, there is no way to assess the integrity of infrastructure. Advanced infrastructure management system including asset and document management should be introduced.

(2) Operation mode change

Operation mode will change from the current "Gas Allocation System" to "Supply to Demand Base System". Operators in gas supply side need to know gas demand profile beforehand and send the gas to meet the actual demand profile. Advanced operation system must be designed to integrate the system from gas fields/LNG terminals to downstream customers. Current Fish Bone system should be modified to Loop System.

(3) Insufficient pipeline capacity for future LNG import

Current pipeline system plan will be insufficient after large amount of gas from LNG import is injected. The pipeline expansion plan should be consistent with LNG import plan.

(4) Absence of LNG import regulation

LNG will be introduced by several different entities. Nature of LNG may also differ from sources to sources. These gases are also mixed with domestic gases in gas transmission system. Different from electricity transmission, gas flow speed is slow. Due to a gas delivery time lags created by pipeline transmission system, proportion of gas mixture may change with the supply profile. Supply profile is the variation of supply to cope with different types of demand such as peak demand and base load demand. LNG may be used to supply to a base load profile, while domestic gas may be used to fill out a middle/peak shaving profile portion. To accommodate these issues, central monitoring and control system should be introduced. As the minimum requirement and at least the following system should be introduced:

- Capacity Right for gas transmission by each supplier
- Quality Bank to rationalize the difference in specification and pricing.

System design must be done by professionals in this sector.

(5) Lack of gas and power infrastructure integrated plan

Current pipeline development plan does not consider gas power and industry development plan. The infrastructure development plan should be coordinated among gas, power, and industry sectors considering future demand and supply quantity. System for sector-wise infrastructure planning should be introduced.

(6) Lack of centralized data and document management system

There is no centralized data and document management system, and thus important drawings, specifications, and other technical documents are dispersed and lost.

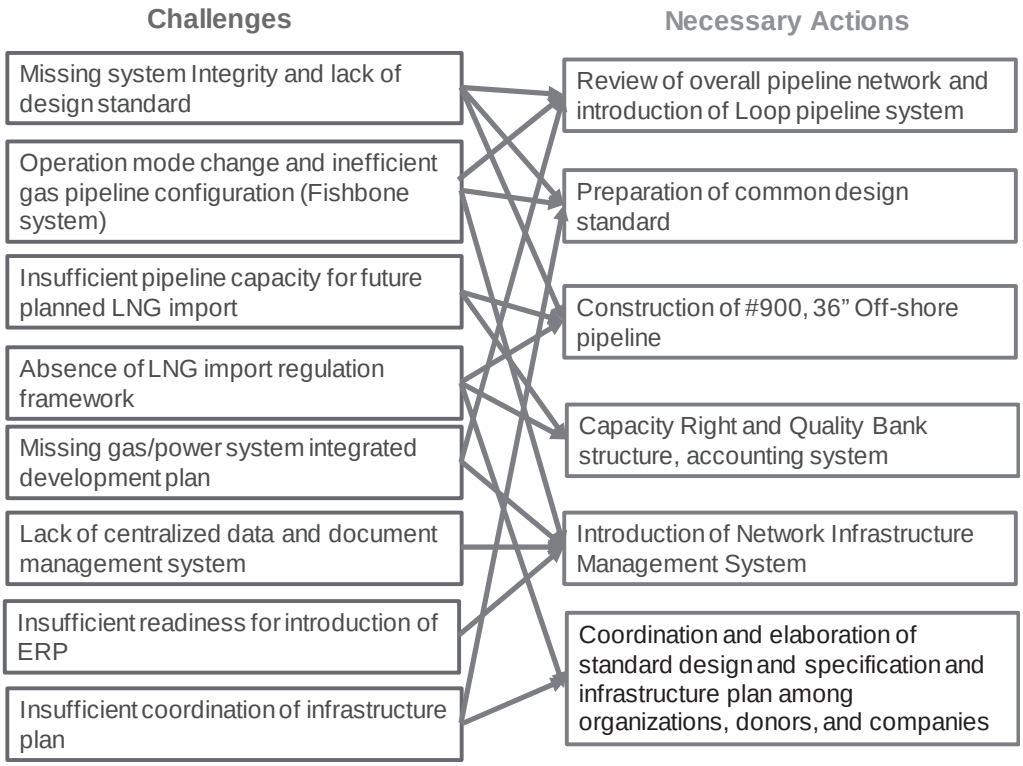
(7) Insufficient readiness for introduction of ERP

Introducing ERP should be designed to solve the issues of the above. However, ERP need to be designed and customized according to each organization's requirement, and system elaboration is necessary. It will be a long-term effort to build ERP and can be achieved through the framework of technical cooperation project.

(8) Insufficient coordination of infrastructure plan among development partners

Coordination among organizations, development partners, and project owners is insufficient in the infrastructure development especially shearing plans and common specification and design standard. It is necessary to determine firstly the most suitable and efficient specification of gas transmission pipeline in Bangladesh and secondly to introduce and apply such specification in all future related projects either financed by international development partners or by the Government own funds.

The issues and challenges and necessary actions are summarized in the following figure.



Source: prepared by JST

Figure 7.1.1 Summary of Challenges and Necessary Actions in Bangladesh Energy Sector

Necessary actions to cope with above challenges are summarized in the figure above, which are:

- Review of overall pipeline network and introduction of Loop pipeline system
- Preparation of common design standard
- Construction of #900, 36" Off-shore pipeline
- Establishment of Capacity Right and Quality Bank structure system and accounting system
- Introduction of Network Infrastructure Management System
- Coordination between government agencies, companies, and development partners and elaboration of unified specification with qualified consultants

7.2 Recommendations and Conclusion

7.2.1 Introduction of Network Infrastructure Management System

To cope with the challenges as described in Chapter 7.1, advanced data management system is inevitable, among several proposed solutions. Reviewing current infrastructure status by drawings and specification documents in detail is necessary to prepare the plan and design for future infrastructure.

However, required data(s) were not in centralized manner nor updated as a matter of fact. There were no structured way of book keeping system in the organization to take care of drawings and specifications. These were mostly kept at a personal level and sometimes dispersed or discarded during office shifting or transfer/retirement of personnel etc.

Under such circumstances, personal influence and connection was also crucial factor to carry out such data collection activities. Without personal influence and relationship with the officers who supposed to own documents, data collection work would be a challenging task and take longer tine.

In order to improve the situation, data management organization and supporting system must be in place to facilitate an access to the data/information by engineers, operators and service contractors, etc.

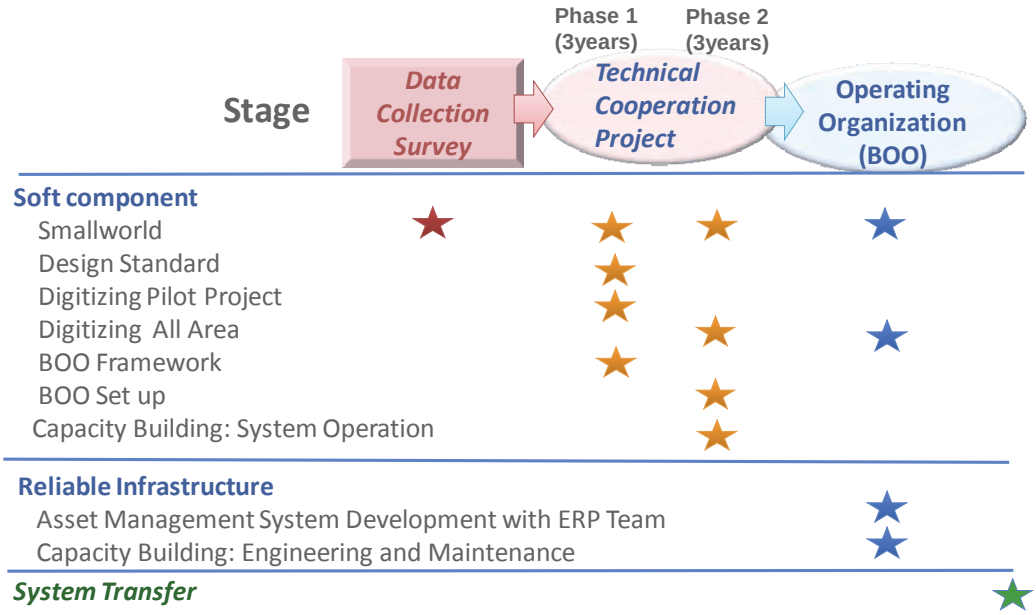
The data must be digitized and the digitized component must be stored in the database, ideally as an object. JST recommend digitizing the gas and power network infrastructure by use of "Smallworld". By which "Network Infrastructure Management System" is constructed reflecting physical infrastructure in the computer system and used as a base for asset management and facilitate application of various analytical tools.

7.2.2 Next Step: Proposed Technical Cooperation (T/C)

It is recommended to use the framework of Technical Cooperation (T/C) Project. Exact program should be discussed and agreed upon with the counterpart in Bangladesh before commencement of Technical Cooperation Program.

Construction of "Network Infrastructure Management System" and capacity building T/C is important to achieve efficient use of gas and modernize the gas operation and management system. For O&M sustainable body of advanced Network Infrastructure Management System in the future after T/C, Build, Operation, Transfer (BOT) model is an idea. The feasibility of such BOT body need to be assessed.

The overall project road map is as shown in the figure below.



Source: Prepared by JST

Figure 7.2.1 Overall Project Road Map

The proposed components of T/C for discussion are as follows. The details will be discussed in the later stage.

(1) Proposed Overall Goal

To modernize the Gas and Power Operation System in a technically and financially sustainable manner so that Gas and Power Infrastructure can be more reliable to contribute to the economic growth of the country

(2) Proposed T/C Purpose

To develop human resources and implementing organization, and establish integrated and advanced gas and power asset management system

(3) Proposed Outputs

1) Network Infrastructure Management System covering selected pilot area in Bangladesh to be constructed. Initial target pilot area will be GTCL Pipeline System, and TGTDCL, BGDCL, KGDCL, or JGTDCL, PBCB, BPDB, DESCO Franchise Areas

2) Capacity building on planning, design, maintenance, and operation safety is conducted and standard is prepared achieve advanced control, asset management and operation safety in gas sector

3) Human resources are developed to attain efficient and harmonized operation of gas and power sectors

4) Institutional structure for provisional organization of gas and power asset management to be founded

(4) Proposed T/C Site

T/C site covers Dhaka and other areas in Bangladesh, including locations of gas transmission systems and all the gas distribution franchise areas, and power plants and grid systems.

(5) Proposed T/C Activity (Provisional, for discussion)

1) Network Infrastructure Management System covering selected pilot area

i. Updated pipe alignment drawings, including transmission and distribution system.

ii. Pipe location to be identified and recorded and digitized.

Since majority of pipe distribution drawings are missing or not readable or exact location was not recorded, exact location must be identified by using Subsurface Object Detection which is one of the effective way to locate the pipe without digging soil.

iii. Create and update data model of power network facility

iv. Update of power sector facility to incorporate soft infra.

v. Create/Update Soft infra model (pilot area)

2) Capacity Building and Design Standard

i Update Process Flow Diagram from gas field to distribution

ii. Review of past maintenance record and assess system integrity

iii. Flow analysis through the use of computer simulator

iv. Prepare and update unified design standard

v. Keep track of Cathodic Protection System

vi. Accident Data Collection, Route Cause Analysis

vii. Prepare Preventive Maintenance and safety plan to minimize the risk of accident and system loss

viii. Prepare Emergency Transaction Plan

ix. Prepare Guidelines/Manual of the above

3) Gas and Power Integrated System Operation

i. Integrated gas operation from gas field, transmission system, to distribution system, and power plants.

ii. Assist continuous monitoring of gas/power through SCADA

4) Institutional Structure for Asset Management

i. Plan for asset management organizational structure

ii. Preparation of financial and operation framework

iii. Organization, regulation, and document preparation for government approval

iv. Transfer of system to operational body

(6) Proposed Input from Counterpart

For the successful implementation of technical cooperation project, the committed input from counterpart is important:

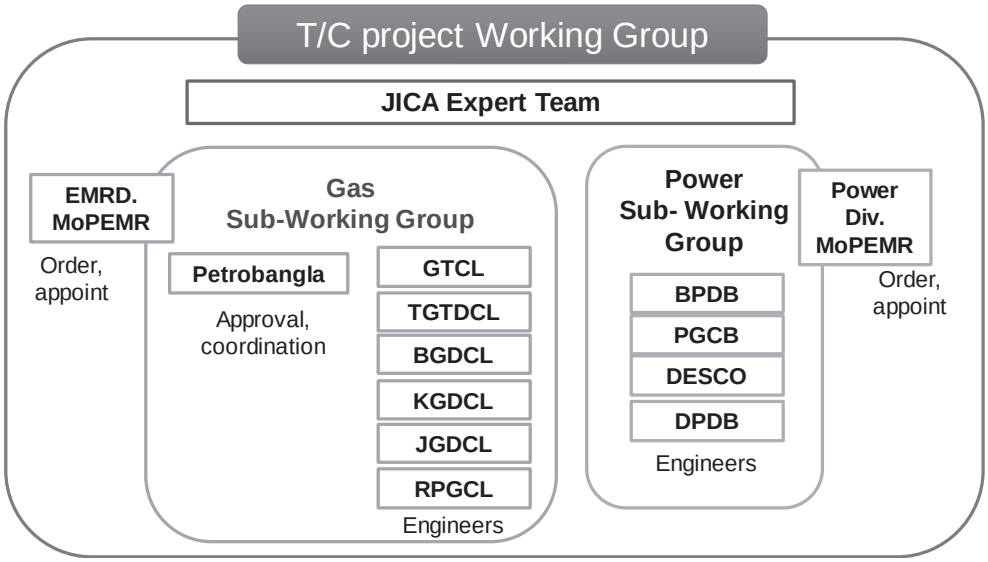
- Allocation of project manager and support staff
- Building of working group among concerned gas and power organizations
- Full time involvement of engineers for project activity in the working group
- Office and equipment for project room

(7) Proposed JICA Expert Team

The following fields of experts are proposed as the member of JICA Expert Team

- Team leader/ gas system specialist
- Network Infrastructure Management System specialist (modeling)
- Network Infrastructure Management System specialist (capacity development)
- Network Infrastructure Management System specialist (database creation)
- Geographical Information System (GIS) Specialist
- System Engineer (information communication system)
- Pipeline engineer (planning and operation)
- Pipeline operation and safety specialist
- Process engineer (gas flow analysis and process design)
- Design engineer (standard and mechanical engineering)
- Electrical engineer (power generation)
- Electrical engineer (transmission/distribution)
- Institutional specialist
- Financial specialist
- Human resource and training expert

Working Group consists of engineers of related gas and power companies are proposed for implementation of T/C activities. The proposed working group structure is as shown in the figure below.



Source: Prepared by JST

Figure 7.2.2 Proposed Structure of Working Group

7.3 Further Recommendation on Future Projects in Gas Sector

This section describes recommendations about future projects that can be carried out to improve and/or maximize the performance in gas sector.

(1) Engineering and Construction of LNG Tank Terminal

The Technology to design and construct 230,000 m^3 LNG tank, the largest in the world, with seismic design is can be provided. Use of larger LNG tank allows to accommodate Q-Max LNG tankers to minimize the transportation cost.

Note that Q-Max LNG tanker size is 345 m long, 53.8 m wide with a draft of 12 m. The tanker has a LNG capacity of 266,000 m^3.

(2) Cryogenic Power Generator as part of Vaporization Facility

Cold energy is released when LNG is vaporized by a vaporizer. Cryogenic Power Generator is to recover the cold energy and utilize it for power generation. Special type of vaporizer is necessary for Cryogenic generation. Maximize the use of cold heat by recovering electric power will save electric energy and thus contribute to CO_2 emission reduction. Available power unit is 6000 kW, in case LNG vaporization capacity is 150 ton/hr, for example.

(3) LNG Terminal Operation

On Job Training Program for LNG terminal operation can be arranged as program of capacity building

(4) LNG Contract Strategy

Japan is the largest importer of LNG in the world and also investor to various LNG development project. Japanese entities including utility companies and/or trading houses would be able to provide consultancy training to Bangladesh

(5) Pipeline System Simulation

Capacity building in hydraulics of pipeline system to enhance the capability in reviewing the operation performance and in planning of expansion project. High Performance Simulator, commonly used in Japan, may be introduced in Bangladesh. Training is part of the program.

(6) Pipeline System Maintenance and Construction Technologies

Training opportunity can be arranged as part of capacity building

Japanese gas and power companies have developed their own LNG import and gas transmission system for the last 40 years. There are numbers of areas in which the entities can assist in developing in the same fields in Bangladesh. In case Bangladesh requests, Government of Japan may consider.

In addition to the above, there are several related matters which are not in the scope of the Study but important for future Bangladesh energy sector. Such issues are indicated as follows:

(1) Provision of Export Insurance

There may be possibility to provide export insurance for the purchase of LNG cargo arranged by Japanese business entity. This will contribute to the stable supply of energy for Bangladesh.

(2) Methane Leakage Prevention Program

Special care is required to develop gas field due to a fragile nature of strata and reservoir sandstones. Four major blowouts have occurred in the Sylhet area, and significant amount of gas resources were lost. Gas is still leaking out to the atmosphere from these blown out wells. Methane, the main component of natural gas, is a strong greenhouse gas which influences on global warming twenty-five times than CO_2. Collection and utilization of leaking methane will contribute to emission reduction of greenhouse gas effectively.