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

Preparatory Survey on The Natural Gas Efficiency Project in The People's Republic of Bangladesh

FINAL REPORT

March 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.

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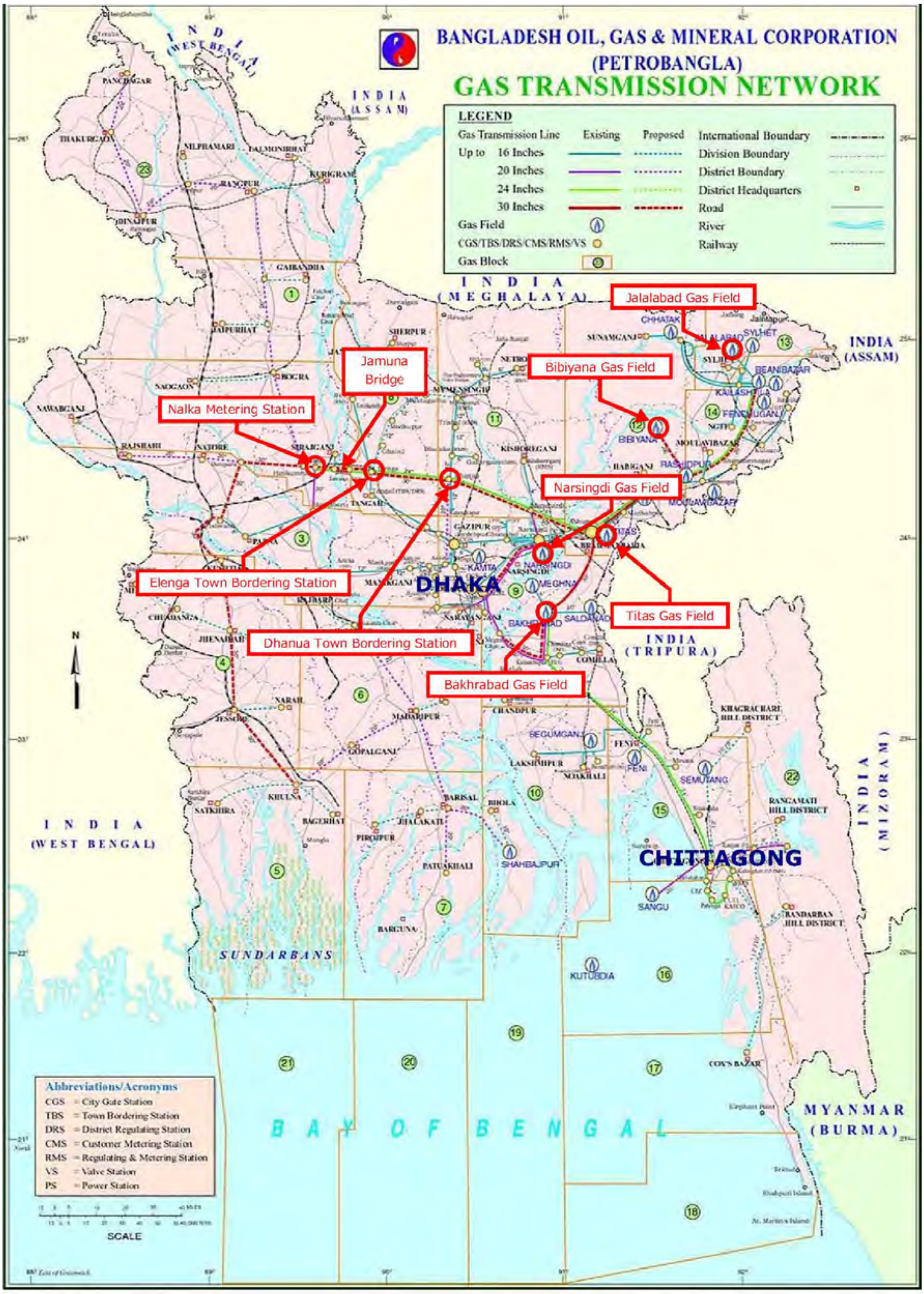

BANGLADESH OIL, GAS & MINERAL CORPORATION
(PETROBANGLA)
GAS TRANSMISSION NETWORK
LEGEND
Gas Transmission Line
Existing
Proposed
Up to 16 Inches
20 Inches
24 Inches
30 Inches
Gas Field
CGS/TBS/DRS/CMS/RMS/VS
Gas Block
International Boundary
Division Boundary
District Boundary
District Headquarters
Road
River
Railway
Jalalabad Gas Field
Jamuna Bridge
Bibiyana Gas Field
Nalka Metering Station
Narsingdi Gas Field
Elenga Town Bordering Station
Titas Gas Field
Dhanua Town Bordering Station
Bakhrabad Gas Field
DHAKA
CHITTAGONG
INDIA (WEST BENGAL)
INDIA (ASSAM)
INDIA (MEGHALAYA)
INDIA (TRIPURA)
INDIA (MIZORAM)
MYANMAR (BURMA)
BAY OF BENGAL
SUNDARBANS
Abbreviations/Acronyms
CGS = City Gate Station
TBS = Town Bordering Station
DRS = District Regulating Station
CMS = Customer Metering Station
RMS = Regulating & Metering Station
VS = Valve Station
PS = Power Station
SCALE

Survey Area

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Abbreviations

AAO	Assistant Account Officer
ADB	Asian Development Bank
AE	Assistant Engineer
AIT	Advanced Income Tax
ARAP	Abbreviated Resettlement Action Plan
BAPEX	Bangladesh Petroleum Exploration & Production Company Limited
Bbl	Barrel
BCF	Billion Cubic Feet
BERC	Bangladesh Energy Regulatory Commission
BGFCL	Bangladesh Gas Fields Company Limited
BGSL	Bakhrabad Gas System Limited
BIWTA	Bangladesh Inland Water Transportation Authority
BPDB	Bangladesh Power Development Board
BRT	Bus Rapid Transit
BUET	Bangladesh University of Engineering & Technology
CBE	Commercial and Business Enterprise
CBM	Coal Bed Methane
CGS	City Gate Station
CNG	Compressed Natural Gas
CP	Cathodic Protection
DC	Deputy Commissioner
DCCI	Dhaka Chamber of Commerce and Industry
Deg. F	Degrees Fahrenheit
DHI	Direct Hydrocarbon Indicator
DoE	Department of Environment
DPP	Development Project Proposal
DRS	Direct Regulating Station
ECA	Environmental Conservation Act
ECC	Environmental Clearance Certificate
ECR	Environmental Conservation Rules
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan

EMRD	Energy and Mineral Resources Division
EPC	Engineering, Procurement, Construction
FGD	Focus Group Discussion (Method)
FIRR	Financial Internal Rate of Return
FWHP	Flowing Wellhead Pressure
GDF	Gas Development Fund
GOB	Government of the People's Republic of Bangladesh
GRC	Grievance Redress Committee
GTCL	Gas Transmission Company Limited
HCU	Hydrocarbon Unit
HDD	Horizontal Directional Drilling
HP	Horse Power
IEE	Initial Environmental Examination
IICT	Institute of Information and Communication Technology
IDC	Interest During Construction
IMF	International Monetary Fund
IOC	International Oil Company
IP	Internal Protection
IP	Internet Protocol
JGTDSL	Jalalabad Gas Transmission and Distribution System Limited
JICA	Japan International Cooperation Agency
JVIT	Joint Verification Inventory Team
KGDCL	Karnaphuli Gas Distribution Company Limited
L/A	Loan Agreement
L/C	Letter of Credit
LCB	Local Competitive Bid
LNG	Liquefied Natural Gas
MMSCFD	Million Standard Cubic Feet per Day
MOF	Ministry of Finance
MoPEMR	Ministry of Power, Energy and Mineral Resources
NSAPR	National Strategy for Accelerated Poverty Reduction
ODA	Official Development Assistance
OGM	Oil and Gas Manager
OJT	On the Job Training
O&M	Operation & Maintenance
PAP	Project Affected Person

PEA	Process Economic Analyser
PGM	Pre-paid Gas Meter
PGCL	Pashchimanchal Gas Company Limited
PIU	Project Implementation Unit
PMO	Project Management Office
POS	Point of Sale
PQ	Pre-qualification
Psi	Pound per Square Inch
Psig	Pound per Square Inch (Gauge)
PSOC	Pakistan Shell Oil Company Limited
PVAC	Property Valuation Advisory Committee
RAJUK	RajdhaniUnnayan Kartripakkha
RAP	Resettlement Action Plan
ROW	Right of Way
SAE	Sub Assistant Engineer
RU	Resettlement Unit
SC	Steering Committee
SGCL	Sundarban Gas Company Limited
SLA	Subsidiary Loan Agreement
SSL	Secure socket layer
S/P	Statement of Performance
TB	Thrust Boring
TGTDCL	Titas Gas Transmission and Distribution Company Limited
TOC	Total Organic Carbon
TOR	Terms of Reference
UPS	Uninterruptible Power Supply
VAT	Value Added Tax
VPN	Virtual private network
WACC	Weighted Average Cost of Capital
WB	World Bank
WTI	West Texas Intermediate

Executive Summary

1. Introduction

Natural gas is the major indigenous resource in Bangladesh and is indispensable for the economic growth of the country.

However, in recent years, the supply of natural gas has been insufficient to meet the demand which has rapidly increased along with the fast growth of the economy. Major reasons for the shortage of natural gas are as follows:

- Delay in the development of new gas fields
- Delay in the improvement of transmission infrastructure
- Inefficient usage of natural gas

Under these circumstances, Japan International Cooperation Agency (JICA) implemented the "Data Collection Survey on Bangladesh Natural Gas Sector" (January 2012), and conferred with the government of the People's Republic of Bangladesh ("GOB") to clarify the bottlenecks in the development of the natural gas sector, and examine the possibility of assistance from JICA to the natural gas sector.

As a result of the above process, the following project components were requested from GOB for the development of the natural gas sector with the assistance of JICA.

Table ES-1 Project Components Requested by GOB

Project Components				Executing Agency
(1)	Development of Gas Production Fields			
	1)	Bakhrabad Gas Field	(Drilling & Well head gas compressors)	BGFCL
	2)	Narsingdi Gas Field	(Well head gas compressors)	BGFCL
	3)	Titas Gas Field	(Well head gas compressors)	BGFCL
(2)	Construction of Gas Transmission Pipelines			
	1)	Dhanua – Elenga	30 inch x 52 km (parallel)	GTCL
	2)	West Bank of Jamuna Bridge – Nalka	30 inch x 14 km (parallel)	GTCL
	3)	Jalalabad – Bibiyana	24 inch x 54 km (new)	GTCL
	4)	Bakhrabad – Chittagong	30 inch x 201 km (new)	GTCL
	5)	Langalband – Maowa	30 inch x 40 km (new)	GTCL
(3)	Construction of Gas Distribution Pipelines			

Project Components				Executing Agency
	1)	River crossing pipelines by HDD (12 sites)	12–16 inch (parallel)	TGTDCL
	2)	Rehabilitation of existing critical pipelines	6–12 inch x 103.5 km	TGTDCL
	3)	Reinforcement of Chittagong ring main	24 inch x 5.5 km (parallel)	KGDCL
(4)	Installation of Pre-paid Gas Meters			
	1)	300,000 units in Dhaka		TGTDCL
	2)	20,000 units in Chittagong		KGDCL

This preparatory survey was carried out in order to analyse the necessity and feasibility of these projects, and provide necessary information for JICA to determine if the project is appropriate for assistance under a Japanese ODA loan.

This “Natural Gas Efficiency Project” should contribute to the mitigation of the supply-demand gap and also to promote stable and efficient gas supply by providing the equipment and facilities that improve production, transmission and efficient use of natural gas. Consequently, it will contribute to the economic development of Bangladesh.

2. Overview of the Natural Gas Sector

Natural gas is the key domestic natural resource in Bangladesh, and Bangladesh is highly dependent on natural gas. Therefore the augmentation of natural gas supply as well as the introduction of alternative energy is required for the best energy mix.

Although economic activities in Bangladesh are highly dependent on natural gas, the supply of natural gas has been insufficient to meet the demand in recent years. According to the latest information from Petrobangla, the current gas supply is approximately 2,300 mmcfd against the demand estimated at 2,800 mmcfd as of July 2013, and it is anticipated that gas production will start decreasing from 2020 due to depletion of production wells while demand continues to increase.

Furthermore, the natural gas price in Bangladesh is currently set much lower than international market prices of other energies for which imports will be increased due to the depletion of natural gas in the future. It will disturb the introduction of alternative energy required for the best energy mix.

As mentioned above, the major reasons for the current energy crisis in Bangladesh are summarized as follows:

- High dependency on natural gas

- Lack of gas supply and expected depletion of natural gas that may increase the supply-demand gap in future
- Gas price much lower than alternative energy, which obstructs the introduction of alternative energy

The following counter measures should be taken in order to overcome these critical circumstances:

- Increase of Natural Gas Supply
- Efficient Use of Gas
- Rise of Natural Gas Price

3. Overview of Executing Agencies

As mentioned in the above, the following state own companies will be the executing agencies for the requested projects if they are selected.

- BGFCL for the Development of Gas Production Fields
- GTCL for the Construction of Gas Transmission Pipelines
- TGTDCL and KGDCL for the Construction of Gas Distribution Pipelines and the Installation of Pre-Paid Gas Metering System

Outline, organization and financial status of these executing agencies are examined in Chapter 3 of this report.

4. Overview of Requested Project Components

Feasibility of the project components requested by GOB listed in Table ES-1 of previous section 1 was examined by Survey Team and described in Chapter 4 of this report in consideration of the following factors:

- Outline
- Objective, necessity and priority
- Site condition
- Duration of the project implementation
- Approximate project cost
- Environmental and social considerations

5. Selection of the Project Components

As a result of the examination of each project component requested by GOB as well as the discussions with each executing agency, the following project components are selected for the "Natural Gas Efficiency Project" under Japanese ODA loan.

Table ES-2　Project Components Selected for "Natural Gas Efficiency Project"

No.	Project Component	Executing Agency
1.	Installation of Well Head Gas Compressors at Titas Gas Field (Location C） and Narsingdi Gas field	BGFCL
2.	Construction of Gas Transmission Pipeline ・Dhanua - Elenga: 30 inch x 52 km ・West Bank of Jamuna Bridge - Nalka : 30 inch x 14 km	GTCL
3.	Installation of Pre-Paid Gas Metering System ・200,000 meters in Dhaka Metropolitan Area	TGTDCL
4.	Installation of Pre-Paid Gas Metering System ・60,000 meters in Chittagong Area	KGDCL

6. Details of Selected Project Components

The following details of each selected project component listed in Table ES-2 above were studied and described in Chapter 6 of this report.

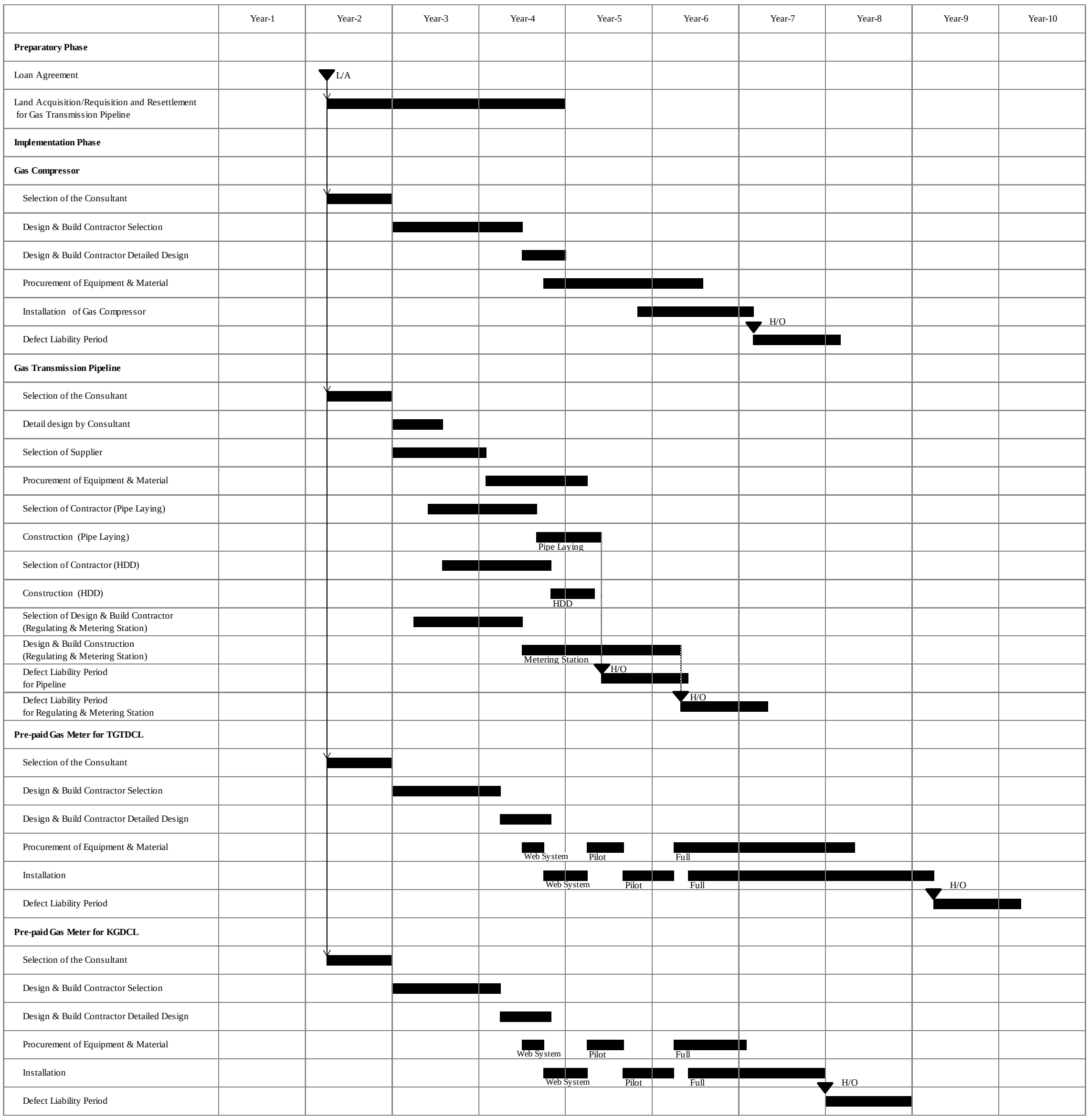
- Project Scope
- Status of Related Projects
- Preliminary Design
- Construction Plan
- Package for the Procurement
- Consulting Services
- Organization for the Project Implementation and O&M
- Project Implementation Schedule
- Project Cost
- Economic and Financial Analysis
- Environmental and Social Considerations

7. Entire Project Summary

As a result of this preparatory survey works, project implementation schedule, project cost and the result of economic and financial analysis are summarized below.

7.1 Entire Project Schedule

The entire project schedule is indicated in the following table.



7.2 Entire Project Cost

The entire project cost is summarized in following table.

	Item	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local
			[Million JPY]			[Million BDT]			[Million USD]	
	Eligible Portion									
a	Construction & Installation (a1+a2+a3+a4)	18,613	13,834	4,778	14,541	10,808	3,733	187	139	48
a1	Gas Compressor	7,380	5,506	1,874	5,766	4,302	1,464	74	55	19
a2	Gas Transmission Pipeline	5,159	3,035	2,124	4,031	2,371	1,660	52	30	21
a3	Pre-paid Gas Meter (TGTDCL)	4,632	4,032	600	3,619	3,150	469	46	40	6
a4	Pre-paid Gas Meter (KGDCL)	1,441	1,261	180	1,126	985	141	14	13	2
b	Consulting Service(including Contingency) (b1+b2+b3+b4)	2,255	1,423	832	1,761	1,112	650	23	14	8
b1	Gas Compressor	844	614	230	659	480	179	8	6	2
b2	Gas Transmission Pipeline	615	386	230	481	301	179	6	4	2
b3	Pre-paid Gas Meter (TGTDCL)	464	242	222	363	189	174	5	2	2
b4	Pre-paid Gas Meter (KGDCL)	331	181	150	259	142	117	3	2	2
C	Contingency (c1+c2)	2,731	1,656	1,075	2,133	1,294	840	27	17	11
c1	Price Contingency on A (F: 1.3%L: 3.4%)(01+02+03+04)	1,714	919	796	1,339	718	622	17	9	8
01	Gas Compressor	706	368	338	552	287	264	7	4	3
02	Gas Transmission Pipeline	436	150	285	340	117	223	4	2	3
03	Pre-paid Gas Meter (TGTDCL)	449	313	136	351	245	106	5	3	1
04	Pre-paid Gas Meter (KGDCL)	123	87	36	96	68	28	1	1	
c2	Physical Contingency on A (5%) (01+02+03+04)	1,016	738	279	794	576	218	10	7	3
01	Gas Compressor	404	294	111	316	229	86	4	3	1
02	Gas Transmission Pipeline	280	159	120	219	124	94	3	2	1
03	Pre-paid Gas Meter (TGTDCL)	254	217	37	198	170	29	3	2	
04	Pre-paid Gas Meter (KGDCL)	78	67	11	61	53	8	1	1	
A	**Total of Eligible Portion (a+b+c)**	23,598	16,913	6,685	18,436	13,214	5,222	237	170	67
	Non Eligible Portion									
d	Administration Cost 5% (including Bank Charge 1%)(d1+d2+d3+d4)	1,301		1,301	1,016		1,016	13		13
d1	Gas Compressor	467		467	365		365	5		5
d2	Gas Transmission Pipeline	445		445	348		348	4		4
d3	Pre-paid Gas Meter (TGTDCL)	290		290	227		227	3		3
d4	Pre-paid Gas Meter (KGDCL)	99		99	77		77	1		1
e	House compensation (e1)	25		25	20		20			
e1	Gas Transmission Pipeline	25		25	20		20			
f	Land Acquisition & Requisition (f1)	2,393		2,393	1,870		1,870	24		24
f1	Gas Transmission Pipeline	2,393		2,393	1,870		1,870	24		24
g	Custom Duties、VAT and AIT (g1+g2)	9,993		9,993	7,807		7,807	100		100
g1	VAT : 15% & AIT: 10% (01+02+03+04)	6,507		6,507	5,083		5,083	65		65
01	Gas Compressor	2,334		2,334	1,823		1,823	23		23
02	Gas Transmission Pipeline	2,230		2,230	1,742		1,742	22		22
03	Pre-paid Gas Meter (TGTDCL)	1,450		1,450	1,133		1,133	15		15
04	Pre-paid Gas Meter (KGDCL)	493		493	385		385	5		5
g2	Custom Duties on Foreign Portion of A (01+02+03+04)	3,486		3,486	2,724		2,724	35		35
01	Gas Compressor 7.1%	401		401	313		313	4		4
02	Gas Transmission Pipeline 42.3%	1,232		1,232	962		962	12		12
03	Pre-paid Gas Meter (TGTDCL) 31.3%	1,417		1,417	1,107		1,107	14		14
04	Pre-paid Gas Meter (KGDCL) 31.3%	436		436	341		341	4		4
h	Interest During Construction (h1+h2+h3+h4)	8	8		6	6				
h1	Gas Compressor	3	3		2	2				
h2	Gas Transmission Pipeline	2	2		2	2				
h3	Pre-paid Gas Meter (TGTDCL)	2	2		2	2				
h4	Pre-paid Gas Meter (KGDCL)	1	1							
B	**Total of Non Eligible Portion (e+f+g+h)**	13,720	8	13,712	10,719	6	10,713	138	.08	138
	Grand Total (A+B)	37,318	16,921	20,397	29,155	13,220	15,935	374	170	205

7.3 Economic and Financial Analysis for the Entire Project

(1) Financial Analysis for the Entire Project

To confirm the underlying financial viability or the true soundness of the Project including components of compressors, pipelines and pre-paid meters, the FIRR of the entire Project was calculated. The result of the calculation of the entire FIRR is at 9.35%, which exceeds 6.45%, the WACC. Therefore, the entire Project is regarded as financially viable and a sound investment.

(2) Economic Analysis for the Entire Project

The entire EIRR is calculated at 21.18%, which clearly supports the economic viability of the Project, because the 21.18% of the entire EIRR is above the 12%, cut off rate of the evaluation criteria for economic analysis. It can be, therefore, concluded that the entire Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

8. Gas Transmission Pipeline Network Analysis

In this pipeline network analysis, flow simulation was carried out to verify capacity of gas transmission and distribution pipelines in 2015, 2020, 2025 and 2030. As the results of this simulation, considerable bottlenecks of the pipeline system were checked and an appropriate improvement plan was proposed for the next engineering stage as an example in Chapter 8 of this report.

As a result of this network analysis, the necessity and effectiveness of the construction of Dhanua – Elenga pipeline and West Bank of Jamuna Bridge – Nalka pipeline were substantiated.

9. Possibility of Future Assistance

Other than the project components selected for this “Natural Gas Efficiency Project”, several projects which will contribute to the development of natural gas sector in Bangladesh are recommended in Chapter 9 of this report.

10. Recommendation for Technical Cooperation

In order to realize the nationwide diffusion of pre-pair gas metering system, the technical cooperation scheme is recommended in Chapter 10 of this report.

11. Workshop in Japan

Workshop in Japan was carried out from 24th February to 05th March 2014. The important persons from EMRD and executing agencies were invited to Japan, and visited Gas Compressor

Factory, LNG Receiving Terminal, Gas Distribution Central Control Centre and Gas Meter Factory in order to study the latest technology of gas related facilities in Japan. Its details are described in Chapter 11 of this report.

Chapter 1 Introduction

1.1 Background of the Survey

Natural gas is the major indigenous resource in Bangladesh and is indispensable for the economic growth of the country.

However, in recent years, the supply of natural gas has been insufficient to meet the demand which has rapidly increased along with the fast growth of the economy. Major reasons for the shortage of natural gas are as follows:

- Delay in the development of new gas fields
- Delay in the improvement of transmission infrastructure
- Inefficient usage of natural gas

Under these circumstances, in order to determine the best way to assist the development of the natural gas sector in Bangladesh, the Japan International Cooperation Agency (JICA) implemented the "Data Collection Survey on Bangladesh Natural Gas Sector" (January 2012) to clarify the bottlenecks in the development of the natural gas sector, and examine the possibility of assistance from JICA to the natural gas sector.

Together with the result of the said data collection survey and subsequent dialogues among the government of the People's Republic of Bangladesh ("GOB"), consisting of the Ministry of Power, Energy and Mineral Resources ("MoPEMR"), Petrobangla and related agencies, and JICA, the projects listed in Table 1.1-1 were requested by the GOB for the development of the natural gas sector with the assistance of JICA.

Table 1.1-1 Projects Requested by GOB

Projects				Executing Agency
(1) Development of Gas Production Fields				
	1)	Bakhrabad Gas Field	(Drilling & Well head gas compressors)	BGFCL
	2)	Narsingdi Gas Field	(Well head gas compressors)	BGFCL
	3)	Titas Gas Field	(Well head gas compressors)	BGFCL
(2) Construction of Gas Transmission Pipelines				
	1)	Dhanua – Elenga	30 inch x 52 km (parallel)	GTCL
	2)	West Bank of Jamuna Bridge – Nalka	30 inch x 14 km (parallel)	GTCL
	3)	Jalalabad – Bibiyana	24 inch x 54 km (new)	GTCL
	4)	Bakhrabad – Chittagong	30 inch x 201 km (new)	GTCL

Projects				Executing Agency
	5)	Langalband – Maowa	30 inch x 40 km (new)	GTCL
(3)	Construction of Gas Distribution Pipelines			
	1)	River crossing pipelines by HDD (12 sites)	12–16 inch (parallel)	TGTDCL
	2)	Rehabilitation of existing critical pipelines	6–12 inch x 103.5 km	TGTDCL
	3)	Reinforcement of Chittagong ring main	24 inch x 5.5 km (parallel)	KGDCL
(4)	Installation of Pre-paid Gas Meters			
	1)	300,000 units in Dhaka		TGTDCL
	2)	20,000 units in Chittagong		KGDCL

1.2 Objective of the Survey

The objective of this Survey is to analyse the necessity and feasibility of the projects requested by the GOB as a result of survey works in Bangladesh, and examine the following items regarding the projects in order to provide necessary information for JICA to determine if the project is appropriate for assistance under a Japanese ODA loan.

- Project Scope (incl. project cost, implementation plan, procurement package, etc.)
- Organizational Structure for the Project Implementation and Operation & Maintenance (O&M)
- Financial and Economic Analysis
- Operation and Effect Indicators
- Environmental and Social Impact

It should be noted that the execution of this Survey does not imply a commitment to the implementation of the project.

1.3 Objective of the Project

The objective of the “Natural Gas Efficiency Project” is to contribute to the mitigation of the supply-demand gap and also to promote stable and efficient gas supply by providing the equipment and facilities that improve production, transmission and efficient use of natural gas. Consequently, it will contribute to the economic development of Bangladesh.

1.4 Survey Team

The Survey Team is composed of 12 experts, one in each field as below.

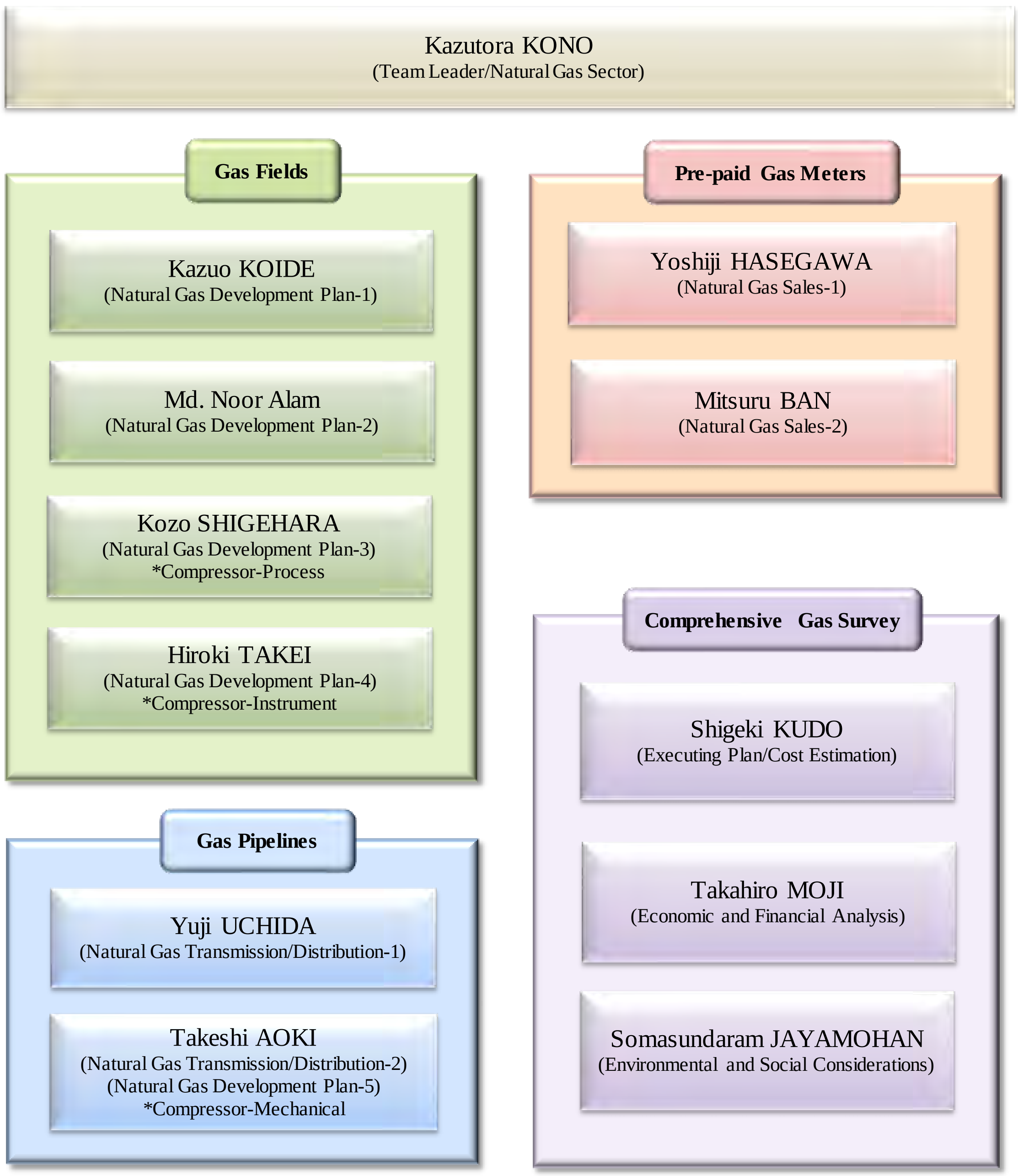


Figure 1.4-1 JICA Survey Team

1.5 Survey Schedule

1.5.1 Entire Schedule

Table 1.5-1 shows the entire schedule of Survey works.

Table 1.5-1 Entire Survey Schedule

Period / Activities	2013							2014		
	June	July	August	September	October	November	December	January	February	March
	M01	M02	M03	M04	M05	M06	M07	M08	M09	M10
Preparation in Japan	- Preparation of IC/R									
1st Survey in Bangladesh		- Explanation of IC/R - Collect latest information - Survey project area - Discussions for project selection								
2nd Study in Japan			- Preparation of IT/R							
2nd Survey in Bangladesh				- Explanation of IT/R - Project Selection						
3rd Study in Japan					- Preparation of DF/R					
3rd Survey in Bangladesh									- Explanation of DF/R	
4th Study in Japan								- Preparation of F/R		
Workshop in Japan										- Workshop in Japan
Reports	IC/R			IT/R			DF/R			F/R

□ : Activities in Japan ■ : Activities in Bangladesh ▼ : Submission of Report

1.5.2 1st, 2nd and 3rd Survey in Bangladesh

The Survey Team had meetings with related entities as shown in Table 1.5-2 during the 1st survey, Table 1.5-3 in the 2nd survey and Table 1.5-4 in the 3rd survey in Bangladesh.

Table 1.5-2 Interviews carried out during 1st Survey in Bangladesh

Date		Meeting commenced at	Meeting with	Contents of the meeting	Attendance								
					Team Leader/Natural Gas Sector	Natural Gas Development Plan -1	Natural Gas Development Plan -2	Natural Gas Transmission & Distribution -1	Natural Gas Transmission & Distribution -2	Natural Gas Sales	Executing Plan/ Cost Estimation	Economic & Financial Analyses	Environmental & Social Considerations
					Kono	Koide	Alam	Uchida	Aoki	Hasegawa	Kudo	Moji	Jayamohan
23-Jun	Sun	Narita --> Singapore --> Dhaka											
24-Jun	Mon	8:30	JICA	Survey outline/ Cooperation to Survey team	○	○	○	○	○	○	○	○	○
		11:30	EMRD	Survey outline/ Cooperation to Survey team	○	○	○	○	○	○	○	○	○
25-Jun	Tue	Survey Team Meeting											
26-Jun	Wed	10:30	WB	Survey outline	○	-	-	-	-	-	-	○	-
		10:30	TGTDCL	Survey outline/ Questionnaire	△	-	○	○	○	○	○	△	○
		14:20	GTCL	Survey outline/ Questionnaire	○	-	○	○	○	-	○	○	○
		16:00	BGFCL	Survey outline/ Questionnaire	○	○	○	○	○	-	○	○	○
27-Jun	Thu	10:00	TGTDCL	Questionnaire	○	-	○	○	○	○	○	○	○
		14:00	GTCL	Questionnaire	○	-	○	○	○	○	○	○	○
28-Jun	Fri	Summarize Survey Results											
29-Jun	Sat	Dhaka --> Chittagong			○	−	−	○	○	○	○	○	○
		Dhaka --> Brahmanbaria			−	○	○	−	−	−	−	−	−
30-Jun	Sun	9:30	KGDCL	Survey outline/ Questionnaire	○	-	-	○	○	○	○	○	○
		12:30	KGDCL	Gas pipeline sites survey	-	-	-	○	○	-	○	-	○
		12:30	KGDCL	Questionnaire	○	-	-	-	-	○	-	○	-
		14:00	KGDCL	Pre-paid gas meter sites survey	-	-	-	-	-	○	-	-	-
		9:30	BGFCL	Survey outline/ Questionnaire/ Gas field sites survey	-	○	○	-	-	-	-	-	-
1-Jul	Mon	8:00	GTCL	Gas pipeline sites survey	-	-	-	○	○	-	○	-	○
		11:30	BGFCL	Gas field sites survey/ Back to Dhaka from the site	-	○	○	-	-	-	-	-	-

1-Jul	Mon	10:00	KGDCL	Questionnaire	-	-	-	-	-	○	-	○	-
		14:00	KGDCL	Survey outline/Pre-paid gas meter sites survey	○	-	-	-	-	○	-	-	-
2-Jul	Tue	7:30	GTCL	Gas pipeline sites survey/Back to Dhaka	○	-	-	○	○	○	○	○	○
		12:00	BGFCL	Gas field sites survey/ Back to Dhaka from the site	-	○	○	-	-	-	-	-	-
3-Jul	Wed	14:30	JICA	Pre-paid gas meter/ Progress of survey	○	-	-	-	-	○	-	○	-
		16:00	ADB	Cancelled due to Hartal	○	-	-	-	-	-	-	○	-
		18:00	BGFCL	Dhaka --> Brahmanbaria	-	-	○	○	○	-	○	-	○
4-Jul	Thu	9:00	BGFCL	Questionnaire/Gas field sites survey/ Sites-->Dhaka	-	-	○	○	○	-	○	-	○
		9:00	TGTDCL	Questionnaire/Pre-paid gas meter sites survey	○	-	-	-	-	○	-	○	-
5-Jul	Fri	Summarize Survey Results											
6-Jul	Sat	8:00	GTCL	Dhaka --> Sylhet	-	-	-	○	-	-	○	-	-
		8:00	GTCL	Dhaka --> Elenga	-	-	-	-	○	-	-	-	○
		Summarize Survey Results			○	○	○	-	-	○	-	○	-
7-Jul	Sun	8:00	GTCL	Gas pipeline sites survey/Back to Dhaka from Bibiyana	-	-	-	○	-	-	○	-	-
		8:00	GTCL	Gas pipeline sites survey/Back to Dhaka from Dhanua	-	-	-	-	○	-	-	-	○
		9:30	TGTDCL	Questionnaire	○	-	-	-	-	○	-	○	-
8-Jul	Mon	10:00	TGTDCL	Questionnaire	○	-	-	-	-	○	-	-	-
		14:00	Contractors	Meeting with contractors	-	-	○	○	○	-	○	-	-
		14:30	GTCL	Questionnaire	-	-	-	-	-	-	-	○	-
9-Jul	Tue	10:00	TGTDCL	Distribution pipeline sites survey	-	-	-	○	○	-	○	-	○
		10:00	TGTDCL	Questionnaire	-	-	-	-	-	○	-	-	-
		10:30	GTCL	Progress of survey/ Candidate projects	○	-	-	-	-	-	-	-	-
		15:30	HCU	Questionnaire	-	○	○	-	-	-	-	-	-
10-Jul	Wed	10:00	Contractors	Postponed due to inconvenience of the contractor	-	-	-	○	○	-	○	-	-
		11:00	Petrobangla	Survey outline/Questionnaire	○	-	-	-	-	-	-	○	-
		14:30	HCU	Questionnaire	-	○	○	-	-	-	-	-	-
		17:00	JICA	Pre-paid gas meter/ Progress of survey	○	-	-	-	-	○	-	○	-
11-Jul	Thu	10:00	TGTDCL	Questionnaire	-	-	-	-	-	○	-	-	-
		10:45	BUET	Pre-paid gas meter pilot project	○	-	-	-	-	○	-	-	-
		11:30	BGFCL	Questionnaire	-	○	○	○	○	-	-	-	-
12-Jul	Fri	13:00	JICA	Progress of survey	○	○	-	○	○	○	○	○	○
13-Jul	Sat	11:00	Pipe liners	Contractor Hearing	-	-	○	○	○	-	○	-	-
		Summarize Survey Results											
14-Jul	Sun	11:00	BETS	Environmental and social consideration	○	-	-	-	-	-	-	-	○
15-Jul	Mon	13:00	JICA	Pre-paid gas meter/ Progress of survey	○	-	-	-	-	○	-	○	-
		14:00	GTCL	Cancelled due to Hartal	-	-	-	○	○	-	○	-	○
		Summarize Survey Results due to Hartal											
16-Jul	Tue	14:00	EMRD	Cancelled due to Hartal	○	-	-	-	-	-	-	-	-

16-Jul	Tue	14:00	GTCL	Cancelled due to Hartal	-	-	-	O	O	-	O	-	O
		Summarize Survey Results due to Hartal											
17-Jul	Wed	14:00	GTCL	Cancelled due to Hartal	-	-	-	O	O	-	O	-	O
		Summarize Survey Results due to Hartal											
18-Jul	Thu	9:00	JICA	Progress of Survey/ Candidate projects	O	O	-	O	O	O	O	O	O
		16:20	KGDCL	Candidate projects	O	-	-	O	-	O	-	-	-
		Summarize Survey Results due to Hartal											
19-Jul	Fri	Summarize Survey Results											
20-Jul	Sat	10:00	TGTDCL	Questionnaire	-	-	-	-	-	O	-	-	-
		11:30	GTCL	Progress of Survey/ Candidate projects	O	-	-	O	O	-	O	O	O
		Summarize Survey Results											
21-Jul	Sun	10:00	TGTDCL	Questionnaire	-	-	-	-	-	O	-	-	-
		11:30	GTCL	Progress of Survey /Candidate projects	O	-	-	O	O	-	O	O	O
		13:00	BGFCL	Progress of Survey/ Candidate projects	O	O	O	O	-	-	-	O	-
		15:00	EMRD	Progress of Survey/ Candidate projects	O	-	-	-	-	-	-	-	-
		15:00	TGTDCL	Progress of Survey/Candidate projects	-	-	-	O	-	O	-	O	-
22-Jul	Mon	10:00	Petrobangla	Questionnaire	-	-	-	-	-	-	-	O	-
		10:00	TGTDCL	Questionnaire	-	-	-	-	-	O	-	-	-
		11:00	GTCL	Questionnaire	-	-	-	O	O	-	O	-	-
		12:00	DOE	Environmental and social considerations	-	-	-	-	-	-	-	-	O
		15:00	JICA	Candidate projects	O	O	-	O	-	O	-	O	-
23-Jul	Tue	10:30	TGTDCL	Questionnaire	-	-	-	O	-	O	-	-	-
		11:00	GTCL	Questionnaire	-	-	-	-	O	-	-	-	O
		11:30	Petrobangla	Candidate projects	O	-	-	-	-	O	-	O	-
24-Jul	Wed	10:30	TGTDCL	Questionnaire	-	-	-	-	-	O	-	-	-
		10:30	Petrobangla	Questionnaire	-	-	-	-	-	-	-	O	-
		11:00	GTCL	Questionnaire	-	-	-	O	O	-	O	-	-
		11:00	RAJUK	Future urban planning	-	-	-	-	-	O	-	-	-
		11:30	EMRD	Confirmation of Minutes of Discussion	O	-	-	-	-	-	-	-	-
25-Jul	Thu	10:00	RAJUK	Future urban planning	-	-	-	-	-	O	-	-	-
		11:00	JICA	Progress of Survey/Candidate projects	O	O	-	O	O	O	O	O	O
		13:00	GTCL	Questionnaire	-	-	-	O	O	-	-	-	-
		14:00	BETS	Draft TOR for EIA study	O	-	-	-	-	-	-	-	O
26-Jul	Fri	9:00	TGTDCL	Distribution pipeline sites survey	-	-	-	-	-	-	O	-	O
		Summarize Survey Results											
27-Jul	Sat	Summarize Survey Results											
28-Jul	Sun	10:15	TGTDCL	Candidate projects/Pre-paid gas meters	O	-	-	-	-	O	-	-	-
		12:00	BGFCL	Questionnaire	-	O	O	O	O	-	-	-	O
		14:30	JICA	Candidate projects	O	-	-	-	-	O	-	O	-
29-Jul	Mon	9:00	BGFCL	Questionnaire/Site survey - Narshigdhi Gas Field	-	O	O	O	O	-	-	-	O

29-Jul	Mon	10:00	Petrobangla	Questionnaire	○	-	-	-	-	-	-	○	-
		11:00	TGTDCL	Questionnaire	○	-	-	-	-	○	-	○	-
		13:45	BERC	Gas price	○	-	-	-	-	-	-	○	-
30-Jul	Tue	10:00	TGTDCL	Questionnaire & Customer data list	-	-	-	-	-	○	-	-	-
		Summarize Survey Results											
31-Jul	Wed	10:00	TGTDCL	Questionnaire & Customer data list	-	-	-	-	-	○	-	-	-
		10:30	TGTDCL	Questionnaire	○	-	-	○	○	○	○	-	○
1-Aug	Thu	10:00	TGTDCL	Customer data list	-	-	-	-	-	○	-	-	-
		10:30	GTCL	Questionnaire	○	-	-	○	○	-	○	-	○
		13:00	TGTDCL	Outstanding information	○	-	-	-	-	-	-	-	-
2-Aug	Fri	Summarize Survey Results											
3-Aug	Sat	13:00	BGFCL	Site Survey: Bakrabad Gas Field	–	○	-	○	○	-	○	–	○
		Summarize Survey Results											
4-Aug	Sun	9:00	ADB	Confirmation of gas projects by ADB	○	-	-	-	-	-	-	○	-
		10:00	BUET	Possibility of cooperative activity	-	-	-	-	-	○	-	-	-
		11:00	GTCL	Questionnaire	○	-	-	○	○	-	-	-	○
		12:00	TGTDCL	Confirmation of 8,600 pre-paid meters by ADB	-	-	-	-	-	○	-	-	-
		12:00	Petrobangla	Questionnaire BAPEX	-	○	○	-	-	-	-	○	-
5-Aug	Mon	11:00	KGDCL	Questionnaire	○	-	-	○	○	○	○	-	○
		16:30	JICA	Wrap-up meeting	○	○	-	-	-	○	-	○	-
		Summarize Survey Results at hotel / Dhaka -->											
6-Aug	Tue	--> Singapore --> Narita											

Table 1.5-3 Interviews carried out during 2nd Survey in Bangladesh

Date		Meeting commenced at	Meeting with	Contents of the meeting	Attendance								
					Team Leader/Natural Gas Sector	Natural Gas Development Plan -1	Natural Gas Development Plan -2	Natural Gas Transmission & Distribution -1	Natural Gas Transmission & Distribution -2	Natural Gas Sales	Executing Plan/ Cost Estimation	Economic & Financial Analyses	Environmental & Social Considerations
					Kono	Koide	Alam	Uchida	Aoki	Hasegawa	Kudo	Moji	Jayamohan
8-Sep	Sun	Narita --> Singapore --> Dhaka			○	○	-	○	-	○	-	○	○
9-Sep	Mon	10:00	JICA	Survey progress & schedule	○	○	-	○	-	○	-	○	○
10- Sep	Tue	14:00	BGFCL	Project selection, details of candidate project	-	○	○	○	-	-	-	○	○

10- Sep	Tue	15:00	TGTDCL	Data collection	-	-	-	-	-	O	-	-	-
11- Sep	Wed	10:00	GTCL	Explanation of the latest state of project component selection	O	-	-	O	-	-	-	-	O
		15:00	TGTDCL	Explanation and confirmation of IT/R	-	-	-	-	-	O	-	-	-
12- Sep	Thu	10:00	GTCL	Organization of O&M: Standard drawings for HDD,TB etc.	-	-	-	O	-	-	-	-	-
		10:00	BETS	Explanation of the latest state of project component selection, and request for quotation	O	-	-	-	-	-	-	-	O
		15:00	TGTDCL	Explanation of the latest state of project component selection	O	-	-	O	-	O	-	-	O
13- Sep	Fri	Summarize Survey Results											
		Dhaka --> Singapore			-	O	-	–	-	-	-	-	-
14- Sep	Sat	Singapore --> Narita			–	O	–	–	–	–	–	–	–
15- Sep	Sun	8:00	JICA	Schedule of JICA fact finding mission (2&3) and tasks during 2nd survey	O	-	-	O	-	O	-	O	O
16- Sep	Mon	10:00	KGDCL	Explanation of the project component selection	O	-	-	O	-	O	-	-	O
		14:00	GTCL	Collection of Technical Data	-	-	-	O	-	-	-	-	-
		14:45	TGTDCL	Explanation of the project component selection	O	-	-	-	-	O	-	-	-
17- Sep	Tue	Narita --> Singapore --> Dhaka			-	-	-	-	O	-	O	-	-
		12:00	BGFCL	Explanation of the project component selection	O	-	-	O	-	-	-	-	O
		15:00	KGDCL	Explanation of the project component selection	O	-	-	O	-	-	-	-	-
		23:45	JICA	Tasks to be done prior to the next fact finding mission (3)	O	-	-	O	O	O	O	O	O
18- Sep	Wed	Make Interim Report due to Hartal											
19- Sep	Thu	Make Interim Report due to Hartal											
20- Sep	Fri	Make Interim Report											
21- Sep	Sat	Make Interim Report											
22- Sep	Sun	11:00	GTCL	Cost confirmation of pipeline and resettlement	-	-	-	-	-	-	O	-	O
		12:00	GTCL	Data collection	-	-	-	O	O	-	-	-	-
		14:00	BGFCL	Confirmation of compressor specification	-	-	-	O	O	-	-	-	-
		14:00	TGTDCL	Resettlement for critical pipelines	-	-	-	-	-	-	-	-	O
		15:00	TGTDCL	Confirmation of installation of pre-paid gas meters	-	-	-	-	-	O	-	-	-
23- Sep	Mon	10:00	DOE	Requirement to be obtain ECC for BGFCL compressor project	O	-	-	-	-	-	-	-	O
		14:00	BGFCL	Confirmation of compressor specification	-	-	-	O	-	-	-	-	-
		15:00	TGTDCL	Data collection	-	-	-	-	-	O	-	-	-
24- Sep	Tue	10:00	TGTDCL	Meeting regarding customer data	-	-	-	-	-	O	-	-	-
		14:00	BETS	Negotiation for the contract	O	-	-	-	-	-	-	-	O
25- Sep	Wed	10:00	TGTDCL	Explanation and confirmation of basic design and organization	-	-	-	-	-	O	-	-	-
		14:00	GTCL	Data collection	-	-	-	O	-	-	-	-	-
26- Sep	Thu	10:00	BETS	Contract signing	O	-	-	-	-	-	-	O	O
		16:00	JICA	Tasks to be done during 2nd survey in Bangladesh	O	-	-	O	O	O	O	O	O

26- Sep	Thu	17:00	KCJAL	Request for cost estimation and Q&A	-	-	-	-	-	○	-	-	-
27- Sep	Fri	10:15	Itron	Questions & answers regarding pre-paid meters	○	-	-	-	-	○	-	-	-
28- Sep	Sat	Make Interim Report											
29- Sep	Sun	10:00	BGFCL	Handing over & explanation of Interim report	○	-	-	-	-	-	-	-	-
		12:00	TGTDCL	Data collection	-	-	-	-	-	○	-	-	-
		12:00	BETS	EIA study kick-off meeting	-	-	-	-	-	-	-	-	○
		15:00	GTCL	Data collection	-	-	-	○	-	-	-	-	-
30- Sep	Mon	10:30	TGTDCL	Handing over & explanation of Interim report	○	-	-	-	-	○	-	-	-
		11:00	GTCL	Explanation of BETS contract and site survey schedule	-	-	-	-	-	-	-	-	○
		14:30	GTCL	Handing over & explanation of Interim report	○	-	-	-	-	-	-	-	-
		15:00	GTCL	Data collection	-	-	-	○	-	-	○	-	-
1-Oct	Tue	9:00	GTCL	Inspection of affected houses (Dhanua - Elenga pipeline)	○	-	-	-	-	-	-	-	○
		10:30	TGTDCL	Data collection	-	-	-	-	-	○	-	-	-
		17:00	JICA	Submission of IT/R	-	-	-	-	-	○	-	○	-
2-Oct	Wed	11:00	BETS	Environmental monitoring plan	-	-	-	-	-	-	-	-	○
		11:30	JICA	Schedule of JICA fact finding mission (3)	○	-	-	-	-	-	○	○	-
		12:00	TGTDCL	Data collection	-	-	-	-	-	○	-	-	-
		14:30	BGFCL	Project component selection	○	-	-	-	-	-	-	-	-
		14:30	GTCL	Data collection	-	-	-	○	-	-	-	-	-
		17:30	JICA	Meeting for BGFCL project component	○	-	-	○	○	-	-	-	-
3- Oct	Thu	11:00	GTCL	EIA TOR for DOE by GTCL	-	-	-	-	-	-	-	-	○
		12:00	TGTDCL	Data collection	-	-	-	-	-	○	-	-	-
		15:00	BETS	Environmental monitoring plan	-	-	-	-	-	-	-	-	○
4- Oct	Fri	14:00	JICA	Tasks for environmental & social considerations	○	-	-	-	-	-	-	-	○
5- Oct	Sat	10:00	Pegasus (Local)	Meeting regarding possibility for local consultant contract	○	-	-	-	-	○	-	-	-
6- Oct	Sun	10:30	GTCL	Data collection	-	-	-	○	-	-	-	-	-
		10:30	TGTDCL	Data collection for Df/R	-	-	-	-	-	○	-	-	-
		11:00	GTCL	Reroute survey and resettlement	-	-	-	-	-	-	-	-	○
		13:30	TGTDCL	Data Collection	-	-	-	-	-	○	-	○	-
		14:00	BETS	EIA/ARAP work plan	-	-	-	-	-	-	-	-	○
		20:00	JICA	Tasks to be done for JICA fact finding mission (3)	○	-	-	○	○	○	○	○	○
7- Oct	Mon	10:30	TGTDCL	Data collection for Df/R	-	-	-	-	-	○	-	-	-
		14:00	BETS	EIA/ARAP work plan and contents	-	-	-	-	-	-	-	-	○
		16:00	GTCL	Procurement package for transmission pipeline project	○	-	-	○	-	-	-	-	-
8- Oct	Tue	10:30	TGTDCL	Data collection for DfR and future possibility of gas distribution	-	-	-	-	-	○	-	-	-
		14:00	BETS	EIA/ARAP work plan and contents	-	-	-	-	-	-	-	-	○
		15:00	GTCL	Data Collection	-	-	-	○	-	-	-	○	-

8- Oct	Tue	16:00	DOE	Requirement to obtain ECC for BGFCL compressor project	○	-	-	-	-	-	-	-	○
9- Oct	Wed	10:00	GTCL	Data collection for flow simulation	-	-	-	○	○	-	-	-	-
		10:30	ADB	Confirmation of gas projects by ADB	-	-	-	-	-	○	-	○	-
		11:30	BETS	EIA/ARAP work plan finalization and MOU	-	-	-	-	-	-	-	-	○
		14:00	BGFCL	Confirmation of compressor specification	-	-	-	○	○	-	-	-	-
10- Oct	Thu	10:30	BETS	Route survey result discussion and wrap-up meeting	-	-	-	-	-	-	-	-	○
		10:30	TGTDCL	Data collection for DfR and invitation plan to Japan	-	-	-	-	-	○	-	-	-
		15:00	JICA	Wrap up meeting	○	-	-	○	○	○	○	-	○
		Dhaka -->											
11- Oct	Fri	--> Singapore --> Narita											

Table 1.5-4 Interviews carried out during 3rd Survey in Bangladesh

Date		Meeting commenced at	Meeting with	Contents of the meeting	Attendance								
					Team Leader/Natural Gas Sector	Natural Gas Development Plan -1	Natural Gas Development Plan -2	Natural Gas Transmission & Distribution -1	Natural Gas Transmission & Distribution -2	Natural Gas Sales	Executing Plan/ Cost Estimation	Economic & Financial Analyses	Environmental & Social Considerations
					Kono	Koide	Alam	Uchida	Aoki	Hasegawa	Kudo	Moji	Jayamohan
27-Jan	Mon	Narita --> Singapore --> Dhaka			○	-	-	-	-	-	-	○	-
28-Jan	Tue	9:00	JICA	3rd survey in Bangladesh	○	-	-	-	-	-	-	○	-
		14:30	BGFCL	Explanation of DFR, Questionnaire, Revised TOR for Consulting Services, etc.	○	-	-	-	-	-	-	○	-
29- Jan	Wed	10:00	GTCL	Explanation of DFR, Questionnaire, Revised TOR for Consulting Services, etc.	○	-	-	-	-	-	-	○	-
		14:00	KGDCL	Explanation of DFR, Questionnaire, Revised TOR for Consulting Services, etc.	○	-	-	-	-	-	-	○	-
		16:00	Petrobangla	Collection of information on the Projects funded by other donors	○	-	-	-	-	-	-	○	-
30- Jan	Thu	10:30	TGTDCL	Explanation of DFR, Questionnaire, Revised TOR for Consulting Services, etc.	○	-	-	-	-	-	-	○	-
		15:00	SGCL	Collection of information on the Projects funded by other donors	○	-	-	-	-	-	-	○	-
		15:30	PGCL	Collection of information on the Projects funded by other donors	○	-	-	-	-	-	-	○	-

31- Jan	Fri	Summarize Suvey Results											
1- Feb	Sat	Summarize Survey Results											
2- Feb	Sun	10:30	TGTDCL	Explanation of Questionnaire and Assistance of DPP	○	-	-	-	-	-	-	○	-
		11:00	Petrobangla	Collection of information on the Projects funded by other donors and Explanation of Questionnaire and.	○	-	-	-	-	-	-	○	-
3- Feb	Mon	11:00	TGTDCL	Explanation of the Project funded by JICA	○	-	-	-	-	-	-	○	-
		12:30	BGFCL	Explanation of the Project funded by JICA	○	-	-	-	-	-	-	○	-
		14:30	KGDCL	Explanation of the Project funded by JICA	○	-	-	-	-	-	-	○	-
4- Feb	Tue	10:30	KGDCL	Confirmation of Questionnaire and Assistance of DPP	○	-	-	-	-	-	-	○	-
		14:00	BGFCL	Assignment Schedule for Consultants	○	-	-	-	-	-	-	○	-
5- Feb	Wed	10:30	GTCL	Project Implementaion schedule and Assistance of DPP	○	-	-	-	-	-	-	○	-
		12:00	TGTDCL	Confirmation of PGMs Cost	○	-	-	-	-	-	-	○	-
6- Feb	Thu	10:00	JICA	Confirmation of Chapter 9 of FR	○	-	-	-	-	-	-	○	-
7- Feb	Fri	Summarize Survey Results											
8- Feb	Sat	Summarize Survey Results											
		Narita --> Singapore			-	-	-	-	-	-	-	-	○
9- Feb	Sun	10:00	GTCL		○	-	-	-	-	-	-	○	-
		10:30	BETS	Cancelled due to 1 night unscheduled stay in Singapore	-	-	-	-	-	-	-	-	○
		15:30	Petrobangla	Future Gas Development	○	-	-	-	-	-	-	○	-
		Singapore --> Dhaka			-	-	-	-	-	-	-	-	○
10- Feb	Mon	10:30	BETS	Draft Final Report from BETS	-	-	-	-	-	-	-	○	○
		14:00	KGDCL	Answer to Questionnaire and Assistance of DPP	○	-	-	-	-	-	-	○	-
		15:30	Petrobangla	Answer to Questionnaire	○	-	-	-	-	-	-	○	-
		16:00	TGTDCL	Assistance of DPP	○	-	-	-	-	-	-	○	-
		17:00	JICA	Wrap up Meeting	○	-	-	-	-	-	-	○	-
11-Feb	Tue	10:00	BETS	Draft Final Report from BETS	-	-	-	-	-	-	-	-	○
		14:00	GTCL	Assistance of DPP	○	-	-	-	-	-	-	○	-
		15:00	GTCL & BETS	Draft Final Report from BETS	○	-	-	-	-	-	-	○	○
12-Feb	Wed	11:00	BGFCL	Answer to Questionnaire	○	-	-	-	-	-	-	○	-
		11:30	Petrobangla	Answer to Questionnaire	○	-	-	-	-	-	-	○	-
		12:00	TGTDCL	Assistance of DPP	○	-	-	-	-	-	-	○	-
		15:00	BETS	Draft Final Report from BETS	-	-	-	-	-	-	-	-	○
		Dhaka --> Singapore			○	-	-	-	-	-	-	○	-
13- Feb	Thu	Singapore --> Narita			○	-	-	-	-	-	-	○	-
		11:00	BETS	Draft Final Report from BETS	-	-	-	-	-	-	-	-	○
		Dhaka --> Singapore			-	-	-	-	-	-	-	-	○
14- Oct	Fri	Singapore --> Narita			-	-	-	-	-	-	-	-	○

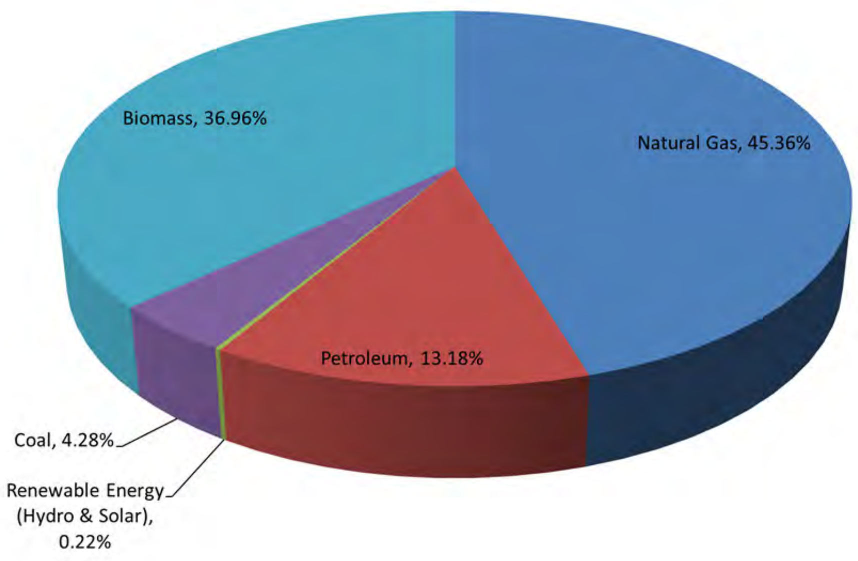
Chapter 2 Overview of the Natural Gas Sector

2.1 Position of Natural Gas in Energy Sector

Natural gas is the key domestic natural resource in Bangladesh, and as shown in Figure 2.1-1 ~ Figure 2.1-3 below, it accounts for:

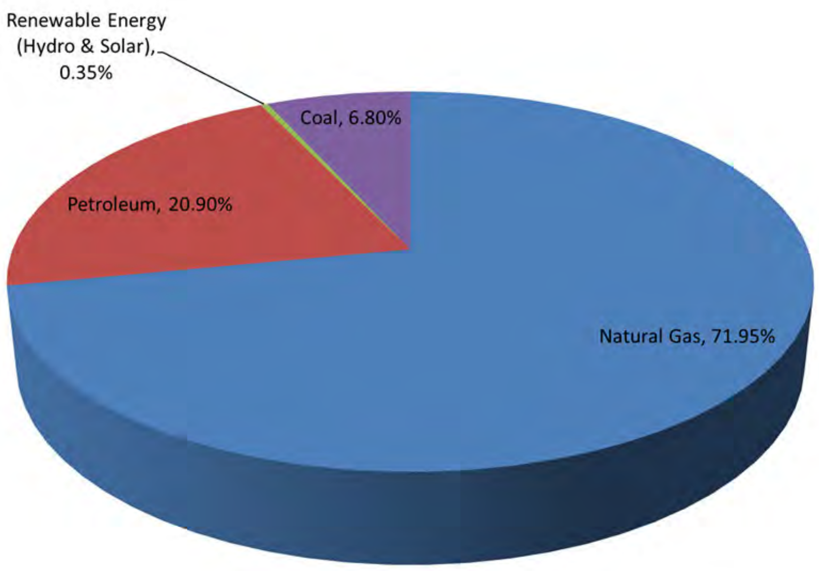
- 45% of Primary Energy
- 72% of Commercial Energy
- 80% of Energy for Power Generation

It is obvious that Bangladesh is highly dependent on natural gas, and introduction of alternative energy is required for the best energy mix.



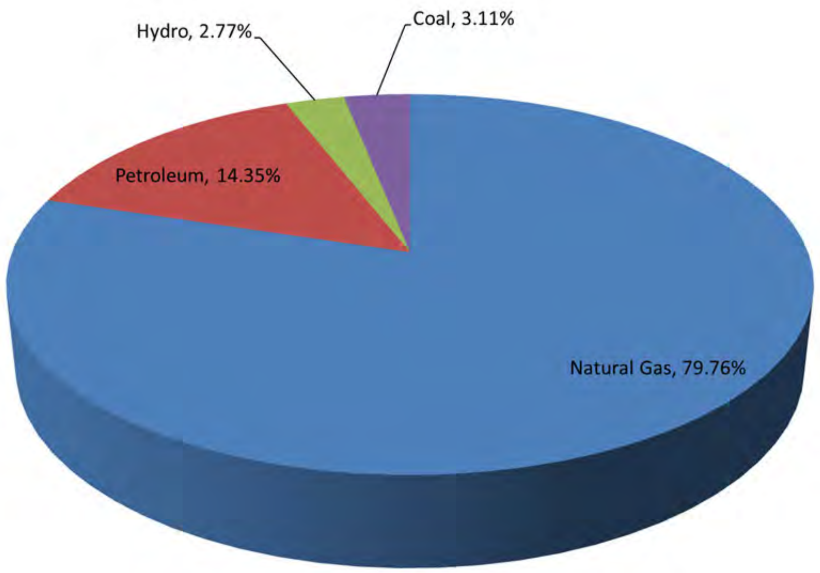
Source: Data received from Petrobangla in July 2013

Figure 2.1-1 Share of Primary Energy



Source: Received from Petrobangla in July 2013

Figure 2.1-2 Share of Commercial Energy



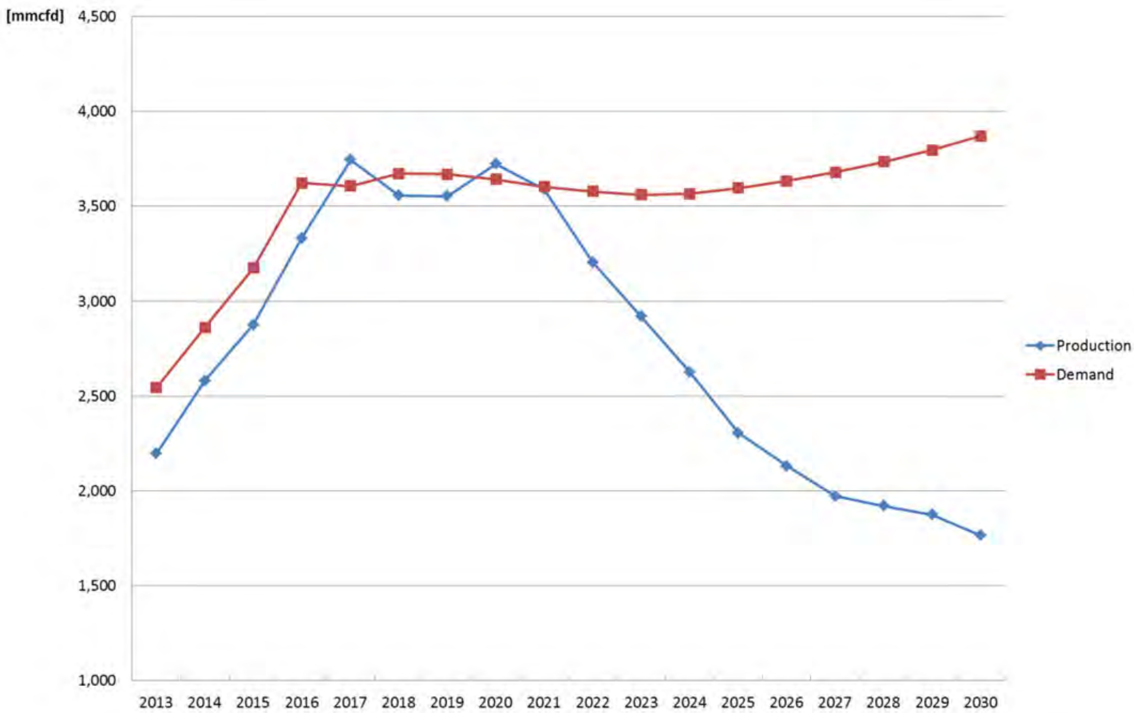
Source: Received from Petrobangla in July 2013

Figure 2.1-3 Share of Power Generation Energy

2.2 Demand and Production

Although economic activities in Bangladesh are highly dependent on natural gas, the supply of natural gas has been insufficient to meet the demand in recent years.

Figure 2.2-1 shows the demand and production of natural gas up to 2030 as forecast in "Consulting Services for Preparation of Implementation and Financing Plan for Gas Sector Development" by Dorsch Consult India Pvt. Ltd. assisted by World Bank.



Source: "Consulting Services for Preparation of Implementation and Financing Plan for Gas Sector Development" (December 2012) from Petrobangla

Figure 2.2-1 Projection of Demand & Production up to 2030

Natural gas production will increase until 2017 by augmentation of production wells and mostly meet demand for several years; however, the production will start decreasing from 2020 due to depletion of production wells while demand continues to increase.

According to the latest information from Petrobangla, the current gas supply is approximately 2,300 mmcfd against the demand estimated at 2,800 mmcfd, as of July 2013. These figures are represented on the lines of the above graph between 2013 and 2014.

2.3 Price of Natural Gas

Table 2.3-1 is the transition of natural gas tariff in Bangladesh since 1968, and it shows that there has been no rise in price since 2009 except for the unit price of CNG feed gas.

Table 2.3-1 Natural Gas Tariff in Bangladesh

Effective From	Power	Fertilizer	Industry	Commer-cial	Tea Estate	Captive Power	CNG Feed Gas	Seasonal (brick)	Domestic		
									Metered	Single Burner	Double Burner
29.07.68	1.20	1.20	2.52	6.00	-	-	-	-	6.00	6.00	10.00
28.06.69	1.60	1.60	2.92	6.40	-	-	-	-	6.40	6.30	10.50
19.06.74	3.72	3.72	7.20	12.00	-	-	-	-	12.00	15.00	28.00
01.12.77	5.00	5.00	9.00	13.00	-	-	-	-	13.00	16.00	30.00
02.06.79	6.25	6.25	16.00	17.00	-	-	-	-	16.00	20.00	36.00
07.06.80	7.75	7.75	18.00	19.00	-	-	-	-	18.00	22.00	40.00
07.06.81	9.30	9.30	27.75	28.00	-	-	-	-	20.00	25.00	45.00
01.07.82	10.50	10.50	31.00	31.00	-	-	-	-	27.00	35.00	65.00
30.06.83	11.50	11.50	36.00	36.00	-	-	-	-	34.00	45.00	80.00
27.06.84	13.05	13.05	36.00	45.20	-	-	-	51.00	34.00	45.00	80.00
30.06.85	15.66	15.66	43.20	54.24	-	-	-	61.20	40.80	60.00	100.00
28.06.86	19.09	19.09	52.14	65.39	-	-	-	78.30	44.88	66.00	110.00
18.06.87	24.82	24.82	52.14	85.00	72.30	-	-	78.30	56.10	80.00	130.00
01.07.88	28.54	28.54	59.96	97.75	83.15	-	-	90.05	56.10	92.00	150.00
01.07.89	33.00	28.54	70.00	110.00	83.15	-	-	-	65.13	100.00	170.00
01.07.90	37.95	32.82	80.42	126.50	95.62	-	-	-	74.75	115.00	195.00
01.07.91	39.08	33.98	85.23	134.22	100.62	-	-	106.19	74.75	115.00	195.00
01.05.92	43.05	37.39	93.74	134.22	110.16	-	43.05	116.67	82.12	126.00	215.00
01.03.94	47.57	41.34	103.07	147.53	113.26	-	-	128.28	82.12	160.00	250.00
01.12.98	54.64	47.57	118.93	169.05	130.56	86.37	-	147.25	94.86	185.00	290.00
01.09.00	62.86	54.65	136.77	195.39	149.80	99.11	-	169.33	109.02	210.00	330.00
01.01.02	65.98	57.48	143.57	205.30	157.16	104.21	-	177.83	114.40	275.00	350.00
01.09.02	70.00	60.00	140.00	220.00	140.00	100.00	-	220.00	120.00	325.00	375.00
15.02.03	-	-	-	-	-	-	70.00	-	-	-	-
01.07.04	72.45	62.15	145.20	228.50	145.20	-	-	228.50	126.10	340.00	390.00
01.09.04	-	-	-	-	-	103.50	-	-	-	-	-
01.01.05	73.91	63.41	148.13	233.12	148.13	105.59	-	233.00	129.98	350.00	400.00
25.04.08	-	-	-	-	-	-	282.30	-	-	-	-
01.08.09	79.82	72.92	165.91	268.09	165.91	118.26	-	-	146.12	400.00	450.00
12.05.11	-	-	-	-	-	-	509.70	-	-	-	-
19.09.11	-	-	-	-	-	-	651.29	-	-	-	-

Source: Petrobangla Annual Report 2010 & 2011

The weighted average unit price of natural gas based on the sales volume and unit prices of different sectors is calculated at USD 1.91/MCF as shown in Table 2.3-2.

Table 2.3-2 Weighted Average of Natural Gas Unit Price in Bangladesh

Sector	Sales in MCF	Price/MCF in Tk	Sales in Tk	Sales in US$
Power	12,791,454.47	79.82	1,021,013,896	12,924,227
Fertilizer	1,961,932.46	72.92	143,064,115	1,810,938
Industrial	13,325,331.99	165.91	2,210,805,830	27,984,884
Commercial	469,504.69	268.09	125,869,512	1,593,285
Tea-Estates	3,329.61	165.91	552,416	6,993
CNG	1,722,920.44	651.29	1,122,120,853	14,204,061
Domestic	4,313,711.38	146.25	630,880,289	7,985,826
Captive Power	1,503,862.54	118.26	177,846,784	2,251,225
Total	36,092,047.58		5,432,153,696	68,761,439
Weighted averaged sales price per MCF				1.91

Source: Petrobangla (April 2013)

The natural gas price in Bangladesh compared with international market prices of other energies is shown in Table 2.3-3. It is obvious that the price of natural gas in Bangladesh is set much lower than other energy sources for which imports will be increased due to the depletion of natural gas in the future.

Table 2.3-3 Comparison of Energy Prices

Energy	Unit Price	Price per mmbtu	Basis of Unit Price
Cruide oil	94.20 USD/bbl	16.24 USD/mmbtu	WTI(West Texas Intermediate) as of 2013Q2
LNG	17.40 USD/mmbtu	17.40 USD/mmbtu	Imported from Indonesia in Japan as of 2013Q2
Coal	92.20 USD/ton	3.78 USD/mmbtu	Australian, export markets as of 2013Q2
Natural Gas in Bangladesh	1.91 USD/MCF	1.80 USD/mmbtu	Petrobangla (weighted ave.) as of April 2013

Source: International Monetary Fund (IMF) - Primary Commodity Prices and Petrobangla

2.4 Challenges of Natural Gas Sector

As mentioned in the above sections, the major reasons for the current energy crisis in Bangladesh are as follows:

- High dependency on natural gas
- Lack of gas supply and expected depletion of natural gas that may increase the supply-demand gap in future
- Gas price much lower than alternative energy, which obstructs the introduction of alternative energy

In consideration of these situations, the major serious challenges of the sector are described in this section. These challenges are also stated in the following National Development Plans and Sector Plan:

- The National Strategy for Accelerated Poverty Reduction II (Revised) FY2009–11 (“NSAPR II”)
- Sixth Five-Year Plan FY2010–2015
- Gas Sector Master Plan and Strategy 2006

2.4.1 Increase of Natural Gas Supply

In order to solve the supply-demand gap, natural gas production should be increased. Related policies stated in National Development Plans as well as the Sector Plan are extracted as below:

- Improve reliable estimation of gas reserves through extended exploration and development programs (NSAPR II)

- Appraise the already discovered fields to prove current and possible reserve estimates (Master Plan and Strategy 2006)
- Undertake exploration in new areas to expand gas reserves (Five-Year Plan 2010-2015)
- Drill additional production wells (Master Plan and Strategy 2006)
- Optimize production from the existing gas fields (NSAPR II)
- Maintain the production level of existing fields operated by national gas companies (Five-Year Plan 2010–2015)
- Reduce disparity of supply of gas to different areas of the country (NSAPR II)
- Establish a national gas transmission network by connecting the main gas fields with the main demand centres in the greater Dhaka and Chittagong area (Five–Year Plan 2010–2015)

2.4.2 Efficient Use of Gas

In order to cope with scarce natural gas supply, the efficient use of natural gas should be realized by means of the following activities stated in the National Development Plans:

- Conserve and make efficient use of gas (NSAPR II)
- Improve energy efficiency, including the efficiency of using scarce gas resources. The prevailing practice of setting gas prices below international prices is encouraging the inefficient use of gas and its use for applications for which more economical alternatives are available. (Five-Year Plan 2010–2015)
- System loss reduction and Improvement of revenue collection rate (Master Plan and Strategy 2006)

2.4.3 Rise of Natural Gas Price

The current gas prices, which are set much lower than international energy prices, discourage the following principles:

- Importation of alternative energies such as LNG and coal to avoid a serious energy crisis due to depletion of national gas in the future
- Improvement of the energy-saving mind set of consumers, and consequently energy efficiency

Therefore, the price of natural gas should be equalized to the price of alternative energy sources. Related policies stated in the National Development Plans are extracted as below:

- Adjust end user gas prices because the prevailing gas pricing structure and high level of government taxes do not provide adequate margins for the national gas companies to undertake the requisite investments in developing new fields (Five-Year Plan 2010–2015)
- Ensure proper pricing of gas to conserve energy and improve the financial operations of the gas sector (Five-Year Plan 2010–2015)
- Domestic gas price reform to link with international fuel oil prices (Master Plan and Strategy 2006)

2.5 Initiative of Other Development Partners

(1) ADB (Asian Development Bank)

According to ADB's Country Partnership Strategy (CPS) 2011-2015 and Country Operations Business Plan (COBP) 2014-2016, the energy sector is one of the key sectors selected for their assistance in Bangladesh. The main objective to assist the energy sector is to realize the reliable power supply with expanded access to power by means of enhancing the following areas:

- Power generation, transmission and conservation
- Energy efficiency
- **Gas processing and transmission**

In line with this strategy, ADB has been assisting the natural gas sector in Bangladesh mainly for the expansion and reinforcement of gas transmission pipelines. Currently the following projects are on-going.

- "Gas Transmission and Development Project" consisting of the following components:
  - Expansion and reinforcement of gas transmission pipelines
  - Field appraisal of producing gas fields
  - Construction of gas distribution network in Rajshahi area
  - Capacity building
- "Natural Gas Access Improvement Project" consisting of the following components:
  - Construction of gas transmission pipeline between Ashuganj and Bakhrabad
  - Construction of compressor stations at Ashuganj and Elenga
  - Safety and supply efficiency improvement in Titas gas field
  - Construction of distribution pipelines in Khulna division
  - Installation of pre-paid meters for domestic customers (pilot basis)
  - Replacing existing meters with remote sensing meters (pilot basis)

ADB intends to continue its assistance to the natural gas sector in Bangladesh.

(2) WB (World Bank)

According to WB's Country Assistance Strategy (CAS) for the fiscal year 2011-14, in order to overcome the power deficit that is a constraint to the growth of the country, WB will support the energy sector in the following areas:

- New power generation
- Rehabilitation
- Expansion of transmission capacity
- **Enhancing the natural gas supply for power and other applications**

In line with this strategy, WB is currently assisting the following projects for the natural gas sector in Bangladesh.

- LNG receiving terminal Moheshkhali island
  WB assists only for the consulting service to this project.
- Construction of gas transmission pipeline between Bakhrabad and Siddhirgonj
  This project is one of the subcomponents of the Siddhirganj Peaking Power Project.

Other than the on-going projects above, WB has currently no future plan for assistance to the natural gas sector.

(3) Details of ADB & WB On-going Projects

Details of on-going projects funded by ADB and WB for the Natural Gas Sector are summarized in the table below, and it was found that there is no interference with the implementation of project components requested by GOB for this “Natural Gas Efficiency Project”.

Table 2.5-1 Comparison Table for On-going Projects funded by ADB & WB

Donor	Project		Present State	Completion Date or Expected Completion Date	Project Cost	PQ	Tender	Contract Type	Construction Supervision	Photos
ADB	Gas Transmission and Development Project (Project Number: 35242)									
	Part A	Gas transmission expansion and reinforcement. Five subcomponents will transmit gas to the consumption centers including less developed regions of the country.								
	Part A-1	Ashuganj-Manohardi-Dhanua-Elenga-Jamuna Bridge east bank gas transmission pipeline (AJGTP). The subcomponent will involve the construction of a 30-inch-diameter, 51 km gas pipeline from Manohardi through the Narsingdi, Ghazipur, and Tangail districts to the east bank of the Jamuna bridge (excluding the 36 km Ashuganj-Manohardi section, which is under construction using Government funds and the existing 24-inch, 52 km Dhanua-Elenga section)	Completed: Route Survey, EIA, IEE, Soil, Sub-soil Test, Land Acquisition & Requisition, Materials Procurement, Pipeline Construction, River Crossing & CP System. On-going: Dhanua MMS.	June 2014	BDT 45,085,072,000	Yes	ICB & LCB	EPC & Separate Package	GTCL No consultant	
	Part A-2	Hatikumrul-Ishwardi-Bheramara gas transmission pipeline (HBGTP). To expand the gas transmission network to the western region of the country, the subcomponent will involve the construction of a 24-inch-diameter, 87 km gas transmission pipeline from Hatikumrul about 14 km from the Jamuna Bridge west to Bheramara through the Sirajganj, Natore, Pabna, and Kushtia districts to transmit 235 MMCFD of gas. (The pipeline size may be increased to 30-inch-diameter during the detailed design stage if such change is proven prudent).	Completed: Route Survey, EIA, IEE, Soil, Sub-soil Test, Land Acquisition & Requisition, Materials Procurement, Pipeline Construction, River Crossing & CP System. Missing portion: Padma River Crossing. On-going: CGS & TBSs. Yet to be started: SCADA System.	December 2015	BDT 7,268,514,000	Yes	ICB & LCB	EPC & Separate Package	GTCL No consultant	
	Part A-3	Bonpara-Rajshahi gas transmission pipeline (BRGTP). Construction of a 12-inch-diameter, 50 km gas transmission pipeline from Bonpara to Rajshahi for transmitting 25 MMCFD.	Completed: Route Survey, EIA, IEE, Soil, Sub-soil Test, Land Acquisition & Requisition, Materials Procurement, Pipeline Construction, River Crossing & CP System. On-going: CGS. Yet to be started: SCADA System	December 2014	BDT 1,835,405,000	Yes	ICB & LCB	EPC & Separate Package	GTCL No consultant	
	Part A-4	Bheramara-Khulna gas transmission pipeline (BKGTP). Construction of a 20-inch-diameter, 165 km gas transmission pipeline from Bheramara to Khulna through Kushtia, Jessore, and Khulna districts, with a capacity of 75–125 MMCFD.	Completed: Route Survey, EIA, IEE, Soil, Sub-soil Test, Land Acquisition & Requisition, Materials Procurement, Pipeline Construction, River Crossing & CP System. On-going: CGS & TBS. Yet to be started: SCADA System	June 2015	BDT 9,038,140,000	Yes	ICB & LCB	EPC & Separate Package	GTCL No consultant	
	Part B	Field appraisal. Five producing gas fields will be appraised to upgrade the estimated gas in place and also to determine the exact location for future drilling activities. A three-dimensional (3-D) survey of the existing gas fields at Rashidpur, Kailastila, and Sylhet in the northeast (owned by the SGFL, and Titas and Bakhrabad gas fields (owned by the BGFCL) in the east will be undertaken. No new exploration activities will be involved.	Completed: All field works On-going: Iterpretation	June 2014	BDT 1,971,500	No PQ	ICB	Separate package 14 pck. for BGFCL 2 pck. for SGFL	BGFCL/SGFL	
	Part C	Rajshahi gas distribution network. Construction of a gas distribution network about 320 km of 1- to 8-inch-diameter gas distribution pipelines in Rajshahi area. This network will subsequently be expanded to 350–400 km.	Completed Package ・Procurement of Material (only this package was funded by ADB) ・Construction of Pipeline by 8 groups ・Construction of 3 DRS (Dist. Regulating station)	Dec 2011	USD 6,670,000	No PQ	ICB	Material Supply only	PGCL	
	Natural Gas Access Improvement Project (Project Number: 38164)									
	Part A	Transmission capacity expansion								
	Part A-1	Ashuganj–Bakhrabad gas transmission loop-line. The subcomponent will construct a 30 inch, 61 km pipeline from Ashuganj to Bakhrabad and install interface metering and regulating stations at the selected locations of Monohordi, Dewanbag, Kutumbupur, Feni, and Barabkundu.	Completed: Route Survey, EIA, IEE, Soil, Sub-soil Test, Materials Procurement, On-going: Land Acquisition & Requisition. Yet not to be started: Pipeline Construction, River Crossing & CP System.	June 2015	BDT 7,433,754,000	Yes	ICB & LCB	EPC & Separate Package	GTCL No consultant	
	Part A-2	Installation of compressors at Ashuganj and Elenga. Under this subcomponent, a compressor will be installed at Ashuganj with a throughput of 1,500 MMCFD and another at Elenga with a throughput of 500 MMCFD.	On-going	September 2015	BDT 14,941,334,000	Yes	ICB	EPC	GTCL & SNC Lavalin International Inc., Canada	
	Part B	Safety and supply efficiency improvement in Titas gas field. This component will service problematic wells in Titas gas field to improve safety and supply efficiency and add four appraisal-cum-development wells and processing plants to increase production by 120 MMCFD.	On-going	June 2014 (extention up to 2015 is proposed.)	BDT 10,000,000,000	No PQ	ICB	EPC & Separate Package	BGFCL No consultant	
	Part C	Access improvement in the southwestern region. The component will construct a 2-inch to 20-inch, 845 km distribution pipeline in the southwest, covering the districts of Kushtia, Jhenidah, Jessore, Khulna, and Bagerhat (including Mongla).	Consists of 4 packages ・2 packages for Material supply ・1 full-turn key package for HDD river crossing ・1 package for training Material supply almost completed. HDD contract awarded, work is yet to be commenced. Note: Pipelaying work will be funded by GOB.	June 2016	BDT 60,000,000	No PQ	ICB	Material supply & EPC for HDD	SGCL No consultant	
	Part D	Supply and demand management. This component will pilot a remote sensing metering system for industrial consumers and a prepaid metering system for domestic consumers within the gas distribution franchise area of Titas Gas Transmission and Distribution Company Limited (TGTDCL). This component will also develop an investment program for improving the efficiency of gas use.	Prepaid Meter : Contract will be awarded soon. Remote Meter : Price proposal will be opened soon.	June 2015	USD 5,000,000 + BDT 208,186,000	Yes	ICB	Turnkey	TGTDCL	
WB	Bakhrabad-Siddiriganj gas transmission pipeline. Construction of a 30-inch-diameter, 60 km gas pipeline from Bakhrabad to Siddiriganj. Sub-component of Siddhirganj Peaking Power Project.		Completed: Route Survey, EIA, IEE, Soil, Sub-soil Test, Land Acquisition & Requisition, Materials Procurement. On-going: Pipeline Construction, River Crossing Yet to be started: CGS, Scada system	June 2014	BDT 8,000,000,000	Yes	ICB	EPC	GTCL DORSCH, Germany	

Source: JICA Survey Team (based on the information from executing agencies)

2.6 Activities of International Oil Companies

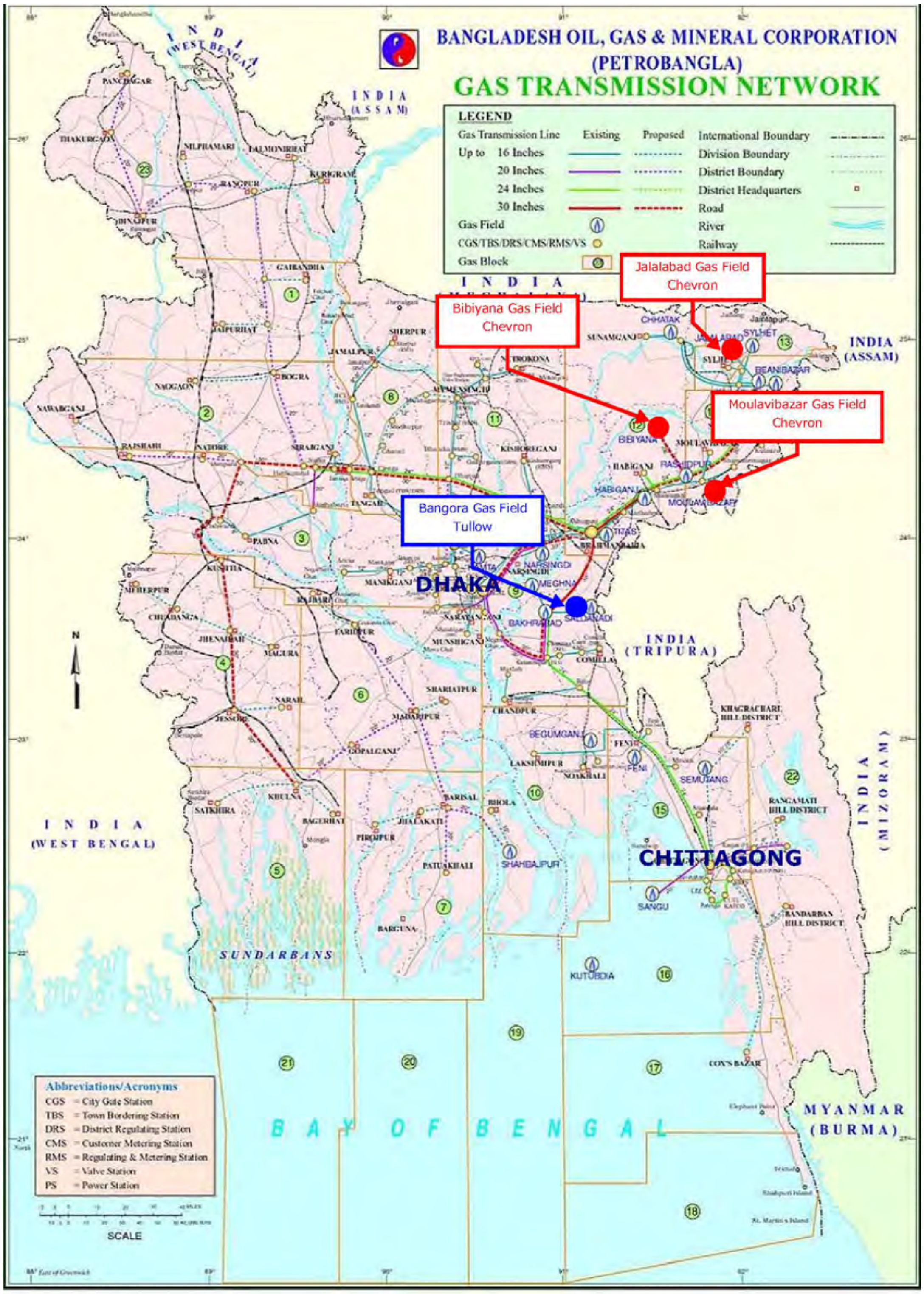


Figure 2.6-1 Productive Gas Fields of IOC

Four IOCs (Chevron, Tullow, Santos and Niko) are involved in exploration and production of natural gas from onshore and offshore fields under PSC with Petrobangla. The present activities and future plans of each IOC based on the information collected during the 1st and 2nd surveys in Bangladesh are mentioned below:

(1) Chevron

Chevron is the largest gas producing IOC operating in Bangladesh with its average gas output of around 1147mmcfd from three fields: Jalalabad, Moulavi Bazar and Bibiyana, which is almost 49 per cent of the country's total output of around 2,312mmcfd in September, 2013. Furthermore, Chevron is planning to increase the production rate of gas and condensate in the near future.

1) Bibiyana gas field ;

   Bibiyana gas field was discovered in 1998 and is one of the most significant discoveries in Bangladesh in both quality and size of the reserve. Currently, the field produces gas at 812mmcfd and condensate at 3270 bbl/d from 12 wells. Chevron has planned to invest 500 Million US$ for the development of Bibiyana gas field (including development wells, process plant etc.) to increase daily gas production by 300 mmcf by 2014. A 3-D seismic survey conducted in 2009, indicated that the field contains a much larger reserve than originally thought.

2) Jalalabad gas field ;

   Chevron operates the Jalalabad gas field in Block 13 in north-eastern Bangladesh. The field produces gas at 249mmcfd and condensate at 1912 bbl/d from 4 wells and there are plans to drill 3 development wells by the end of 2013 for an additional 100 mmcfd of gas. A 3D seismic survey is being conducted for assessing the northeastern extension of Jalalabad field.

3) Moulavi Bazar gas field ;

   Chevron produces natural gas from the Moulavi Bazar Field in Block 14 in north-eastern Bangladesh. The field produces gas at 85.4mmcfd and condensate at 11 bbl/d from 6 wells and there are plans to drill additional development wells for additional gas production based on the well appraisal results. Chevron conducted a 3D seismic survey in Moulvibazar field in 2008.

4) Exploring Block 7

   Chevron has a 43 percent interest in Block 7 in the southwest of Bangladesh. In 2010, Chevron drilled an exploration well at Char-Kajol structure in Block-7. Unfortunately, this was a failure as the company found it "not economically viable."

(2) Tullow Bangladesh Ltd.

Tullow has informed Petrobangla that it would wind-up its operation in Bangladesh by the end of 2013. KrisEnergy of Singapore finalized talks to buy Tullow's local stake in Bangladesh and is waiting for the approval of Petrobangla. Tullow discovered Bangora/Laimai gas field in 2004 in Block-9, and it is now producing gas at 111 mmcfd and condensate at 335 bbl/d from 4 wells. Cumulative gas production at June, 2012 was 194 bcf and the remaining gas reserve will be 327.44 bcf. This suggests that 37% of total reserves have already been produced. Furthermore, Tullow is planning to increase the production rate of gas and condensate in the near future.

(3) Santos Sangu Field Ltd.

Gas production from Sangu had dropped from 160 mmcfd during the initial years to 3.4 mmcfd in September, 2013. As a result Santos finally stopped gas production from Sangu field on the 30th September, 2013. Santos says even 10mmcfd is not profitable for their operation.

Cairn Energy discovered the Sangu gas field in 1996 in block 16, the first offshore gas field in Bangladesh. At the end of 2010, Santos acquired PSC Block-16 and Sangu gas field from Cairn Energy. Cumulative gas production at June 2012 was 481 bcf and the remaining gas reserve is 95.99 bcf. This suggests that about 83% of total reserves have already been produced.

However, Santos and KrisEnergy of Singapore will be awarded jointly to explore Block SS-11 under a new PSC agreement.

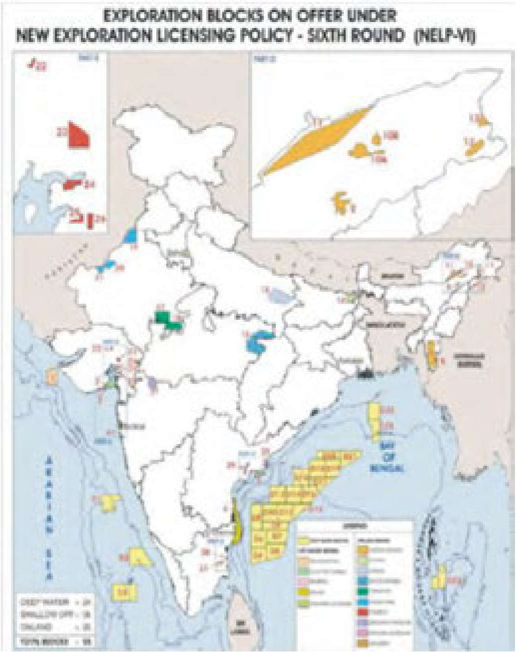
(4) Niko

Due to the dispute between Niko Resources and Petrobangla over compensation for two gas blowout accidents at Tangratila in Sunamganji district in 2005, gas production from the Niko-BAPEX operated Feni Gas field in Block 15 remains suspended. Recently the case has been resolved in an international court. Bangladesh can now raise its claim for some compensation for the loss due to their blowout accident.

(5) ConocoPhillips

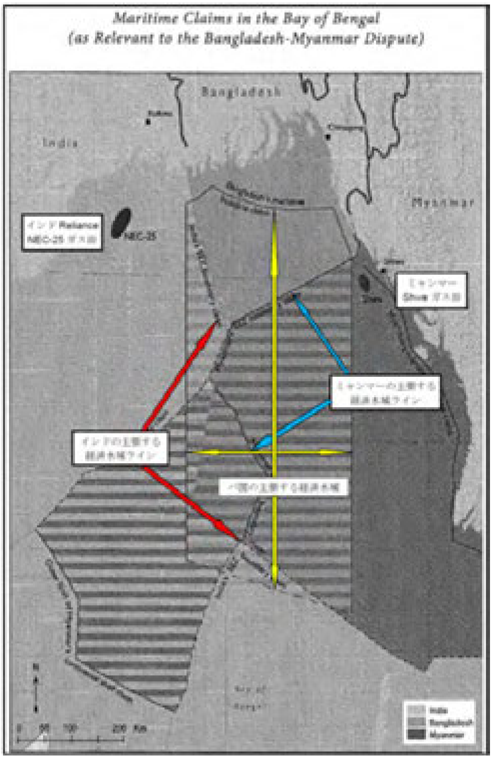
ConocoPhillips have been exploring offshore blocks DS-08-10 and DS-08-11 under a PSC-2008 agreement. But they could work only on the 70% of DS-08-10 and 85% DS-08-11 blocks due to a maritime dispute between Bangladesh, India and Myanmer. In 2012 the dispute with Myanmer has been settled in UNCLOS. Recently, in September, 2013, Petrobangla signed a draft agreement with ConocoPhillips for a shallow-water block SS-07 in the Bay of Bengal under Model PSC 2012. Now, Bangladesh is trying to resolves the maritime boundary dispute with India.

Figure 2.6-2 shows the Exclusive Economic Zones, EEZ of India, Myanmar and Bangladesh.



Exploration Blocks of India

Exploration Blocks of Myanmar



Source：The Maritime Boundary Dispute between Bangladesh and Myanmar.

The National Bureau of Asian Research, Seattle, Washington July 2010

Figure 2.6-2　EEZ (Exclusive Economic Zone) of India and Myanmar

(6) Drilling by Gazprom

Gazprom is conducting their drilling operation in Bangladesh under an agreement (turn-key project) with the GOB to drill 10 wells (4 wells in Titas gas field for BGFCL, 1 well in Shahbazpur gas field for BAPEX, 2 wells in Semutang, 1 well in Sundalpur and 1 well in Rashidpur for SGFL). So far Gazprom successfully drilled Srikail-3, completed Titas -20 and their 3rd drilling in Begumganj is in progress.

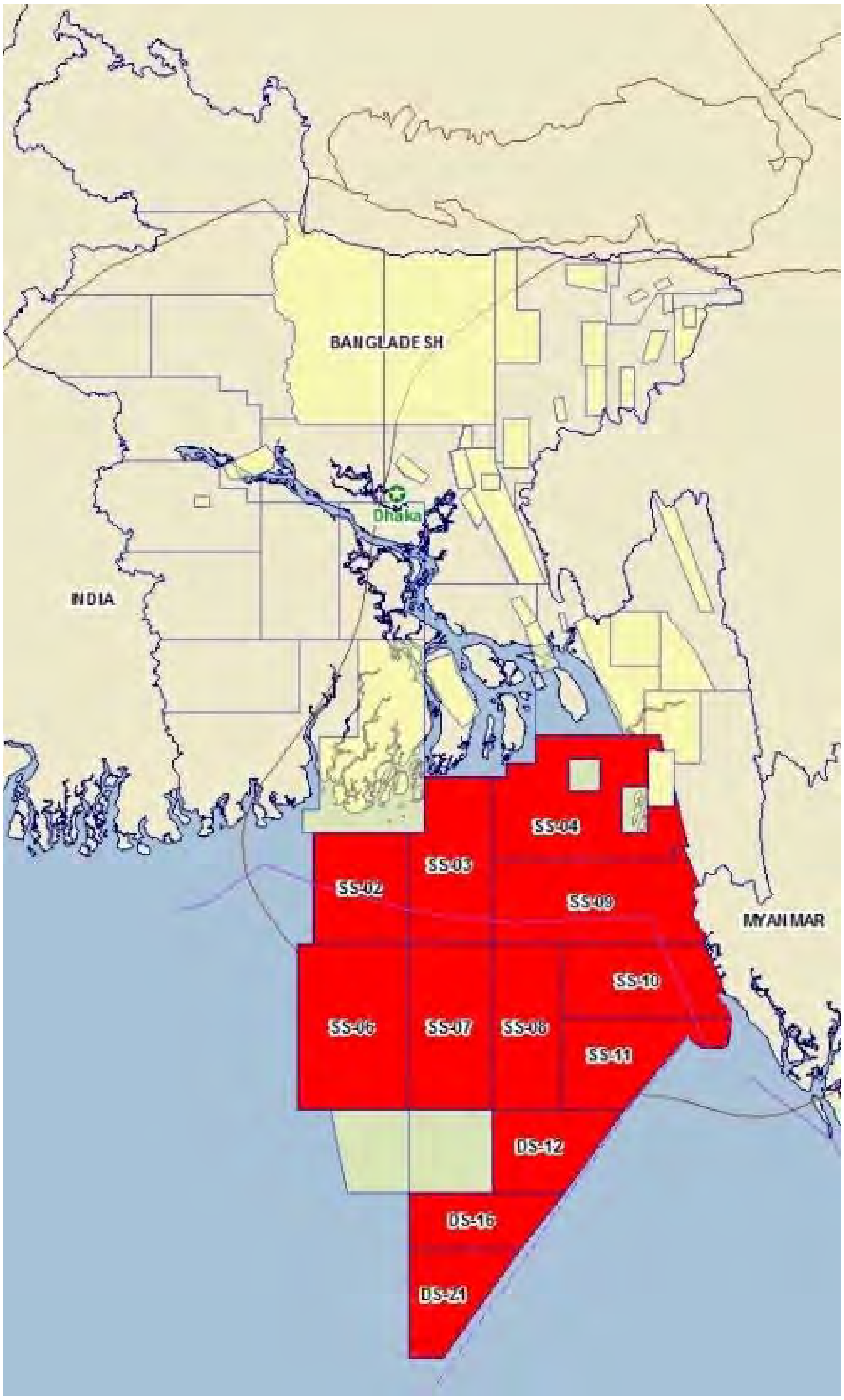
(7) Expected Future Activities in Offshore Bidding Round 2012

In response to bidding under PSC 2012, Petrobangla has signed a draft agreement with ConocoPhillips for the shallow-water block SS-07 in the Bay of Bengal.

Petrobangla has also signed an initial production sharing contract with Indian oil and gas company, ONGC Videsh Ltd., for two sea shallow blocks, Blocks SS-4 and SS-9. Final agreement may be signed in November.

EMRD has approved a proposal to sign the initial agreement with Australia-based Santos and Singapore-based Kris Energy, a JV, under model production sharing contract (MPSC)-2012 to explore oil and gas in the shallow offshore Block SS-11.

Figure 2.6-3 shows Bangladesh PSC Blocks Status in 2012.



Source: PetroView® (Deloitte)

Figure 2.6-3 Blocks offered in Bangladesh Offshore Licensing Round 2012.

(8) Other Development

In order to cope with the scarce gas supply, especially in Chittagong area, and to realize the introduction of alternative energy, the construction of an LNG receiving terminal at Moheshkhali island is planned to import LNG, and an agreement is under process to sign between GOB and a Bidder. A Memorandum of Understanding between GOB and Qatar has already been signed to import LNG.

2.7 Environmental and Social Consideration for Natural Gas Sector

The legislative basis for environmental and social consideration in Bangladesh regarding environmental (and social) impact assessments are the Environmental Conservation Act (ECA) of 1995 and the subsequent Environmental Conservation Rules (ECR) of 1997. The ECA has been amended recently in 2010, but its English translated version is not yet available.

As per the ECA (1995) for the establishment of all industrial units in Bangladesh, prior environmental clearance from DoE of the Ministry of Environment and Forest as ECC (environmental clearance certificate) is mandatory. Moreover, as per the ECR (1997) industrial projects are divided into 4 categories of Green, Amber-A (Orange-A), Amber-B (Orange-B) and Red according to their potential significance of environmental impact and the location of the project.

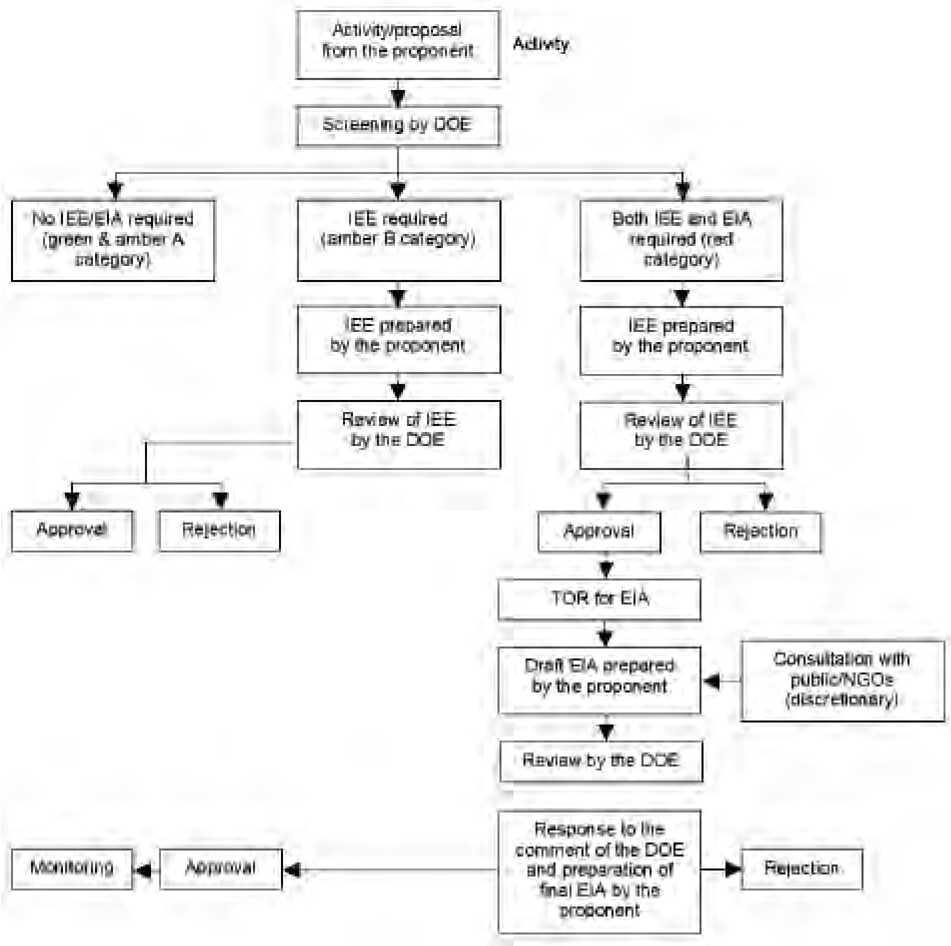
Red category projects (regarded as high potential for adverse environmental impacts) require mandatory conducting of an EIA (followed with IEE (initial environmental examination) that may be exempted for public sector projects) as the basic requirement for obtaining ECC from DoE, while Green category projects (with least potential for adverse impacts or no potential adverse impacts) do not require either IEE or EIA for the receipt of ECC. Still, except for Green category projects, all the other 3 category industrial projects require alternative consideration on project location like avoidance of residential areas with preference being given to industrial zones so as to minimize potential adverse impacts.

It is further noted that for this 4 group categorization of industries, the scale of the project or significance of social impacts like the scale of involuntary resettlement is not taken into consideration. Furthermore, the natural gas sector, as represented by gas extraction including gas pipelines, falls under the Red category requiring mandatory EIA since this sector is part of the project sectors that are specified as Red category as per the ECR (1997).

- Industrial Gases (excluding nitrogen, oxygen and carbon dioxide)
- Laying down/replacement/expansion of water, power and gas distribution lines

■ Exploration/extraction/distribution of mineral resources

A typical Flowchart of the environmental assessment process in Bangladesh, the basis to obtain approval from DoE and hence ECC is shown in Figure 2.7-1.



Source: Profile on Environmental and Social Considerations in Bangladesh, JICA, July 2012

Figure 2.7-1 Flowchart of Environmental Assessment Process in Bangladesh

As could be visualized from Figure 2.7-1 there are 3 officially recognized process systems for obtaining ECC from DoE depending on the environmental category of the project. They are to conduct an IEE and EIA (for RED category project), IEE only (for AMBER-B category project) and no need for either IEE or EIA (GREEN and AMBER-A category project).

Regarding social impacts due to projects, in particular with respect to the most significant impacts like land acquisition and involuntary resettlement and related compensation “The Acquisition and Requisition of Immovable Property Ordinance” of 1982 (revised in 2004) is the only pertinent legal instrument. Ordinance II of this legal instrument focuses on government project work related to land acquisition and requisition (requisition implies temporary land acquisition during project construction/implementation) and requires due compensation to be paid for lands and assets acquired (including houses, trees and standing crops) and for any other related impacts consequent to such involuntary land acquisition. It has been revised several times with respect to compensation in 1989, 1993, 1994 and 2004.

Although this ordinance provides certain safeguards for land owners and has provisions for payment of fair value for compensation for the property acquired, expenses related to relocation, change in income level after relocation, and compensation for illegal residents have not been specified in detail. Moreover, no requirement on the conducting of a RAP study or the subsequent monitoring of resettlement (RAP) implementation is specified and is not required.

Consequently, all social aspects including involuntary land acquisition and resettlement aspects consequent to a project are dealt with comprehensively only as a social component of an EIA study in Bangladesh for locally funded projects. Only foreign and bilateral donor funded projects undertake separate EIA and RAP studies and subsequent monitoring of RAP implementation by the project implementation unit of the executing agency of the Project.

As such, even though legislation on the conducting of an EIA study as a requirement for obtaining ECC for industrial projects is regarded as adequate and meets acceptable international norms, legislation concerned with involuntary land acquisition and resettlement (including non-requirement for RAP) still lacks the internationally acceptable safeguard policies of JICA and also the relevant WB Operation Policy (OP 4.12) on Involuntary Resettlement.

2.8 Bidding and Contract for the Project

The procurement for public works in Bangladesh is carried out according to the following rule and act under the control of the "Central Procurement Technical Unit".

- The public Procurement Rules 2008
- The Public Procurement Act 2006

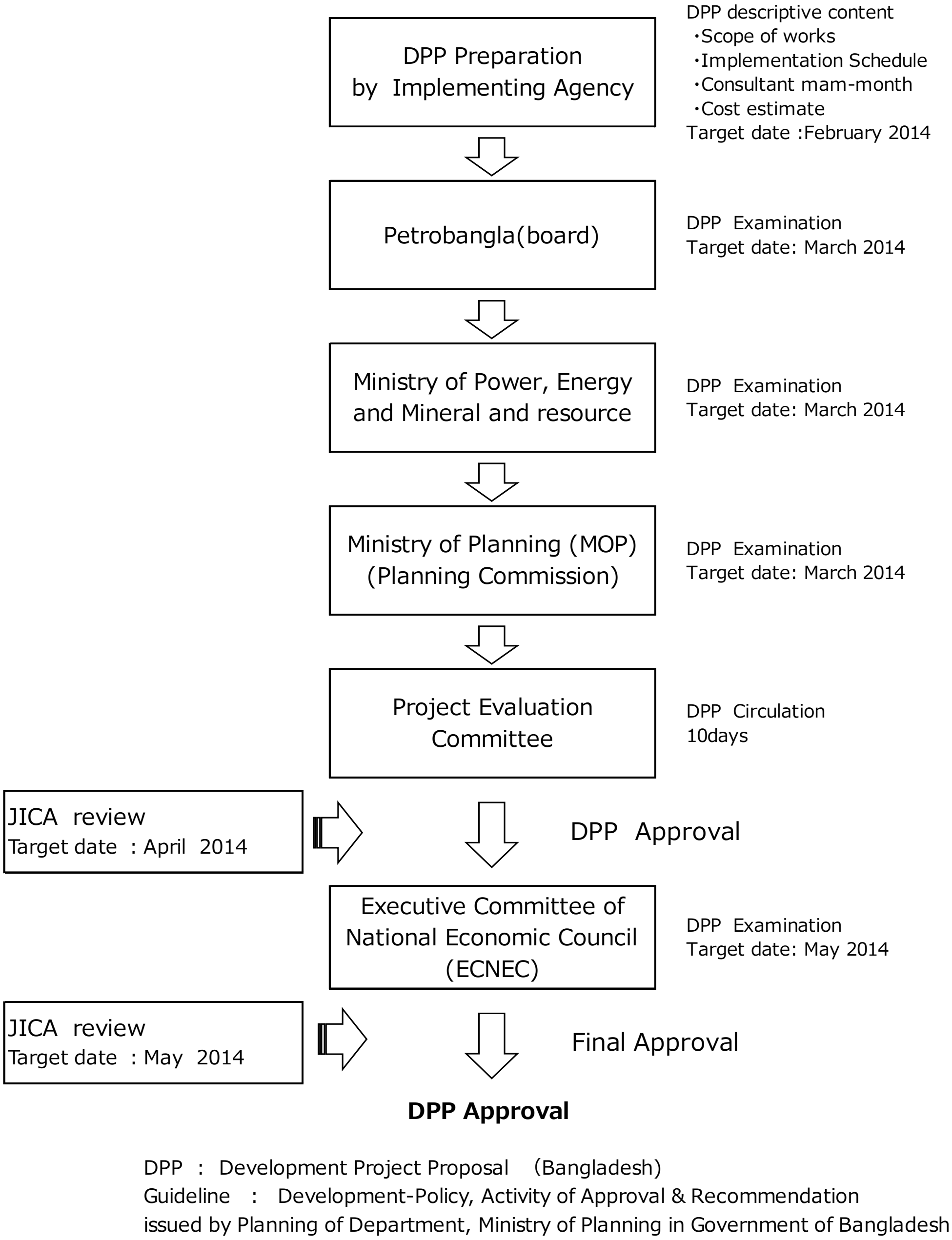
However, the procurement for the projects funded by international development donors is carried out in accordance with their guidelines which pre-empt these local rules and acts.

With regard to the approval of a tender or proposal, the Board of each executing company is authorized by GOB to make all decisions, and need not seek to obtain approval from the line ministry and/or Petrobangla.

2.9 Support to the preparation of DPP

Prior to the Loan Agreement ("L/A") between both governments, the Development Project Proposal ("DPP") should be approved by GOB.

The implementing agency of the selected project should prepare the DPP and obtain the approval from the government prior to the Loan Agreement. Figure 2.9-1 shows the flow chart of the DPP application and approval process.



Source: JICA Survey Team

Figure 2.9-1 DPP Application and Approval Process in Bangladesh

After the preparation of DPP, it will take at least three months to obtain the final approval from ECNEC, one month for approval from the boards of both the executing company and Petrobangla, plus two months for approval from EMRD, Planning Commission and ECNEC.

The JICA Survey Team has supported each executing agency of the selected project for the preparation of DPP by providing necessary data and information included in this report during the survey period.

2.10 Safety Control

The state owned gas companies follow the following rules and acts for safety control.

- Mineral Gas Safety Rules 1971
- Natural Gas Safety Rules 1991
- The Bangladesh Petroleum Act 1994
- The Factories Act,1965

2.11 Organization and Activities for Anti - Corruption

There is an Anti-corruption Commission (ACC) in GOB which has the power to investigate any suspicious mater or any person of the state suspected to be involved in corruption. Moreover for career development like promotion to a higher post for any employee of the government, semi-government or autonomous body, ACC clearance is mandatory.

Furthermore, the management body of each executing agency has the authority to take necessary departmental actions regarding any employee involved in corruption.

Chapter 3 Overview of Executing Agencies

An overview of each executing agency and each requested project component based on the result of the Survey works is described below.

3.1 Executing Agencies

The following state-owned companies are the executing agencies that have requested the candidate projects.

3.1.1 BGFCL

(1) Outline

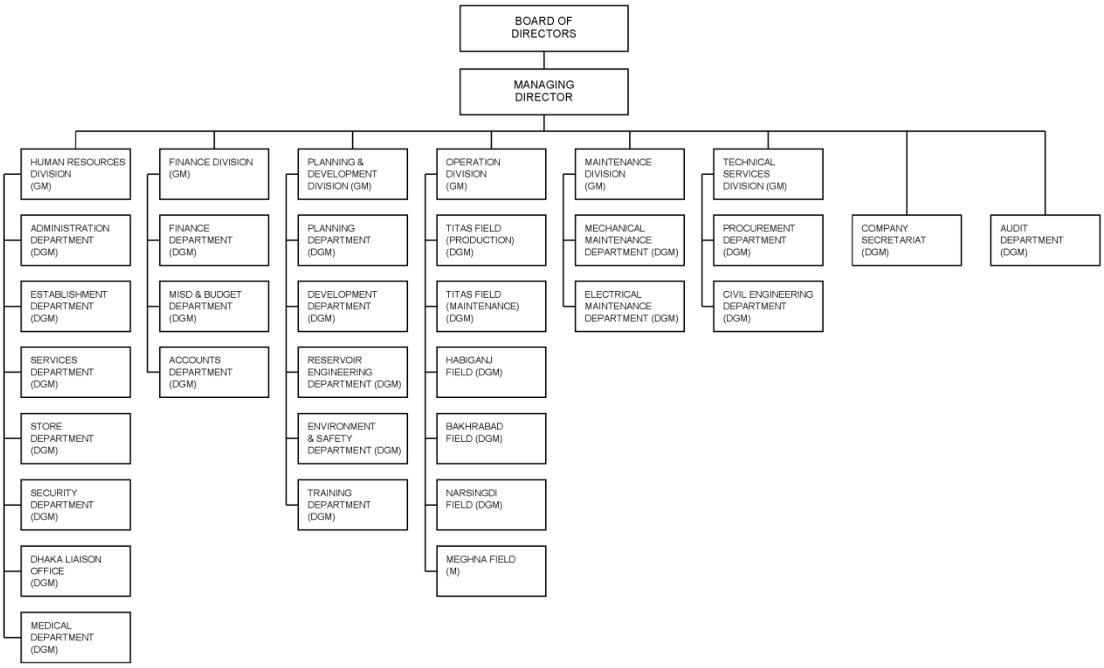
BGFCL is the largest natural gas producing organization in Bangladesh. BGFCL originates from the Pakistan Shell Oil Company Limited (PSOC), which was formed in 1956, and started operation on Titas and Habiganj Gas Fields in the late sixties. GOB bought all the shares of PSOC and it was renamed BGFCL in 1975.

Sales of gas to companies that are engaged in gas transmission and distribution are a source of income for BGFCL. BGFCL produced 277.77 billion cubic feet (bcf) of natural gas, which accounted for approximately 38% of the total gas production in Bangladesh from five gas fields: Titas, Habiganj, Bakhrabad, Narsingdi and Meghna during fiscal year 2011/12.

(2) Organisation

BGFCL complies with the Company’s Act of 1994 and the Articles of Association of the Company. The statutory general meeting of the company is held annually in accordance with Section 81 of the Act. In this general meeting, a brief account of the performance of the company, highlighting implementation and progress of projects etc. is generally presented. Furthermore, necessary resolutions such as audited accounts, balance sheets and profit & loss accounts are adopted. Any director may be appointed or removed by the company in the general meeting at the opinion of Petrobangla/the government.

There is a provision for 1,163 employees in this organisation. In fiscal year 2011/2012, 393 officers out of 493 and 490 staff out of 670 totalling 883 were in service. The organisation chart of BGFCL is shown in the figure below.



Source: BGFCL's answer (Attachment-1 of BO-1) to questionnaire by JICA Survey Team

Figure 3.1-1 Organisation Chart of BGFCL

The members of the board of directors of BGFCL as of 2013 are shown in the table below.

Table 3.1-1 Board of Directors of BGFCL

Name	Position in BGFCL	Other Position
Md. Mozammel Haque Khan	Chairman	Secretary, Energy & Mineral Resources Division
Prof. Dr. Md. Hussain Monsur	Director	Chairman, Petrobangla
Major Taher Uddin Akhanjee (Rtd)	Director	Ex-Director, Petrobangla
Professor Dr. Khalilur Rahman Chowdhury	Director	Department of Geological Sciences, Jahangirnagar University
Mr. Mohammad Rafiqul Islam Khan	Director	Director (Finance), Petrobangla
Mr. Muhammad Imaduddin	Director	Director (PSC), Petrobangla
Mr. Mohammed Shaiful Alam Chowdhury	Director	Director (Planning), Petrobangla
Mr. Md. Nurul Absar	Director	Managing Director, Bangladesh Gas Fields Company Ltd.,
Mr. A. T. M. Mostafa Kamal	Director	Deputy Secretary (Administration), Energy & Mineral Resources Department

Source: BGFCL's website

(3) Financial Statement Analysis

We examined and analysed the financial soundness of BGFCL on the basis of their financial statements. Their financial statement and performance indicators are shown in the table below.

Table 3.1-2 Financial Statements and Performance Indicators of BGFCL

Unit: Million Taka

Balance Sheet					
	2007-2008	**2008-2009**	**2009-2010**	**2010-2011**	**2011-2012**
Capital & Reserves	11,391	13,098	14,062	14,767	14,332
Capital Employed	22,148	24,271	25,810	39,446	42,908
Fixed Assets	13,598	13,993	15,180	16,347	17,979
Current Assets	5,451	5,620	5,372	5,335	6,359
Liqid Assets	5,345	5,398	5,176	5,088	6,104
Current Liabilities	4,454	4,076	5,286	5,766	9,075
Profit & Loss					
Sales	16,111	17,650	19,277	19,996	23,244
Net Profit before Tax	1,308	1,866	1,815	1,615	1,970
Net Profit after Tax	817	1,166	1,135	1,009	1,231

Financial Performance Indicators					
Profitability Ratios					
year	**2007-2008**	**2008-2009**	**2009-2010**	**2010-2011**	**2011-2012**
Pre-tax Profit Margin (%)	8.12%	10.57%	9.42%	8.08%	8.48%
Return on Capital Employed (%)	5.91%	7.69%	7.03%	4.09%	4.59%
Liquidity Ratios					
Quick Ratio (Acid Test) (%)	120%	132%	98%	88%	67%
Current Ratio (%)	122%	138%	102%	93%	70%
Return on Equity (%)	7.17%	8.90%	8.07%	6.83%	8.59%

Source: Made by JICA Survey Team, referring to Annual report of BGFCL

1) Profitability

As indicated in Table 3.1-2, sales of BGFCL have steadily increased from 16.1 billion Taka in fiscal year 2007/2008 to 23.2 billion Taka in fiscal year 2011/2012. Accordingly, the balance sheet has expanded. The pre-tax profit margins show over 8% during the period from 2007/2008 to 2011/2012. The ratio of return on capital employed during the same period was positive and stayed over 5% on average. Hence, it can be said that the profitability of BGFCL is sufficiently high.

2) Debt Service Capacity

The majority of assets in BGFCL in 2011/2012 are the proved properties (10.9 billion Taka) followed by production assets (3.2 billion Taka), and subsequently bank deposits (3.1 billion Taka), according to the balance sheet in the annual report of BGFCL.

The average quick ratio and current ratio during the period of 2007/2008 to 2011/2012 had surpassed 100%. Both such ratios in the fiscal year 2011/2012 drastically decreased, because the deferred income tax in current liabilities was recorded simply due to the accounting processing. The ratio of return on equity during the period of 2007/2008 to 2011/2012 was positive and stayed over 6%. Accordingly, the debt service capacity of BGFCL for the short-term is not significantly worrying. It is, therefore, considered that the financial condition of BGFCL is favourable.

3.1.2 GTCL

(1) Outline

GTCL is a natural gas transmission company incorporated in 1993 and has the following objectives:

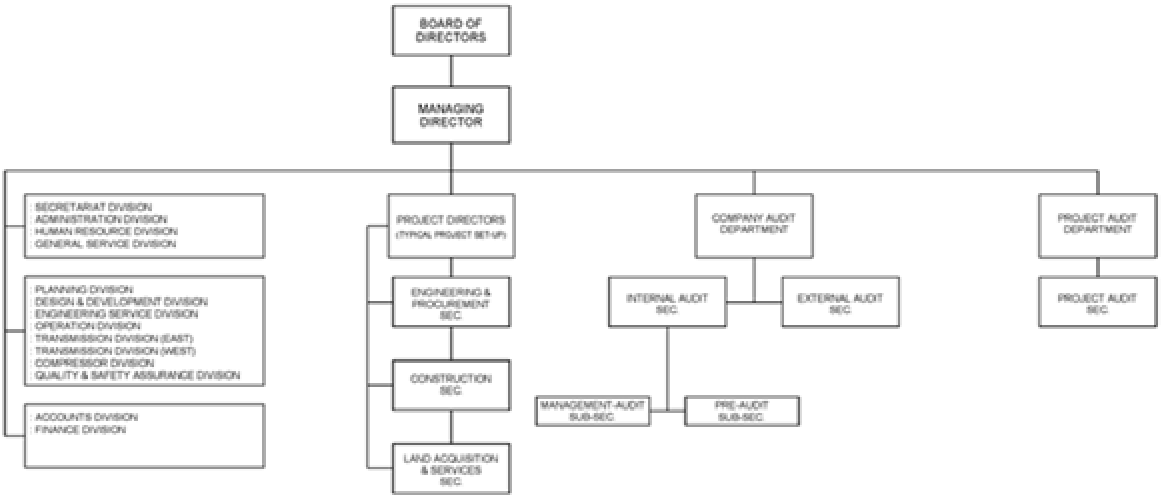
- Centralized O&M of national gas grid
- Expanding of national gas grid ensuring balanced supply & usage of natural gas in all regions of the country

Gas transmission charge is a source of income for GTCL. GTCL transmitted 539 bcf of natural gas through 1,091 km of high pressure pipelines during fiscal year 2011/12. GTCL also transported a total of 80 million litres of condensate though its North-South Condensate Pipeline (175 km) during the year.

(2) Organisation

GTCL complies with the Company’s Act of 1994 and the Articles of Association of the Company. The statutory general meeting of the company is held annually in accordance with Section 81 of the Act. In this general meeting, a brief account of the performance of the company, highlighting implementation and progress of projects etc. is generally presented. Furthermore, necessary resolutions such as audited accounts, balance sheets and profit & loss accounts are adopted. Any director may be appointed or removed by the company in the general meeting at the opinion of Petrobangla/the government.

There was a provision for 1,990 employees in this organisation in fiscal year 2011/2012. The manpower consists of 650 officers, 257 staff, 1083 hired basis staff and 2 retainer doctors. The organisation chart of GTCL is shown in the figure below.



Source: GTCL's answer (Appendix-1 of GO-1) to questionnaire by JICA Survey Team

Figure 3.1-2 Organisation Chart of GTCL

The members of the board of directors of GTCL as of 2013 are shown in the table below.

Table 3.1-3 Board of Directors of GTCL

Name	Position in GTCL	Other Position
Prof. Dr. Md. Hussain Monsur	Chairman	Chairman, Petrobangla
Dr. Mohammed Osman Amin	Director	Director General, Hydrocarbon Unit, Energy & Mineral Resources Division, Ministry of Power, Energy & Mineral resources
Md. Sefaul Alam	Director	Joint Secretary (Development), Ministry of Power, Energy & Mineral resources
Mr. Mohammad Ziaur Rahman	Director	Joint-Secretary, Ministry of Power, Energy & Mineral resources
Dr. Maglub Al Nur	Director	Professor, Bangladesh University of Engineering & Technology (BUET)
Mr. Mohammed Shaiful Alam Chowdhury	Director	Director (Planning), Petrobangla
Md. Shahed Ali	Director	Deputy Secretary(Admin-1), Ministry of Power, Energy & Mineral resources
Anwar Hossain	Director	-
Md. Aminur Rahman	Director	Managing Director, GTCL

Source: GTCL's website

(3) Financial Statement Analysis

We examined and analysed the financial soundness of GTCL on the basis of their financial statements. Their financial statement and performance indicators are shown in the table below.

Table 3.1-4 Financial Statements and Performance Indicators of GTCL

Unit: Million Taka

Balance Sheet					
	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Capital & Reserves	17,510	19,969	24,933	29,024	32,686
Capital Employed	25,779	28,201	38,281	43,601	50,616
Fixed Assets	20,065	19,155	29,112	31,202	38,647
Current Assets	8,278	5,675	4,099	4,715	6,855
Liqid Assets	7,584	4,118	3,776	4,414	6,511
Current Liabilities	2,564	2,183	2,403	2,471	3,026
Profit & Loss					
Sales	4,178	4,186	4,526	4,637	4,955
Net Profit before Tax	2,731	2,841	3,218	3,493	4,075
Net Profit after Tax	2,614	2,655	2,982	3,185	3,653

Financial Performance Indicators					
Profitability Ratios					
Year	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Pre-tax Profit Margin (%)	65.37%	67.87%	71.10%	75.33%	82.24%
Return on Capital Employed (%)	10.59%	10.07%	8.41%	8.01%	8.05%
Liquidity Ratios					
Quick Ratio (Acid Test) (%)	296%	189%	157%	179%	215%
Current Ratio (%)	323%	260%	171%	191%	227%
Return on Equity (%)	14.93%	13.30%	11.96%	10.97%	11.18%

Source: Made by JICA Survey Team, referring to Annual report of GTCL

1) Profitability

As indicated in Table 3.1-4, sales of GTCL have steadily increased from 4.2 billion Taka in fiscal year 2007/2008 to 5.0 billion Taka in fiscal year 2011/2012. The pre-tax profit margins had shown over 65% and had stably increased during the period from 2007/2008 to 2011/2012. The ratio of return on capital employed during the same period was positive and stayed over 8%. Hence, it can be said that the profitability of GTCL is sufficiently high.

2) Debt Service Capacity

The majority of assets in GTCL in 2011/2012 are the capital works-in-progress (20.2 billion Taka) followed by the property, plant and equipment (18.4 billion Taka) and subsequently bank fixed deposits (3.1 billion Taka), according to the balance sheet in the annual report of GTCL.

The quick ratio and current ratio during the period of 2007/2008 to 2011/2012 had surpassed 150%. The ratio of return on equity during the period of 2007/2008 to 2011/2012 was positive and stayed over 10%. Accordingly, the debt service capacity of GTCL for the short-term is favourable. Hence, it can be said that the financial condition of GTCL is sound.

3.1.3 TGTDCL

(1) Outline

TGTDCL is the prime energy company of Bangladesh, distributing 1.3 bcf of natural gas per day to over 1.53 million consumers, and its franchise area covers Dhaka Division except for the west side of the Jamuna River.

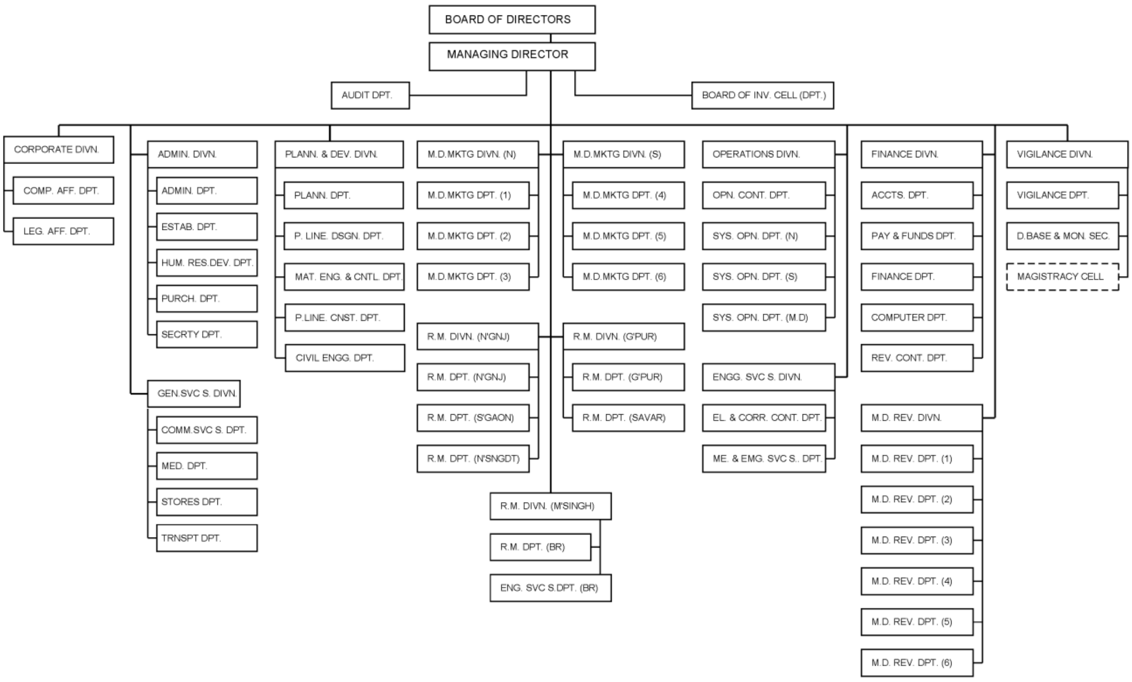
TGTDCL was formed in 1964 as a joint stock company of the government of Pakistan and PSOC. After the independence of Bangladesh, TGTDCL became a government-owned company and was placed under the administrative control of Petrobangla in 1975. A total of 75% of TGTDCL’s shares are currently owned by Petrobangla, while 25% of TGTDCL’s shares are held by the private sector as a part of promotion of private sector participation in the sector. The shareholders in the private sector mainly consist of individuals including resident and non-resident Bangladeshi, local and foreign companies, investment corporations and foreign individuals. The majority of the above 25% of its shares are owned by individuals including resident and non-resident Bangladeshi.

Gas sales are a source of income for TGTDCL. TGTDCL distributed 480.28 bcf of natural gas, which accounted for approximately 63% of total gas sales in Bangladesh during fiscal year 2011/12.

(2) Organisation

TGTCL complies with the Company’s Act of 1994 and the Articles of Association of the Company. The statutory general meeting of the company is held annually in accordance with Section 81 of the Act. In this general meeting, a brief account of the performance of the company, highlighting implementation and progress of projects etc. is generally presented. Furthermore, necessary resolutions such as audited accounts, balance sheets and profit & loss accounts are adopted. Any director may be appointed or removed by the company in general meeting at the opinion of Petrobangla/the government.

The total manpower is 3,629, out of which the number of officers was 1,181 and that of staff is 2,448 in fiscal year 2011/2012. The organisation chart of TGTDCL is shown in the figure below.



Source: TGTDCL's website

Figure 3.1-3   Organisation Chart of TGTDCL

The members of the board of directors of TGTDCL as of 2013 are shown in the table below.

Table 3.1-5 Board of Directors TGTDCL

Name	Position in TGTDCL	Other Position
Md. Mozammel Haque Khan	Chairman	Secretary, Energy & Mineral Resources Division
Abdul Malek	Director	Private Secretary-1 to Hon'ble Prime Minister
Prof. Dr. Md. Hussain Monsur	Director	Chairman, Petrobangla
Md.Monsur Ali Shikder	Director	Chairman, Bangladesh Chemical Industries Corporation
Md. Abdul Wahab Khan	Director	Chairman, Bangladesh Power Development Board
Md. Golam Mostofa	Director	Additional Secretary, Energy & Mineral Resources Division
Engr. Md. Nowshad Islam	Director	Managing Director (Additional Charge), Titas Gas T&D Co. Ltd.
Akhter Hossain	Director	-
Md. Sabur Khan	Director	President, Dhaka Chamber of Commerce and Industry (DCCI)

Source: TGTDCL's website

(3) Financial Statement Analysis

We examined and analysed the financial soundness of TGTDCL on the basis of their financial statements. Their financial statement and performance indicators are shown in the table below.

Table 3.1-6 Financial Statements and Performance Indicators of TGTDCL

Unit: Million Taka

Balance Sheet					
	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Capital & Reserves	13,693	16,639	20,998	28,246	36,163
Capital Employed	22,751	26,651	31,112	38,431	45,212
Fixed Assets	11,713	11,745	11,408	33,213	42,224
Current Assets	19,051	20,966	23,251	26,632	27,603
Liqid Assets	17,614	19,134	21,432	24,817	27,603
Current Liabilities	14,149	16,282	19,397	21,415	23,438
Profit & Loss					
Sales	44,700	52,903	64,557	68,551	71,375
Net Profit before Tax	5,662	7,328	9,860	12,331	12,012
Net Profit after Tax	4,218	5,453	7,333	9,177	8,912

Financial Performance Indicators					
Profitability Ratios					
Year	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Pre-tax Profit Margin (%)	12.67%	13.85%	15.27%	17.99%	16.83%
Return on Capital Employed (%)	24.89%	27.50%	31.69%	32.09%	26.57%
Liquidity Ratios					
Quick Ratio (Acid Test) (%)	124%	118%	110%	116%	118%
Current Ratio (%)	135%	129%	120%	124%	118%
Return on Equity (%)	30.80%	32.77%	34.92%	32.49%	24.64%

Source: Made by JICA Survey Team, referring to Annual report of TGTDCL

1) Profitability

Net profit before tax of TGTDCL had more than doubled from 5.7 billion Taka in 2007/2008 to 12.0 billion Taka in 2011/2012, as indicated in Table 3.1-6. Accordingly, the balance sheet had rapidly expanded. The pre-tax profit margins show over 12% during the period from 2007/2008 to 2011/2012. The ratio of return on capital employed during the same period was positive and stayed over 24%. Thus, it can be said that the profitability of TGTDCL is sufficiently high.

2) Debt Service Capacity

The majority of assets in TGTDCL in 2011/2012 were long-term bank deposits and others (29.4 billion Taka) followed by trade receivables (14.6 billion Taka) and subsequently property, plant and equipment (10.9 billion Taka), according to the balance sheet in the annual report of TGTDCL.

The quick ratio and current ratio during the period of 2007/2008 to 2011/2012 surpassed 110%. The ratio of return on equity during the same period was positive and stayed over 24%. Accordingly, the short-term debt service capacity of TGTDCL is sound. Hence, it is considered that the financial condition of TGTDCL is favourable.

3.1.4 KGDCL

(1) Outline

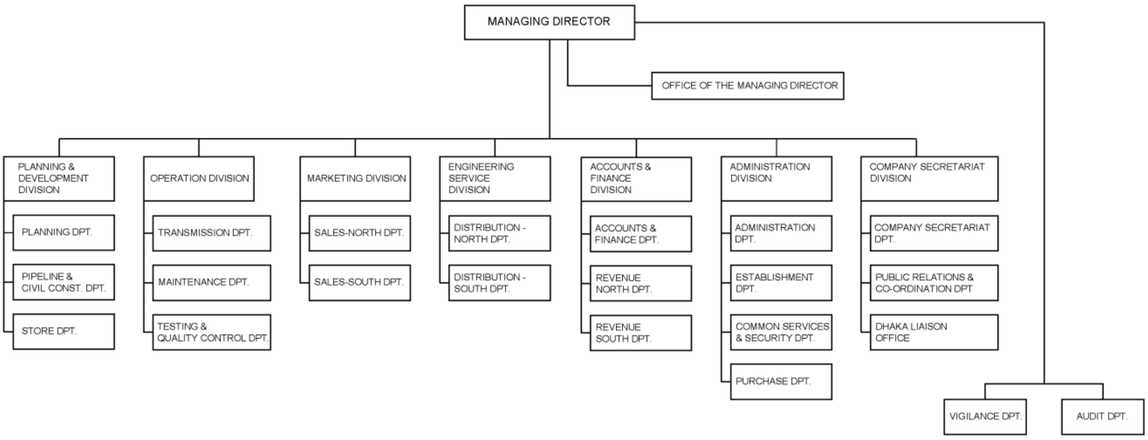
KGDCL is the natural gas distribution company in the franchise area of greater Chittagong and Chittagong Hill Tract. Due to the expansion of industrial and commercial customers and the increased demand for natural gas as a fuel, the Bangladesh government took the positive initiative to build a separate gas distribution company for better management and efficient customer service for the greater Chittagong region. KGDCL was formed in 2010 and commenced commercial activities from 1 July 2010.

Gas sales are a source of income for KGDCL. KGDCL distributed 81.76 bcf of natural gas during fiscal year 2011/12. The total number of gas connections was recorded as 369,703 during the same period.

(2) Organisation

KGDCL complies with the Company's Act of 1994 and the Articles of Association of the Company. The statutory general meeting of the company is held annually in accordance with Section 81 of the Act. In this general meeting, a brief account of the performance of the company, highlighting implementation and progress of projects etc. is generally presented. Furthermore, necessary resolutions such as audited accounts, balance sheets and profit & loss accounts are adopted. Any director may be appointed or removed by the company in general meeting at the opinion of Petrobangla/the government.

KGDCL had a total of 650 manpower including 275 officers and 375 staff in fiscal year 2011/2012. The organisation chart of KGDCL is shown in the figure below.



Source: KGDCL's answer (KO-1) to questionnaire by JICA Survey Team

Figure 3.1-4 Organisation Chart of KGDCL

The members of the board of directors of KGDCL as of 2013 are shown in the table below.

Table 3.1-7 Board of Directors of KGDCL

Name	Position in KGDCL	Other Position
Prof. Dr. Md. Hussain Monsur	Chairman	Chairman, Petrobangla
Md. Rafiqul Islam	Director	Director (Admin), Petrobangla
Mohammad Imaduddin	Director	Director (PSC), Petrobangla
Mr. Mohammed Shaiful Alam Chowdhury	Director	Director (Planning), Petrobangla
Md. Quamruzzaman	Director	Director (Operation & Mines), Petrobangla
Md. Imam Hossain	Director	Secretary, Petrobangla
Engr. Jamil Ahmed Alim	Director	Managing Director, KGDCL
Sohel Ahmed	Director	Dy. Secretary, Energy & Mineral Resources Division
Md. Abdul kader	Director	Director (admin & training), Bangladesh Petroleum Institute
Nazmul Ahsan	Director	Dy. Secretary, Energy & Mineral Resources Division
Md. Nurul Alam	Director	Dy. Secretary, PS to State Minister, Energy & Mineral Resources Division

Source: KGDCL's website

(3) Financial Statement Analysis

We examined and analysed the financial soundness of KGDCL on the basis of their financial statements. Their financial statement and performance indicators are shown in the table below.

Table 3.1-8 Financial Statements and Performance Indicators of KGDCL

Unit: Million Taka

Balance Sheet		
	2010-2011	2011-2012
Capital & Reserves	887	2,298
Capital Employed	1,101	36,163
Fixed Assets	41	241
Current Assets	5,456	8,284
Liqid Assets	5,413	8,244
Current Liabilities	4,354	5,724
Profit & Loss		
Sales	14,048	17,005
Net Profit before Tax	4,790	6,490
Net Profit after Tax	2,994	4,056

Financial Performance Indicators		
Profitability Ratios		
Year	2010-2011	2011-2012
Pre-tax Profit Margin (%)	34.10%	38.17%
Return on Capital Employed (%)	435.06%	17.95%
Liquidity Ratios		
Quick Ratio (Acid Test) (%)	124%	144%
Current Ratio (%)	125%	145%
Return on Equity (%)	338%	177%

Source: Made by JICA Survey Team, referring to Annual report of KGDCL

1) Profitability

As indicated in Table 3.1-8, sales of KGDCL were recorded as 14.0 billion Taka and 17.0 billion Taka in fiscal year 2010/2011 and 2011/2012 respectively.

The pre-tax profit margins show over 34% during the same period, while the ratio of return on capital employed was positive and stayed over 17%. Particularly, the return on capital employed in fiscal year 2010/2011 was considerably high, because revenue reserve in fiscal year 2010/2011 was limited due to the establishment of KGDCL in this year. In general, it can be said that the profitability of KGDCL is sufficiently high.

2) Debt Service Capacity

The majority of assets in KGDCL in 2011/2012 are investments in bank deposits (4.0 billion Taka) followed by trade receivables (1.9 billion Taka) and subsequently cash and cash equivalents (1.8 billion Taka), according to the balance sheet in the annual report of KGDCL.

The quick ratio and current ratio in fiscal year 2010/2011 and 2011/2012 reached 120%. Accordingly, the short-term debt service capacity for of KGDCL is favourable. Hence, it can be said that the financial condition of KGDCL is sound.

Chapter 4 Overview of the Requested Project Components

In order to select the project components appropriate for assistance under a Japanese ODA loan, the following items of each project component requested by GOB were studied by the Survey Team during the 1st Survey in Bangladesh, and the results of such studies are summarized in this chapter.

- Outline (Project Scope)
- Objective, necessity and priority
- Site condition
- Duration of the project implementation
- Approximate project cost
- Environmental and social considerations

4.1 Development of Gas Production Fields

4.1.1 Drilling New Well(s) in Bakhrabad Gas Field (BGFCL)

(1) Outline

This project aims to drill new well(s) in the Bakhrabad Gas Field located in Muradnagar of Comilla district in order to augment gas production. A detailed drilling plan including the number of well(s) to be newly drilled depends on the following results.

- Bakhrabad well no. 9 being currently drilled
- Interpretation of 3D seismic data being currently conducted by BAPEX

The drilling of Bakhrabad well no. 9 was just completed in August 2013 while the interpretation of 3D seismic data is still being done.

(2) Objective, Necessity and Priority

BGFCL requested the drilling of new well(s) in Bakhrabad Gas Field to augment natural gas production.

Gas production by drilling new well(s) is expected to have a relatively immediate effect to cope with the large production decline accompanied by wellhead pressure decline on a field scale, and it will meet the increasing gas demand of the country. In addition, the drilling of new well(s) in Bakhrabad Gas Field contributes to a better understanding of the real cause/reason for the pressure decline at the wellhead, which is still not clearly understood.

(3) Omission of the Component

During the 1st survey in Bangladesh, this project component was excluded from the candidate projects because the GOB stated that this component would be funded by a Gas Development Fund (GDF).

4.1.2 Appraisal of Existing Production Wells for the Installation of Compressors at Bakhrabad, Narsingdi and Titas Gas Fields

(1) Introduction

Several methods can be applied for well and field evaluation for the installation of wellhead gas compressors in the Bakhrabad, Narsingdi and Titas Gas Fields. A combination of some of the methods is practically used and two types of evaluation methods were applied in this evaluation.

A quick look evaluation was required for prioritization of the candidate fields/locations for installation of wellhead gas compressors in a very short time frame. Therefore, an evaluation method using mainly well production data was employed. This type of evaluation method was focused on the estimates of the remaining production period based on the flowing wellhead pressure (FWHP) data in each well. This method can be applied for evaluation of different fields without geological knowledge.

(2) Major Factors for Well and Field Evaluation

A quick look well and field evaluation for installation of wellhead gas compressors is based on the following factors.

- Remaining reserves
- Remaining production period
- Relationship between current flowing wellhead pressure and transmission line pressure

Remaining reserves of the field also control the remaining production period.

(3) Remaining Reserves

The recoverable reserves, cumulative production and remaining reserves of the gas fields under BGFCL have been recently updated. In this update, the Narsingdi Gas Field indicated a significant increase in the recoverable reserves although the size of the Narsingdi Gas Field is much smaller than the Bakhrabad and Titas Gas Fields.

The remaining reserves of the Bakhrabad, Narsingdi and Titas Gas Fields are as follows.

- Bakhrabad: 647 bcf (47% of the recoverable reserves)
- Narsingdi: 202 bcf (58% of the recoverable reserves)
- Titas: 3975 bcf (54% of the recoverable reserves)

The recent success in gas production from Bakhrabad well no. 9 will add some recoverable reserves in the Bakhrabad Gas Field, which will result in an increase in the remaining reserves.

The remaining reserves of the Narsingdi Gas Field are relatively small, but as mentioned later, the long-term production forecast, which depends on the remaining reserves, indicates that there is no apparent difference in the remaining production period between the Narsingdi Gas Field and the Bakhrabad and Titas Gas Fields. This suggests that the remaining reserves do not have a significant effect on the field evaluation in this case.

(4) Estimates of Remaining Production Period

There are two approaches to the estimates of the remaining production periods for the Bakhrabad, Narsingdi and Titas Gas Fields:

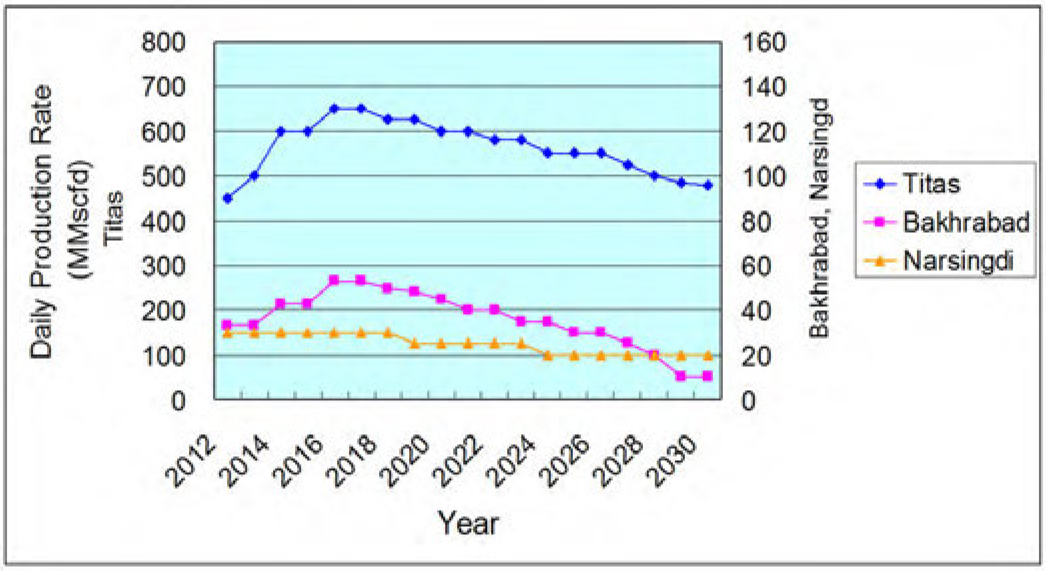
- Production Forecast-1: Long-term production forecast on a field-by-field basis
- Production Forecast-2: Review of production profiles on a well-by-well basis

The Production Forecast-1 is based on both the production forecast for the gas fields under BGFCL prepared in February 2012 and the updated production forecast for the Narsingdi Gas Field. The production forecast by BGFCL covers the period of 2012 to 2030 (Figure 4.1-1). The production forecasts for the Bakhrabad, Narsingdi and Titas Gas Fields are prepared by assuming the installation of compressors and the field abandonment pressures of 250 Pound per Square Inch Gauge (psig) for the Bakhrabad Gas Field and 500 psig for the Narsingdi and Titas Gas Fields. A long-term production forecast also depends on the remaining reserves, number of producing wells and production capacity per well.

The long-term production forecasts for the Bakhrabad, Narsingdi and Titas Gas Fields indicate that all of these fields will still be producing gas in 2030. In other words, the remaining production periods for all of these fields are estimated to be longer than 18 years.

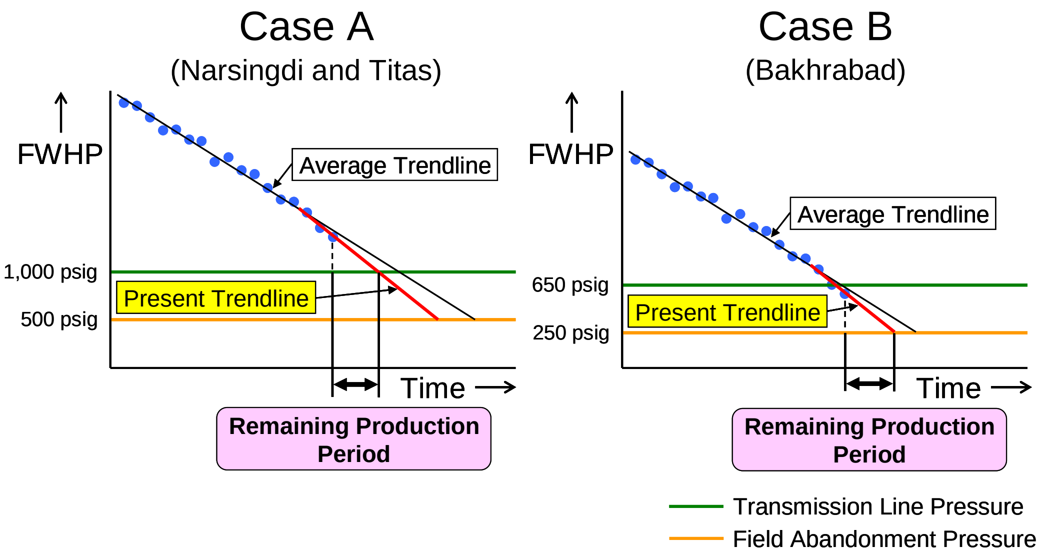
Production Forecast-2 is used to analyse trend lines (indicating pressure decline rate) for a pressure decline curve on a well-by-well basis. According to the data provided by BGFCL, two types of trend lines, present and average, can be drawn for the plot of FWHP data vs. elapsed time for most of the producing wells. Present trend lines were used for estimating remaining production periods in this evaluation.

Production Forecast-2 is also closely related to the relationship between current FWHP and transmission line pressure described below. Figure 4.1-2 shows the definition of the remaining production period in this evaluation. The remaining production period is defined here as the period from the latest data point to the point at which the FWHP declines to the level of the transmission line pressure of 1,000 psig for the Narsingdi and Titas Gas Fields (case A in Figure 4.1-2), and to the level of the assumed field abandonment pressure of 250 psig for the Bakhrabad Gas Field (case B in Figure 4.1-2).



Source: JICA Survey Team based on the information from BGFCL

Figure 4.1-1 Long-term production forecast for the Bakhrabad, Narsingdi and Titas Gas Fields



Source: JICA Survey Team

Figure 4.1-2 Estimates of remaining production period based on the relationship between current FWHP and transmission line pressure.

Based on this definition, the remaining production periods were counted from May 2013 for the wells in the Bakhrabad and Narsingdi Gas Fields, and from August 2012 for the Titas Gas Field.

The remaining production periods by Production Forecast-2 are roughly estimated (Table 4.1-1, Table 4.1-2 and Table 4.1-3), and summarized as follows.

- Bakhrabad: 1.8–5.4 years
- Narsingdi: 2.5–6.2 years
- Titas Location A: 2.4–6.1 years
- Titas Location C: 0.3[1]–9.7 years
- Titas Location E: 3.7–12.8 years
- Titas Location G: Not able to estimate[2]

[1] 0.3 years for the gas production from the B & C sand; however, the production will continue from the A sand after workover.
[2] No data is available from BGFCL because production has just started and the FWHP data is insufficient for determining the trend line.

Table 4.1-1 Estimates of remaining production periods: Bakhrabad Gas Field

Well No.	Flow Rate (MMscfd)		FWHP (psig)		Wellhead Pressure Drop (psig)		Remaining Production Period (yr)		Remarks
	Jan. 2010	May 2013	Jan. 2010	May 2013	By 3.4 years	Per Year	Present Trendline	Average Trendline	
1	8.0	4.5	613	390	223	66	1.8	3.3	J sand
2	2.9	2.3	671	531	140	41	4.7	6.8	G sand
3	8.1	7.2	662	550	112	33	5.3	7.8	G sand
7	5.7	4.5	630	416	214	63	2.3	3.3	J sand
8	10.6	10.1	711	569	142	42	5.4	8.5	J sand

Note: 1) All data were provided by BGFCL.
2) Trendlines for FWHPs are drawn by BGFCL based on the data up to May 2013.
3) The remaining production periods are defined here as the period from the latest FWHP data point to the point at which the FWHP declines to a level of transimission line pressure of 250 psig.
4) The remaining production periods for the wells were estimated using the present trendlines and were counted from May 2013.

Source: JICA Survey Team based on the information from BGFCL

Table 4.1-2 Estimates of remaining production periods: Narsingdi Gas Field

Well No.	Flow Rate (MMscfd)		FWHP (psig)		Wellhead Pressure Drop (psig)		Remaining Production Period (yr)		Remarks
	Jan. 2010	May 2013	Jan. 2010	May 2013	By 3.4 years	Per Year	Present Trendline	Average Trendline	
1	18.1	17.3	1676	1499	177	52	6.2	7.8	Lower sand
2	16.3	12.7	1436	1220	216	64	2.5	3.9	Lower sand

Note: 1) All data were provided by BGFCL.
2) Trendlines for FWHPs are drawn by BGFCL based on the data up to May 2013.
3) The remaining production periods are defined here as the period from the latest FWHP data point to the point at which the FWHP declines to a level of transimission line pressure of 1,000 psig.
4) The remaining production periods for the wells were estimated using the present trendlines and were counted from May 2013.

Source: JICA Survey Team based on the information from BGFCL

Table 4.1-3 Estimates of remaining production periods: Titas Gas Field

Well No.	Location	Flow Rate (MMscfd)		FWHP (psig)		Wellhead Pressure Drop (psig)		Remaining Production Period (yr)		Remarks
		Jan. 2010	Mar. 2013	Jan. 2010	Mar. 2013	By 3.2 years	Per Year	Present Trendline	Average Trendline	
1	A	32	37	1755	1365	390	120	3.6	5.0	A sand
2	A	33	37	1782	1310	472	148	3.4	3.4	A sand
4	A	32	36	1876	1400	476	148	3.6	4.0	A sand
5	A	31	39	1775	1425	350	110	3.6	5.3	A sand
7	A	34	39	1800	1545	255	80	6.1	8.1	A sand
15	A	32	36	1765	1325	440	138	2.4	3.8	A sand
6	C	34	36	1715	1485	230	72	-	9.7	A sand
8	C	22	22	1500	1260	240	75	2.8	5.9	B&C sand
9	C	27	26	1575	1260	315	98	3.2	4.8	B&C sand
10	C	16.5	8	1370	1075	295	92	0.3	1.1	B&C sand; A workover is planned.
11	C	23.5	30	1925	1610	315	98	8.3	-	A sand
16	C	32	35	1825	1530	295	92	5.9	9.3	A sand
12	E	-	14	-	1870	-	-	12.8	-	A sand
13	E	30	32	1925	1500	425	133	5.4	7.0	A sand
14	E	-	25	-	1690	-	-	3.7	-	A sand
17	G	-	16	-	1750	-	-	-	-	A sand; No production profile is available.

Note: 1) All data were provided by BGFCL.
2) Trendlines for FWHPs were drawn by BGFCL based on the data up to August 2012.
3) The remaining production periods are defined here as the period from the latest FWHP data point to the point at which the FWHP declines to a level of transimission line pressure of 1,000 psig.
4) The remaining production periods were estimated using the present trendlines and were counted from August 2012.
5) Present trendline for the well no. 6 seems to be the same as the average trendline.

Source: JICA Survey Team based on the information from BGFCL

(5) Relationship between Current FWHP and Transmission Line Pressure

Two cases are recognized for the relationship between current FWHP and transmission line pressure for the Bakhrabad, Narsingdi and Titas Gas Fields and these two cases are schematically shown in Figure 4.1-2.

- FWHP higher than transmission line pressure: Narsingdi and Titas Gas Fields
- FWHP lower than transmission line pressure: Bakhrabad Gas Field

The transmission line pressures are assumed to be 650 psig for Bakhrabad Gas Field, and 1000 psig for the Narsingdi and Titas Gas Fields. In the case of the Narsingdi and Titas Gas Fields, the difference in the pressure between FWHP and transmission line pressure and the level of the FWHP are taken into account for evaluation.

The transmission line for the Narsingdi Gas Field is currently operated at 650 psig but will be operated at 1,000 psig after starting the operation of the Ashuganj compressor station according to BGFCL.

(6) Evaluation of Field/Location for Installation of Wellhead Gas Compressors

The highest or first priority is given to the Bakhrabad Gas Field, at which, all of the producing wells have FWHPs lower than the transmission line pressure of 650 psig. In addition, the recoverable reserves in the entire field are expected to increase as a result of the success of well no. 9. This will result in the extension of the life of the field.

The second priority can be given to the Narsingdi Gas Field from the viewpoint of sustaining production levels of a field. The FWHP in Narsingdi no. 2 well is estimated to reach the transmission line pressure of 1,000 psig in about 2.5 years. In addition, no plans for new well drilling for the Narsingdi Gas Field have been presented. Therefore, a relatively large decrease in field-wide gas production will occur when well no. 2 is shut-in due to pressure drop to around 1,000 psig because there are only two producing wells in the Narsingdi Gas Field.

The third priority is given especially to Titas wells no. 8 and 9 at Titas Location C. These wells are estimated to have relatively short remaining production periods of about 2.8 and 3.2 years, respectively, which correspond to the differences in the pressures of 260 and 260 psig, between the current FWHPs and the transmission line pressure of 1,000 psig. The remaining production period and differences in the pressures are similar to those in Narsingdi well no. 2. However, Titas wells no. 8 and 9 are currently producing gas from the B and C sand, and the level of production can be expected to be sustained by producing gas from the A sand by recompletion when the FWHPs in the wells reach the level of the transmission line pressure of 1,000 psig. In fact, according to BGFCL, there is a plan for recompletion in the A sand in Titas well no. 10 in the near future so that the priority was not given to well no. 10 even though the well shows the short remaining production period of 0.3 years and the small difference in the pressure between the current FWHP and the transmission line pressure.

Titas wells no. 11 and 16 at Titas Location C may be excluded from candidates for installation of wellhead gas compressors in terms of estimated remaining production period and level of FWHP in this evaluation. Wellhead gas compressors will also be required for the wells in the future but there is no urgency for the installation of wellhead gas compressors for these two wells.

The fourth priority was given to Titas Location A. The wells other than well no. 7 at this location show remaining production periods ranging from about 2.4 to 3.6 years. Therefore, there are no significant differences in the ranges of the estimated remaining production periods and level of FWHP for the wells between Titas Location A and C except for wells no. 7, 11 and 16. There is no urgency for the installation of wellhead gas compressors for well no. 7 at the Titas Location A.

Meanwhile, the wells at Titas Location E and G still have relatively high FWHPs of 1,500 psig or more. The remaining production period for well no. 14 is estimated to be 3.7 years even though the current FWHP shows 1,690 psig. Taking the estimated remaining production period into consideration, the fifth priority was given to Location E.

Therefore, the sixth or lowest priority was given to Location G. Unfortunately, the production profile is not available for well no. 17 at this location because the well has just started production in March 2013 and it is difficult to analyse a pressure decline curve. Therefore it is difficult to estimate the remaining production period using the pressure decline curve.

The results of the evaluation mentioned above are based only on a quick look method using mainly the pressure decline curve. Therefore, another method or approach such as relating the current status of the production/pressure of the wells with the spatial distribution of the reservoir sands within each field is needed for further screening and prioritization on a well-by-well basis.

(7) Summary of Evaluation

The priority levels for the installation of the wellhead gas compressors range from 1 (highest) to 6 (lowest) in this evaluation. The results of a quick look evaluation using production data, especially pressure decline curves, are summarized below in the order of priority.

1) Bakhrabad Gas Field
2) Narsingdi Gas Field
3) Titas Gas Field Location C
4) Titas Gas Field Location A
5) Titas Gas Field Location E
6) Titas Gas Field Location G

4.1.3 Installation of the Wellhead Gas Compressors at Bakhrabad Gas Field

(1) Outline

BGFCL requested the installation of wellhead gas compressors at Bakhrabad Gas Field located in Muradnagar of Comilla district, that will replace the existing rental compressors, due to further declining flowing wellhead pressures (“FWHP”).

New compressors would be installed upstream of the existing processing facility because thereby the increase of the condensate recovery volume will be expected to be higher than the case of installation downstream of the process plant.

(2) Objective, Necessity and Priority

In Bakhrabad Gas Field, FWHP, which currently ranges about 390~570 psig, is already lower than the transmission pipeline pressure of 650 psig; therefore, rental compressors have been installed between the existing plant and the transmission line to transfer the gas into the transmission line.

Since FWHP is still declining and expected to reach a well abandonment pressure of 250 psig in 2.5~6.4 years as evaluated in Section 4.1.2 (4), the installation of new compressors is urgently required.

(3) Site Condition

Through site surveys of existing gas production facilities where installation of compressors is requested, the site condition was checked in view of producing modification plans for the existing facilities and future space for the new facilities. The following photographs show an overview of Bakhrabad Gas Field.

1) Overview of Bakhrabad Gas Field

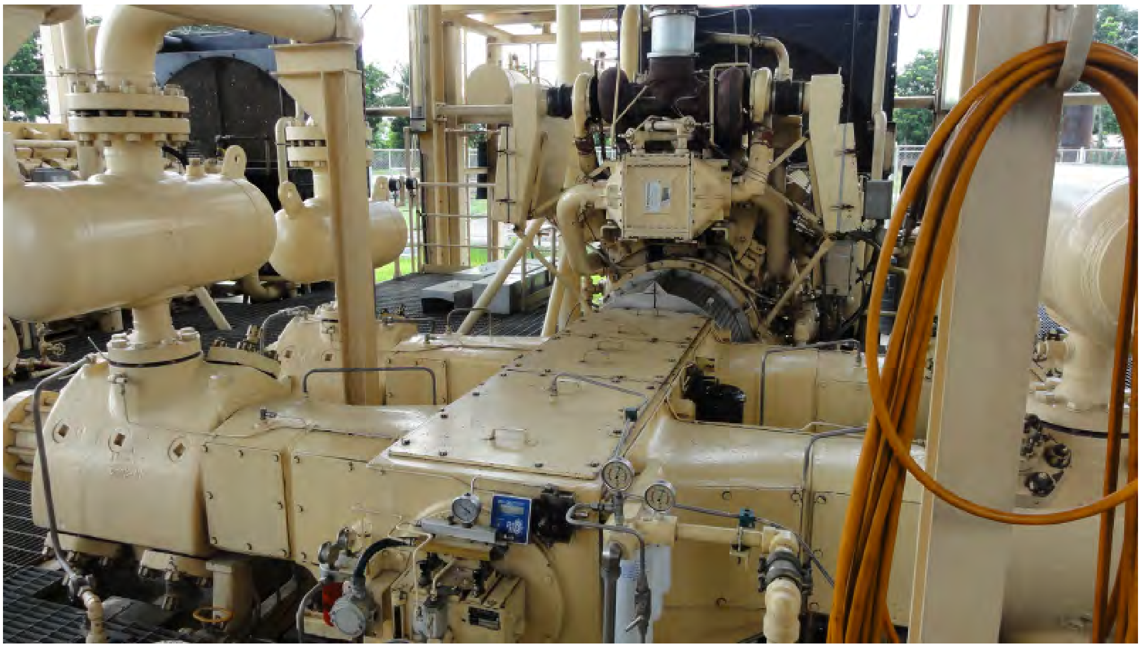
2) Overview of existing gas processing facility

3) Condensate tank yard

4) Future space for proposed compressors

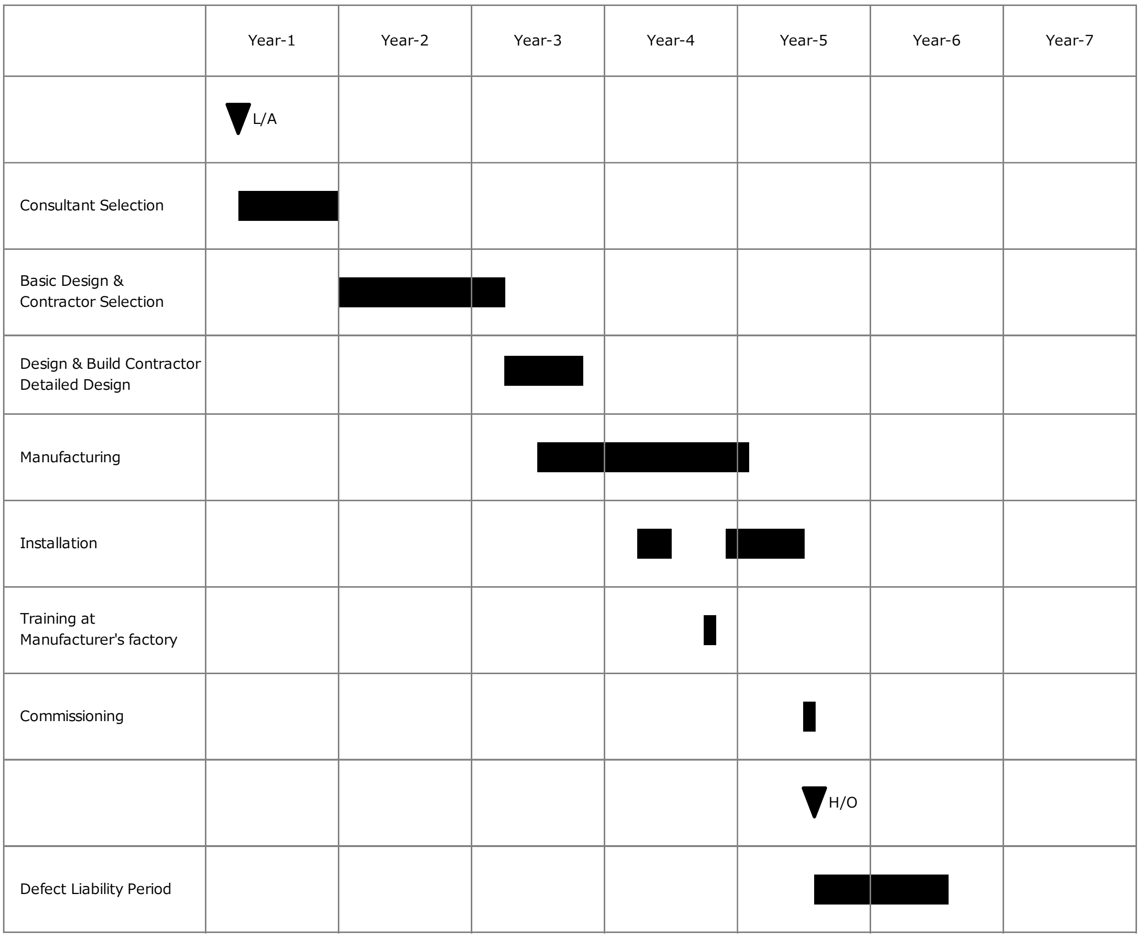
5) Existing rental compressor units (1/2)

6) Existing rental compressor units (2/2)



(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

Project cost is preliminary estimated based on the following conditions.

- It is assumed that three compressors are to be newly installed in Bakhrabad Gas Field. As an operational philosophy, those compressors are to be planned as two operational and one stand-by.
- Inlet/outlet pressure of the compressors is assumed based on BGFCL requirements, which were preliminarily provided for selection of the project components.
- Compressor specifications adopted for the cost estimation are shown in the table below.

Description		Specification
Gas Production Rate	(MMscfd)	30
Gas Flow Rate / train	(MMscfd)	15
Compressor Configuration	-	50 % x 3 trains
Inlet Pressure	(psig)	250
Outlet Pressure	(psig)	1,150
Inlet Temperature	(F)	145
Outlet Temperature	(F)	120
Type of Compressor	-	Reciprocating
Type of Driver	-	Gas Engine

Note: Based on information of the first survey, the above specifications for the proposed compressors were tentatively established for the purpose of selection of the project components.

The project cost consists of direct cost and indirect cost. The direct cost was estimated approximately based on material cost and its installation cost with auxiliary equipment including not only heat exchangers and gas scrubbers, but also utility facilities (instrument gas system, fuel gas supply system, lube oil system, etc.), shed, bulk materials and so on. And the indirect cost including engineering, project management, manufacturers' field supervision services, export packing and shipping, spare parts & special tools, etc. was estimated at a proper ratio based on the direct cost.

The total construction cost of the gas compressors was estimated at approximately 3,303 million Japanese yen using OGM (Oil and Gas Manager) and PEA (Process Economic Analyser) software, which are widely utilized in the feasibility study phase in the oil & gas industry for the purpose of checking approximate project cost. However, the total cost does not include the cost of two years operation and maintenance to be requested by BGFCL.

(6) Environmental & Social Considerations

The project is basically intended for replacement of the already existing and operational gas compressor. This compressor is operated on a contract rental basis by the contractor. With the accomplishment of this project, the existing rental compressor would be replaced with a new compressor owned and operated by BGFCL (executing agency of the project and the representative project owner).

The project, in its operational stage, would be similar to the current condition (with operational rented compressor) that would not result in any additional extraction of gas from the Bakhrabad Gas Field. It is noted that any additional gas extraction (consequent to the operation of the compressor) would require a mandatory EIA study because such an industrial project would fall under the RED category (as per the environmental conservation rule of DoE (1997)).

Moreover, the new compressor system will be installed within the existing property boundary of the gas field area (industrial area) owned by BGFCL and there would be no significant adverse environmental effects on the natural environment since the project area is already an existing industrial area. Moreover, no land acquisition or involuntary resettlement is involved; hence, there is no significant social adverse effects consequent to the project.

Accordingly, no EIA study would be required and the environmental clearance certificate (ECC) from DoE is expected to be obtained with the submission and approval of EMP (environmental management plan) focused on EHS (environment, health and safety) aspects of both construction/installation and operational stages (duly separated between these two stages) of the new gas compressor system.

4.1.4 Installation of the Wellhead Gas Compressors at Narsingdi Gas Field

(1) Outline

BGFCL requested the installation of new wellhead gas compressors to recover the declining FWHP at Narsingdi Gas Field located in Shibpur of Narsingdi district.

New compressors would be installed upstream of the existing processing facility because increase of the condensate recovery volume will be expected to be higher than the case of installation downstream of the process plant.

(2) Objective, Necessity and Priority

The FWHP of wells at Narsingdi Gas Field currently ranges around 1,200~1,500 psig. The transmission pipeline pressure is currently at 650 psig, and it will increase to 1,000 psig when the Ashuganj compressor station starts operation scheduled at the end of 2013.

Because the FWHP is still declining and expected to reach a transmission pipeline pressure of 1,000 psig in 2.5~6.2 years as evaluated in Section 4.1.2 (4), the installation of new compressors is urgently required.

(3) Site Condition

Through a site survey of the existing gas production facility where installation of the compressors is requested, site condition was checked in view of a modification plan of the existing facility and future space for the new facility. The following photographs show an overview of Narsingdi Gas Field.

1) Overview of Narsingdi Gas Field

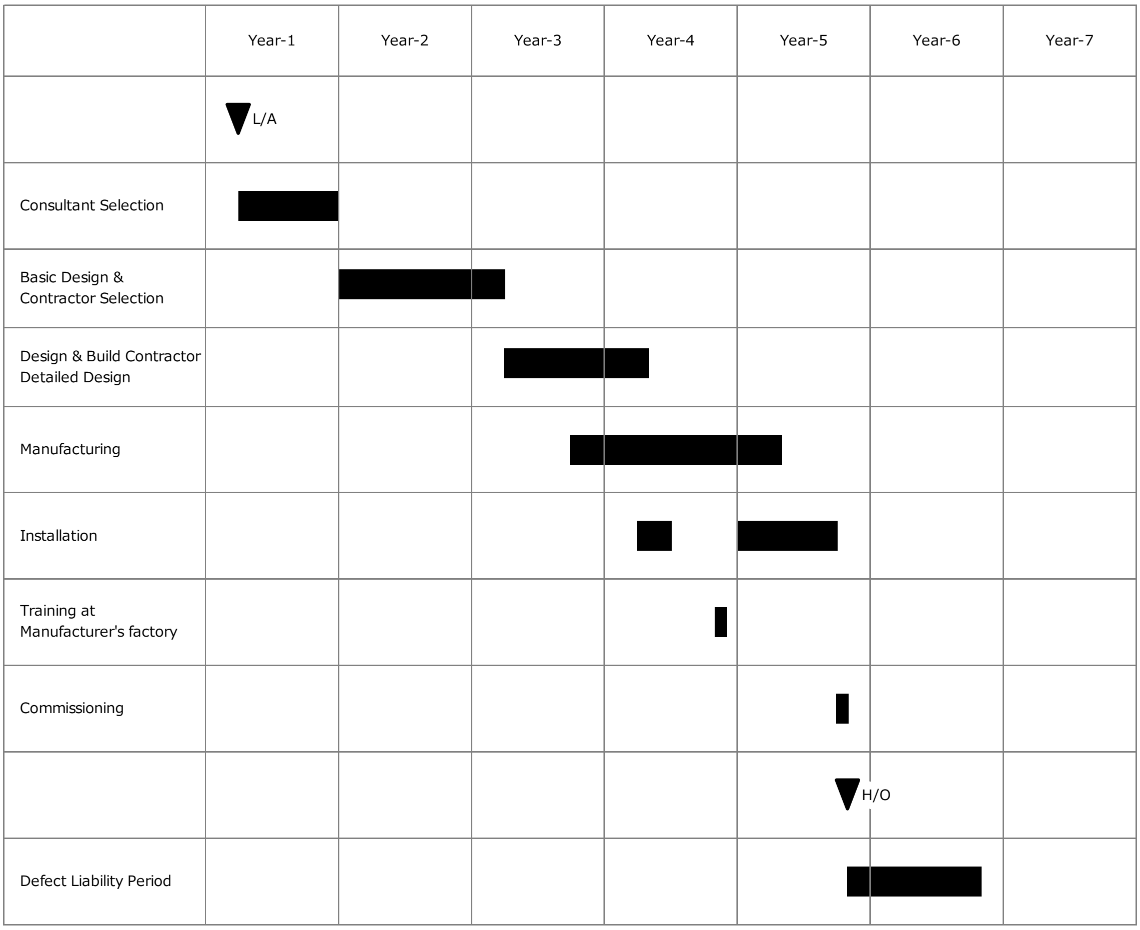
2) Overview of existing gas processing facility

3) Condensate tank yard and wellhead area

4) Future space for proposed compressors

(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

Project cost is preliminarily estimated based on the following conditions.

- It is assumed that three compressors are to be newly installed in Narsingdi Gas Field. As an operational philosophy, those compressors are to be planned as two operational and one stand-by.
- Inlet/outlet pressure of the compressors is assumed based on BGFCL requirements, which were preliminarily provided for selection of the project components.
- Compressor specifications adopted for the cost estimation are shown in the table below.

Description		Specification
Gas Production Rate	(MMscfd)	30
Gas Flow Rate / train	(MMscfd)	15
Compressor Configuration	-	50% x 3 train
Inlet Pressure	(psig)	800
Outlet Pressure	(psig)	1,500
Inlet Temperature	(F)	145
Outlet Temperature	(F)	120
Type of Compressor	-	Reciprocating
Type of Driver	-	Gas Engine

Note: Based on information of the first survey, the above specifications of proposed compressors were tentatively established for the purpose of selection of project components.

The project cost consists of direct cost and indirect cost. The direct cost was estimated approximately based on material cost and its installation cost with auxiliary equipment including not only heat exchangers and gas scrubbers, but also utility facilities (instrument gas system, fuel gas supply system, lube oil system, etc.), shed, bulk materials and so on. And the indirect cost including engineering, project management, manufacturer's field supervision services, export packing and shipping, spare parts & special tools, etc. was estimated at a proper ratio based on the direct cost.

The total construction cost of gas compressors was approximately estimated at 2,094 million Japanese yen using OGM (Oil and Gas Manager) and PEA (Process Economic Analyser) software, which are widely utilized at the feasibility study phase in the oil & gas industry for the purpose of checking approximate project cost. However, the total cost does not include the cost of two years operation and maintenance as requested by BGFCL.

(6) Environmental & Social Considerations

This project component is somewhat similar to that of the compressor installation project in Bakhrabad Gas Field as dealt with under item (6) of Section 4.1.3 except for the fact that this would be a new compressor installation because there are no operational compressors in any other gas fields of this project (including this Narsingdi Gas Field).

Still, there would be no additional extraction of gas consequent to operation of the newly installed compressor. Moreover, the compressor would be installed within the property boundary of the existing gas field belonging to BGFCL (existing industrial area and there would be no significant adverse effects on the natural environment); and there are no land acquisition or resettlement related social issues involved.

As such, no EIA study would be required and the environmental clearance certificate (ECC) from DoE is expected to be obtained with the submission and approval of EMP (environmental management plan) focused on EHS (environment, health and safety) aspects of both construction/installation and operational stages (duly separated between these two stages) of the gas compressor system.

4.1.5 Installation of the Wellhead Gas Compressors at Titas Gas Field, Location A

(1) Outline

BGFCL requested the installation of new wellhead gas compressors to recover the declining FWHP at Location A of Titas Gas Field located in Brahamanbaria Sadar of Brahamanbaria district.

New compressors would be installed upstream of the existing process plant because increase of the condensate recovery volume will be expected to be higher than the case of installation downstream of the process plant.

(2) Objective, Necessity and Priority

The FWHP of wells at Location A of Titas Gas Field currently ranges around 1,300~1,550 psig and the transmission pipeline pressure is 1,000 psig.

Because the FWHP is still declining and expected to reach a transmission pipeline pressure of 1,000 psig in 2.4~6.1 years as evaluated in Section 4.1.2 (4), the installation of new compressors is urgently required. However, the priority of this project is lower than Bakhrabad and Narsingdi Gas Field because the FWHP is relatively high.

(3) Site Condition

Through a site survey of the existing gas production facility where installation of compressors is requested, the site condition was checked in view of a modification plan for the existing facility and future space for the new facility. The following photographs show an overview of Titas Gas Field (Location A).

1) Overview of Titas Gas Field (Location A)

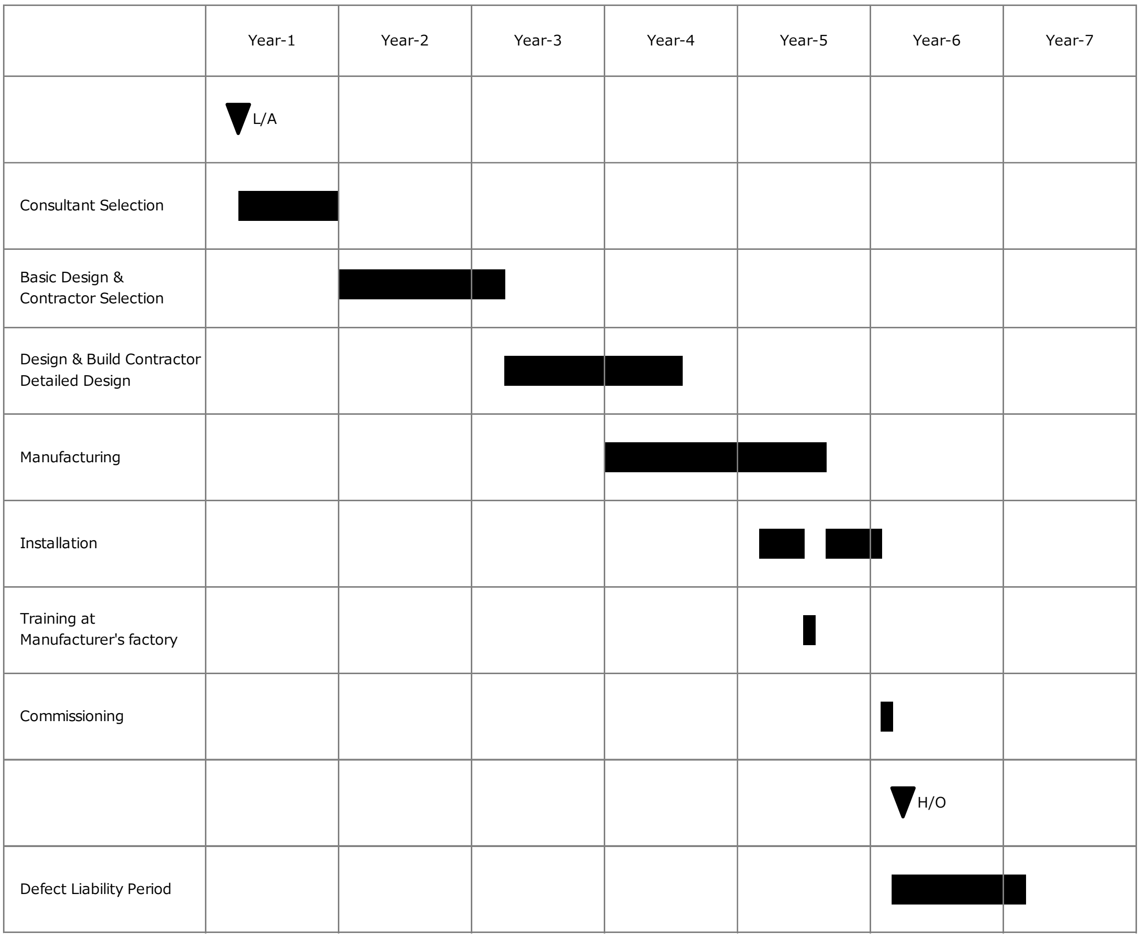
2) Overview of existing gas processing facility

3) Condensate tank yard

4) Future space for proposed compressors

(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

Project cost is preliminarily estimated based on the following conditions.

- It is assumed that three compressors are to be newly installed at Location A in Titas Gas Field. As an operational philosophy, those compressors are to be planned as two operational and one stand-by.
- Inlet/outlet pressure of the compressors is assumed based on BGFCL requirements, which were preliminarily provided for selection of the project components.
- One production separator is to be newly installed at Titas Location A because there is no existing separation unit upstream of the compressors.
- Compressor specifications adopted for the cost estimation are shown in the table below.

Description		Specification
Gas Production Rate	(MMscfd)	230
Gas Flow Rate / train	(MMscfd)	115
Compressor Configuration	-	50% x 3 trains
Inlet Pressure	(psig)	800
Outlet Pressure	(psig)	1,500
Inlet Temperature	(F)	145
Outlet Temperature	(F)	120
Type of Compressor	-	Reciprocating
Type of Driver	-	Gas Engine

Note: Based on information of the first survey, the above specifications of proposed compressors were tentatively established for the purpose of selection of project components.

The project cost consists of direct cost and indirect cost. The direct cost was estimated approximately based on material cost and its installation cost with auxiliary equipment including not only heat exchangers and gas scrubbers, but also utility facilities (instrument gas system, fuel gas supply system, lube oil system, etc.), shed, bulk materials and so on. And the indirect cost including engineering, project management, manufacturer’s field supervision services, export packing and shipping, spare parts & special tools, etc. was estimated at a proper ratio based on the direct cost.

The total construction cost of the gas compressors was approximately estimated at 6,682 million Japanese yen using OGM (Oil and Gas Manager) and PEA (Process Economic Analyser) software, which are widely utilized at the feasibility study phase in the oil & gas industry for the purpose of checking approximate project cost. However, the total cost does not include the cost of two years operation and maintenance to be requested by BGFCL.

(6) Environmental & Social Considerations

This project component is also a new compressor installation project in Titas Gas Field (Location A) and hence is quite similar to the new compressor installation project in Narsingdi Gas Field as dealt with under item (6) of Section 4.1.4. Thus, the environmental and social aspects are very similar with no significant adverse effects on either the natural or social environments.

As such, no EIA study would be required and the environmental clearance certificate (ECC) from DoE is expected to be obtained with the submission and approval of EMP (environmental management plan) focussed on EHS (environment, health and safety) aspects of both construction/installation and operational stages (and also duly separated between these two stages) of the gas compressor system.

4.1.6 Installation of the Wellhead Gas Compressors at Titas Gas Field, Location C

(1) Outline

BGFCL requested the installation of new wellhead gas compressors to recover declining FWHP at Location C of Titas Gas Field located in Brahamanbaria Sadar of Brahamanbaria district.

New compressors would be installed upstream of the existing process plant because the increase of condensate recovery volume will be expected to be higher than the case of installation downstream of the process plant.

(2) Objective, Necessity and Priority

The FWHP of wells at Location C of Titas Gas Field currently ranges around 1,100~1,600 psig and the transmission pipeline pressure is 1,000 psig.

Because the FWHP is still declining and expected to reach a transmission pipeline pressure of 1,000 psig in 0.3[3]~8.3 years as evaluated in Section 4.1.2 (4), the installation of new compressors is urgently required. However, the priority of this project is lower than Bakhrabad and Narsingdi Gas Fields because the FWHP is relatively high.

(3) Site Condition

Through a site survey of the existing gas production facility where installation of the compressors is requested, the site condition was checked in view of a modification plan of the existing facility and future space for the new facility. The following photographs show an overview of Titas Gas Field (Location C).

[3] 0.3 years for the gas production from B & C sand; however, the production layer will be changed to A sand and continued after workover of this well.

1) Overview of Titas Gas Field (Location C)

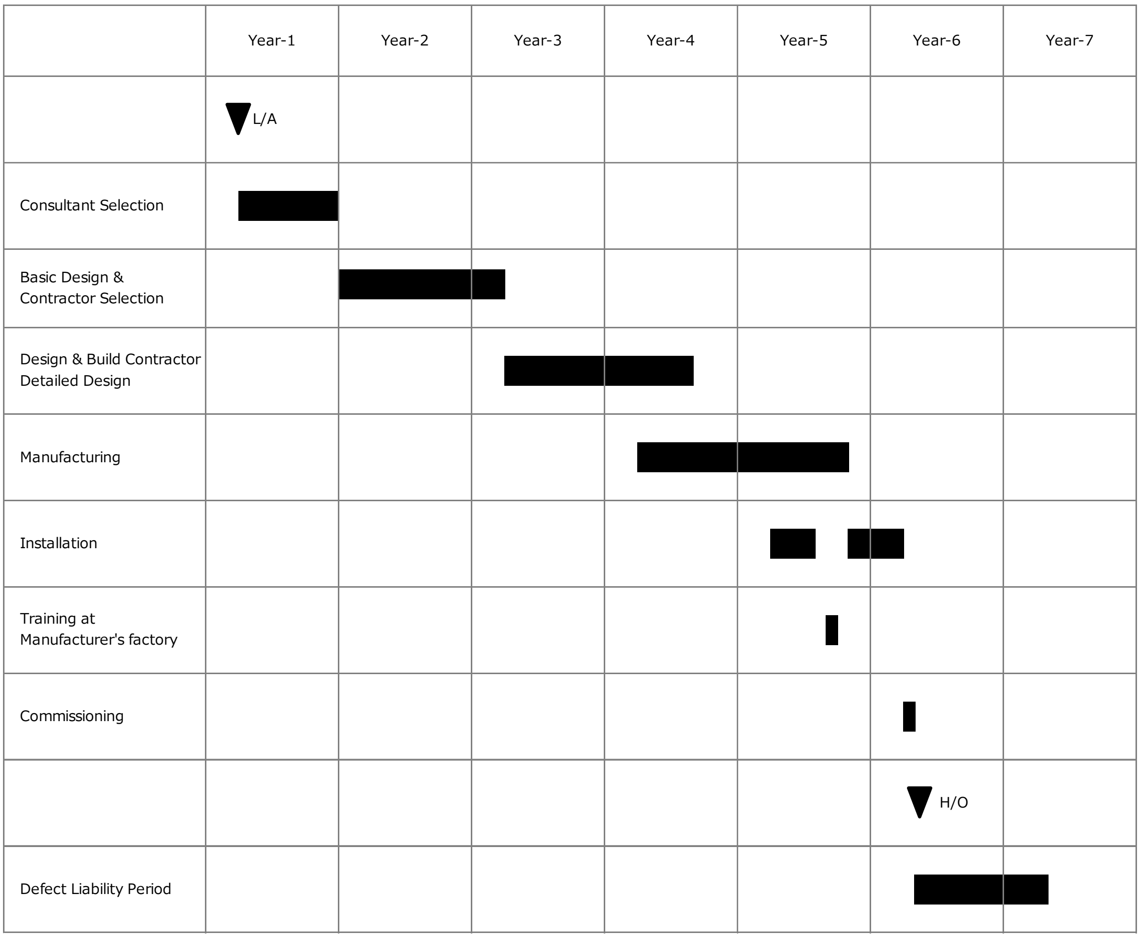
2) Overview of existing gas processing facility

3) Wellhead facility

4) Future space for proposed compressors

(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

Project cost is preliminarily estimated based on the following conditions.

- It is assumed that three compressors are to be newly installed at Location C in Titas Gas Field. As an operational philosophy, those compressors are to be planned as two operational and one stand-by.
- Inlet/outlet pressure of the compressors is assumed based on BGFCL requirements, which were preliminarily provided for selection of the project components.
- One production separator is to be newly installed at Titas Location C because there is no existing separation unit upstream of the compressors.
- Compressor specifications adopted for the cost estimation are shown in the table below.

Description		Specification
Gas Production Rate	(MMscfd)	160
Gas Flow Rate / train	(MMscfd)	80
Compressor Configuration	-	50% x 3 trains
Inlet Pressure	(psig)	800
Outlet Pressure	(psig)	1,500
Inlet Temperature	(F)	145
Outlet Temperature	(F)	120
Type of Compressor	-	Reciprocating
Type of Driver	-	Gas Engine

Note: Based on information of the first survey, the above specifications of proposed compressors were tentatively established for the purpose of selection of project components.

The project cost consists of direct cost and indirect cost. The direct cost was estimated approximately based on material cost and its installation cost with auxiliary equipment including not only heat exchangers and gas scrubbers, but also utility facilities (instrument gas system, fuel gas supply system, lube oil system, etc.), shed, bulk materials and so on. And the indirect cost including engineering, project management, manufacturer’s field supervision services, export packing and shipping, spare parts & special tools, etc. was estimated at a proper ratio based on the direct cost.

The total construction cost of the gas compressors was approximately estimated at 5,114 million Japanese yen using OGM (Oil and Gas Manager) and PEA (Process Economic Analyser) software, which are widely utilized at the feasibility study phase in the oil & gas industry for the purpose of checking approximate project cost. However, the total cost does not include the cost of two years operation and maintenance as requested by BGFCL.

(6) Environmental & Social Considerations

This project component is also a new compressor installation project in Titas Gas Field (Location C) and hence is quite similar to the new compressor installation project in Narsingdi Gas Field as dealt with under item (6) of Section 4.1.4 (and for Location A of the same Titas Gas Field). Thus, the environmental and social aspects are very similar with no significant adverse effects on either the natural or social environments.

As such, no EIA study would be required and the environmental clearance certificate (ECC) from DoE is expected to be obtained with the submission and approval of EMP (environmental management plan) focused on EHS (environment, health and safety) aspects of both construction/installation and operational stages (duly separated between these two stages) of the gas compressor system (Refer to section 2.7).

4.1.7 Installation of the Wellhead Gas Compressors at Titas Gas Field, Location E

(1) Outline

BGFCL requested the installation of new wellhead gas compressors to recover declining FWHP at Location E of Titas Gas Field located in Brahamanbaria Sadar of Brahamanbaria district.

New compressors would be installed upstream of the existing process plant because the increase of the condensate recovery volume will be expected to be higher than the case of installation downstream of the process plant.

(2) Objective, Necessity and Priority

The FWHP of wells at Location E of Titas Gas Field currently ranges around 1,500~1,900 psig and the transmission pipeline pressure is 1,000 psig.

Because the FWHP is still declining and expected to reach a transmission pipeline pressure of 1,000 psig in 3.7~12.8 years as evaluated in Section 4.1.2 (4), the installation of new compressors is required. However, the priority of this project is lower than the compressors in Bakhrabad, Narsingdi and Titas Locations A & C since the FWHP is still relatively high.

(3) Site Condition

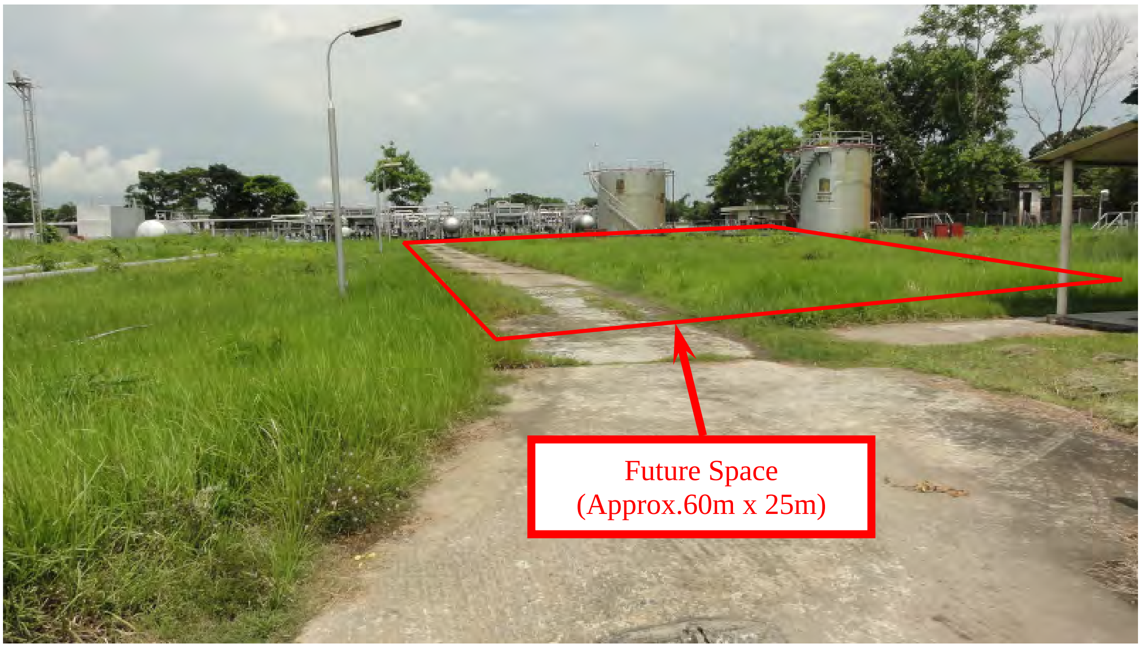
Through a site survey of the existing gas production facility where installation of the compressors is requested, the site condition was checked in view of a modification plan of the existing facility and future space for the new facility. The following photographs show an overview of Titas Gas Field (Location E).

1) Overview of Titas Gas Field (Location E)

2) Overview of existing gas processing facility

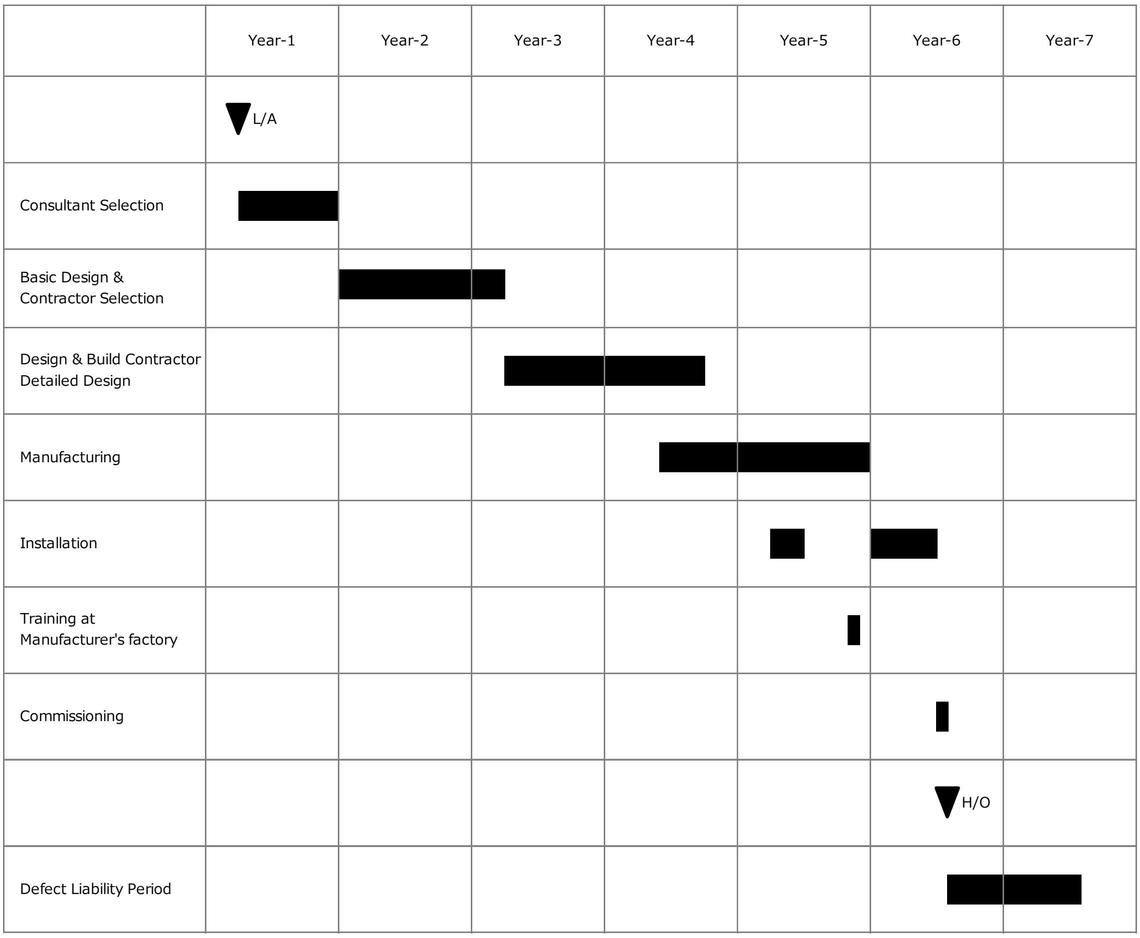
3) Condensate tank yard

4) Future space for proposed compressors



(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

Project cost is preliminary estimated based on the following conditions.

- It is assumed that three compressors are to be newly installed at Location E in Titas Gas Field. As an operational philosophy, those compressors are to be planned as two operational and one stand-by.
- Inlet/outlet pressure of the compressors is assumed based on BGFCL requirements, which were preliminarily provided for selection of the project components.
- One production separator is to be newly installed in Titas Location E because there is no existing separation unit upstream of the compressors.
- Compressor specifications adopted for the cost estimation are shown in the table below.

Description		Specification
Gas Production Rate	(MMscfd)	70
Gas Flow Rate / train	(MMscfd)	35
Compressor Configuration	-	50% x 3 trains
Inlet Pressure	(psig)	800
Outlet Pressure	(psig)	1,500
Inlet Temperature	(F)	145
Outlet Temperature	(F)	120
Type of Compressor	-	Reciprocating
Type of Driver	-	Gas Engine

Note: Based on information of the first survey, the above specifications of proposed compressors were tentatively established for the purpose of selection of project components.

The project cost consists of direct cost and indirect cost. The direct cost was estimated approximately based on material cost and its installation cost with auxiliary equipment including not only heat exchangers and gas scrubbers, but also utility facilities (instrument gas system, fuel gas supply system, lube oil system, etc.), shed, bulk materials and so on. And the indirect cost including engineering, project management, manufacturer's field supervision services, export packing and shipping, spare parts & special tools, etc. was estimated at a proper ratio based on the direct cost.

The total construction cost of the gas compressors was approximately estimated at 3,276 million Japanese yen using OGM (Oil and Gas Manager) and PEA (Process Economic Analyser) software, which are widely utilized at the feasibility study phase in the oil & gas industry for the purpose of checking approximate project cost. However, the total cost does not include the cost of two years operation and maintenance to be requested by BGFCL.

(6) Environmental & Social Considerations

This project component is also a new compressor installation project in Titas Gas Field (Location E) and hence is quite similar to the new compressor installation project in Narsingdi Gas Field as dealt with under item (6) of Section 4.1.4 (and for Locations A and C of the same Titas Gas Field). Thus, the environmental and social aspects are very similar with no significant adverse effects on either the natural or social environments.

As such, no EIA study would be required and the environmental clearance certificate (ECC) from DoE is expected to be obtained with the submission and approval of EMP (environmental management plan) focussed on EHS (environment, health and safety) aspects of both construction/installation and operational stages (duly separated between these two stages) of the gas compressor system.

4.1.8 Installation of the Wellhead Gas Compressors at Titas Gas Field, Location-G

(1) Outline

BGFCL requested the installation of new wellhead gas compressors to recover declining FWHP at Location G of Titas Gas Field located in Brahamanbaria Sadar of Brahamanbaria district.

New compressors would be installed upstream of the existing process plant because the increase of the condensate recovery volume will be expected to be higher than the case of installation downstream of the process plant.

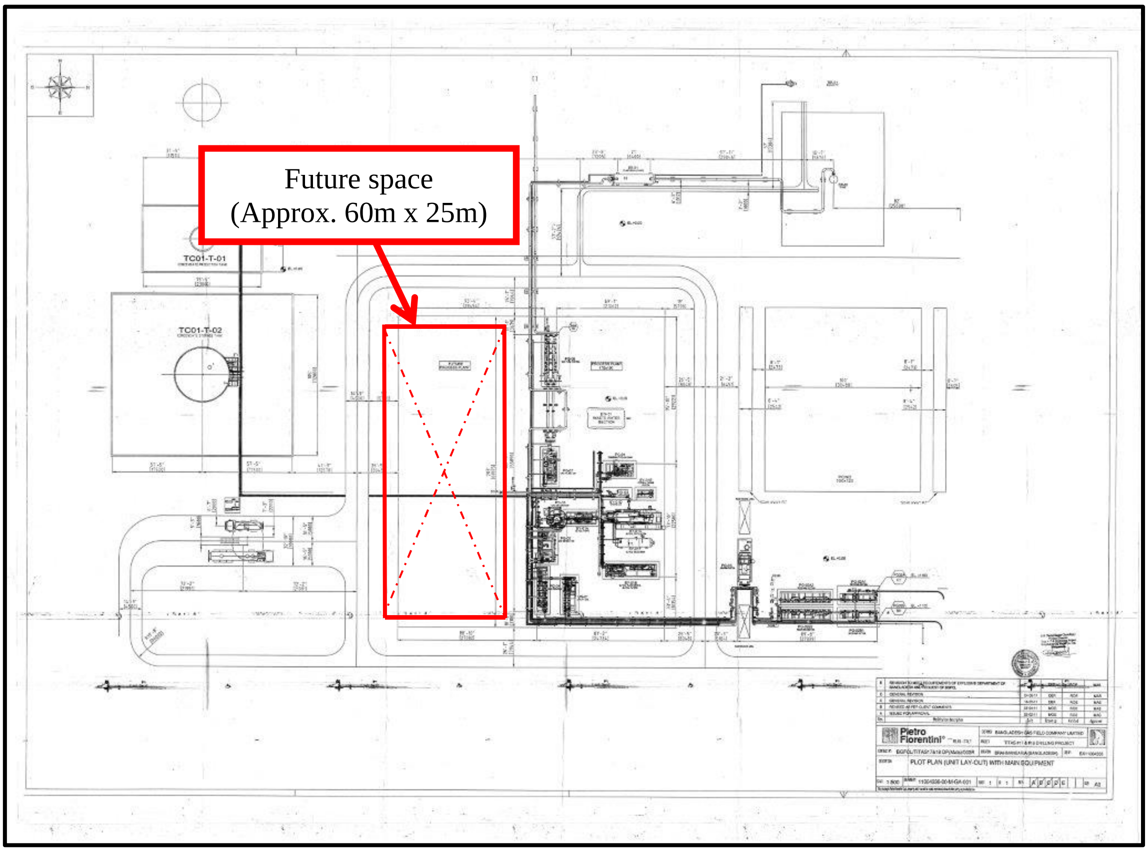
(2) Objective, Necessity and Priority

The FWHP of the well at Location G of Titas Gas Field is currently at about 1,750 psig and the transmission pipeline pressure is 1,000 psig.

Since the FWHP is still declining, the installation of new compressors is required. However, the priority of this project is lower than the compressors in Bakhrabad, Narsingdi and Titas Locations A & C since the FWHP is still relatively high.

(3) Site Condition

Through a site survey of the existing gas production facility where installation of the compressors is requested, the site condition was checked in view of a modification plan of the existing facility and future space for the new facility. The following drawing shows the plant layout of Titas Gas Field (Location G). On the drawing, an area marked in red indicates the future space for the proposed compressors.

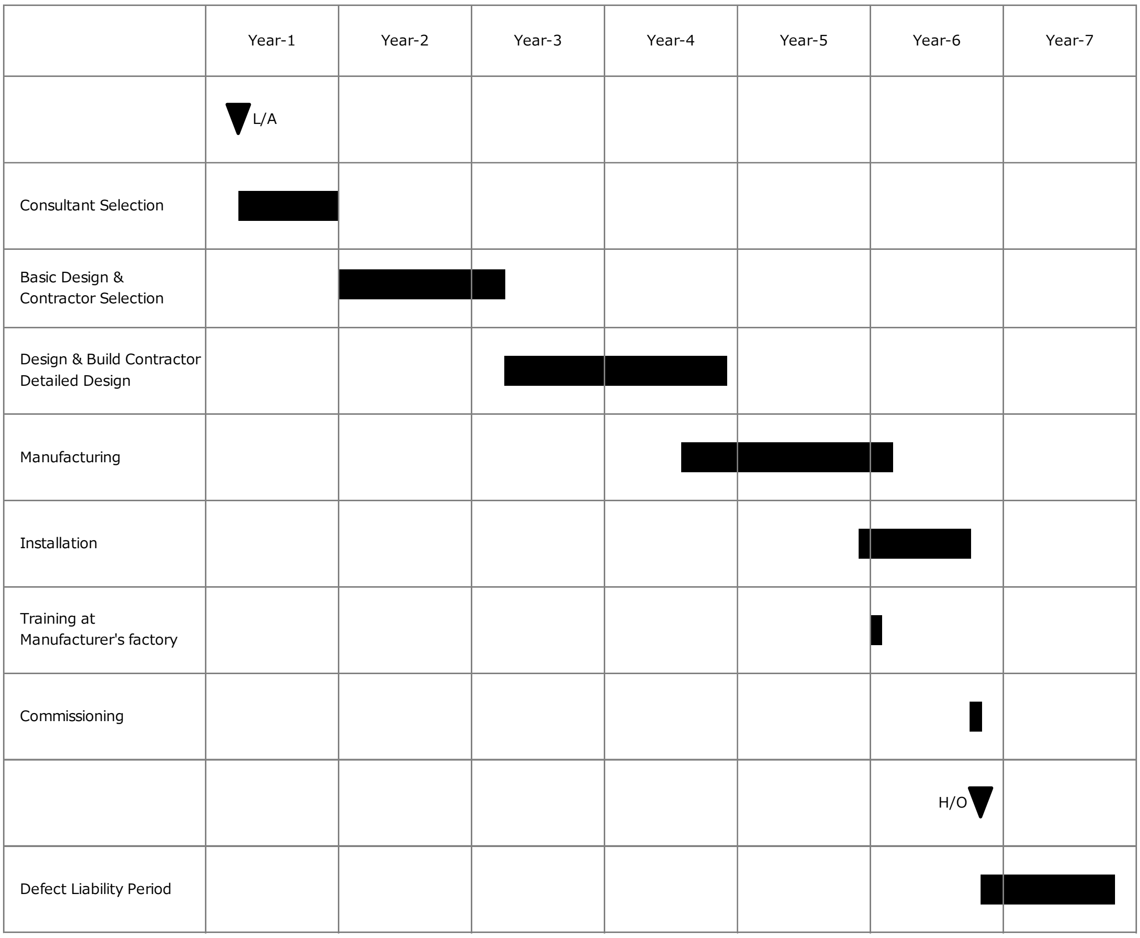


Source: BGFCL

Figure 4.1-3 Plant Layout of Titas Gas Field (Location G)

(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

Project cost is preliminarily estimated based on the following conditions.

- It is assumed that three compressors are to be newly installed at Location G in Titas Gas Field. As an operational philosophy, those compressors are to be planned as two operational and one stand-by.
- Inlet/outlet pressure of the compressors is assumed based on BGFCL requirements, which were preliminarily provided for selection of project components.
- Compressor specifications adopted for the cost estimation are shown in the table below.

Description		Specification
Gas Production Rate	(MMscfd)	16
Gas Flow Rate / train	(MMscfd)	8
Compressor Configuration	-	50% x 3 trains
Inlet Pressure	(psig)	800
Outlet Pressure	(psig)	1500
Inlet Temperature	(F)	145
Outlet Temperature	(F)	120
Type of Compressor	-	Reciprocating
Type of Driver	-	Gas Engine

Note: Based on information of the first survey, the above specifications of proposed compressors were tentatively established for the purpose of selection of project components.

The project cost consists of direct cost and indirect cost. The direct cost was estimated approximately based on material cost and its installation cost with auxiliary equipment including not only heat exchangers and gas scrubbers, but also utility facilities (instrument gas system, fuel gas supply system, lube oil system, etc.), shed, bulk materials and so on. And the indirect cost including engineering, project management, manufacturer’s field supervision services, export packing and shipping, spare parts & special tools, etc. was estimated at a proper ratio based on the direct cost.

The total construction cost of the gas compressors was estimated at 2,312 million Japanese yen using OGM (Oil and Gas Manager) and PEA (Process Economic Analyser) software, which are widely utilized at the feasibility study phase in the oil & gas industry for the purpose of checking approximate project cost. However, the total cost does not include the cost of two years operation and maintenance as requested by BGFCL.

(6) Environmental & Social Considerations

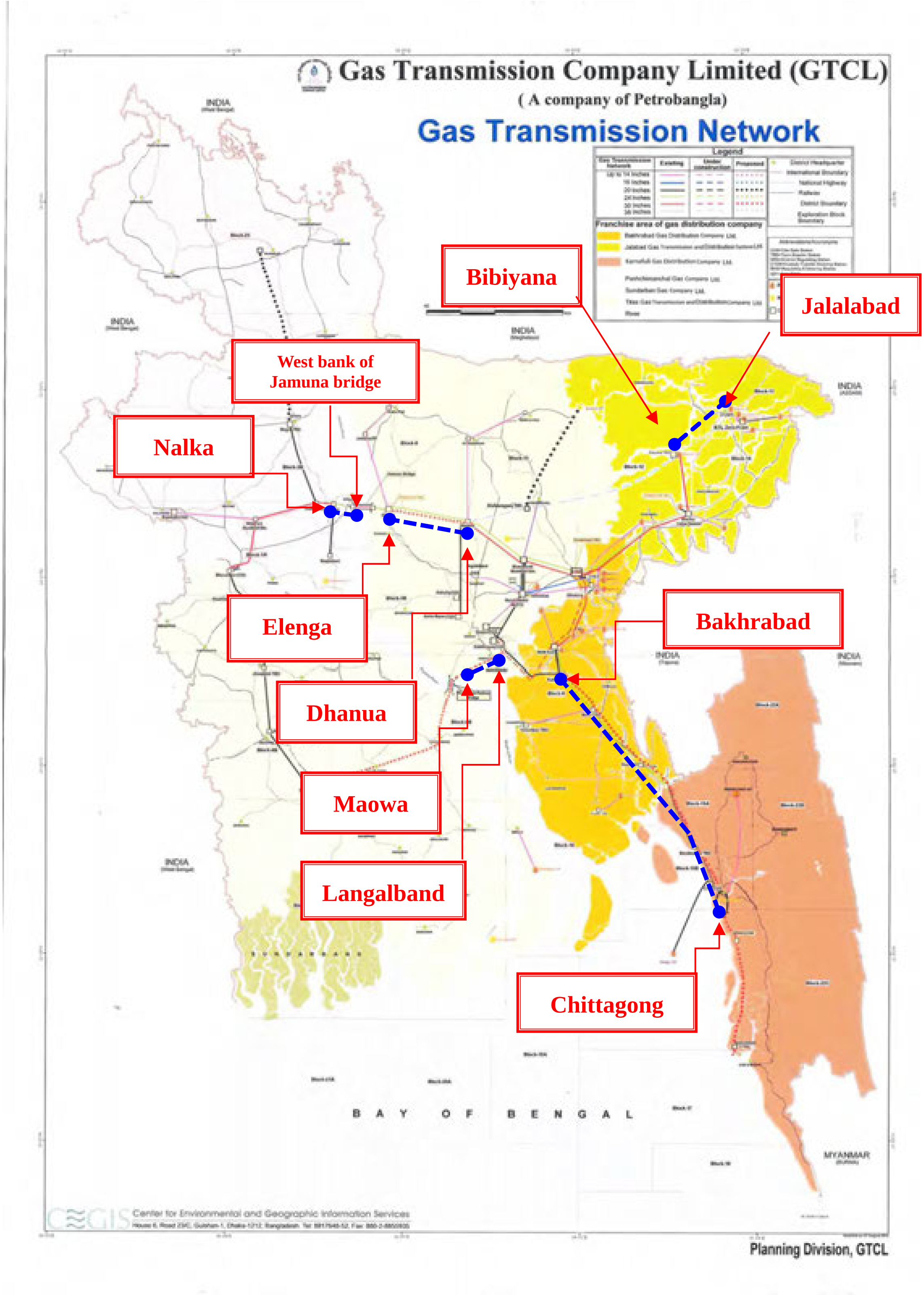
This project component is also a new compressor installation project in Titas Gas Field (Location-E) and hence is quite similar to the new compressor installation project in Narsingdi Gas Field as dealt with under item (6) of Section 4.1.4 (and for Locations A, C and E of the same Titas Gas Field). Thus, the environmental and social aspects are very similar with no significant adverse effects on either the natural or social environments.

As such, no EIA study would be required and the environmental clearance certificate (ECC) from DoE is expected to be obtained with the submission and approval of EMP (environmental management plan) focused on EHS (environment, health and safety) aspects of both construction/installation and operational stages (duly separated between these two stages) of the gas compressor system.

4.2 Construction of Gas Transmission Pipeline (GTCL)

The Figure 4.2-1 shows the current gas transmission pipeline network in Bangladesh, and the routes of the following gas transmission pipelines that are requested for the Project.

1) Dhanua-Elenga pipeline
2) West Bank of Jamuna Bridge-Nalka Pipeline
3) Jalalabad-Bibiyana Pipeline
4) Bakhrabad-Chittagong Pipeline
5) Langalband-Maowa Pipeline



Source: GTCL

Figure 4.2-1 Gas Transmission Network

4.2.1 Dhanua – Elenga Pipeline: 30 inch x 52 km

(1) Outline

Contents of the Dhanua – Elenga gas pipeline project are shown in the table below.

No.	Item	Description
1.	Pipe Diameter	30 inch
2.	Pipeline Length	52 km
3.	Maximum Allowable Operating Pressure	1,130 psig
4.	HDD Salda river 311.29m Tonki-1 river 327.07m Tonki-2 rriver 325.9m Bongsi river 365.64m Safai river 315.61m Langalia river 345.61m	Total 1,991.12 m
5.	Road crossing Major	5 Locations
	Minor	15 Locations
6.	Railway Crossing (Rajabari area)	1
7.	Interface Metering station	2
8.	Valve station	2
9.	In-take/Off-take Nozzle	7
10.	Pig Launcher (relocation)/ Pig Receiver (existing)	1(relocation)
11.	Design Code	ASME B31.8
12.	Pipe Specification	API 5L X60 L-SAW
13.	Pipe wall thickness	14.3, 15.9(HDD)
14.	SCADA	Cable connection
15.	Location (District)	Gazipur,Mymensingh and Tamgail

(2) Objective, Necessity and Priority

This pipeline is used to reinforce gas transmission capacity to the western part of the country. Because an existing pipeline is already operating in this pipeline section, a loop pipeline will be added after construction of this pipeline.

Although construction of this pipeline was planned as one of the ADB support projects, it has been postponed until now due to lack of funds. However, it is considered that this pipeline will certainly contribute to overcome the regional gap in natural gas supply of the country and will provide gas supply to Bheramara Power Station.

In addition, the GOB has been promoting reinforcement of natural gas supply for the western parts comprehensively through implementation of the following gas field development and pipeline construction projects:

No.	Project	Status (as of August 2013)
1.	Development of new gas wells at Bibiyana Gas Field (Expected gas increase: 300 MMSCFD)	by June 2015
2.	Construction of loop pipeline (Ashuganj – Monohordi)	Under operation
3.	Construction of loop pipeline (Monohordi – Dhanua)	Ditto
4.	Construction of new pipeline (Bibiyana – Dhanua)	Under construction
5.	Construction of loop pipeline (Elenga – East Bank of Jamuna Bridge Valve Station)	Under operation
6.	Construction of new pipeline (Bheramara – Khulna)	Under construction
7.	Construction of Ashuganj Compressor Station	Under construction
8.	Construction of Elenga Compressor Station	Under construction

As shown in the above table, some portions of the western-part pipelines have already been constructed and operated, and necessary compressor stations are under construction in Ashuganj and Elenga. If the 30” Dhanua-Elenga Pipeline and 30” West Bank of Jamuna Bridge – Nalka Pipeline are laid additionally, looping of pipelines will be achieved between Ashuganj and Nalka with a length of 164 km. Therefore, it can be said that the construction of this pipeline will contribute to reduce the disparity of natural gas supply to different areas of the country that is advocated in NSAPR II.

(3) Site Condition

This pipeline is laid along the existing 24 inch pipeline between Dhanua Valve Station and Elenga Valve Station. Almost all the pipeline is located in paddy fields, grass land and partially swampy area. The following photographs show parts of this pipeline route.

1) Site condition around pipeline starting point (Dhanua Valve Station)

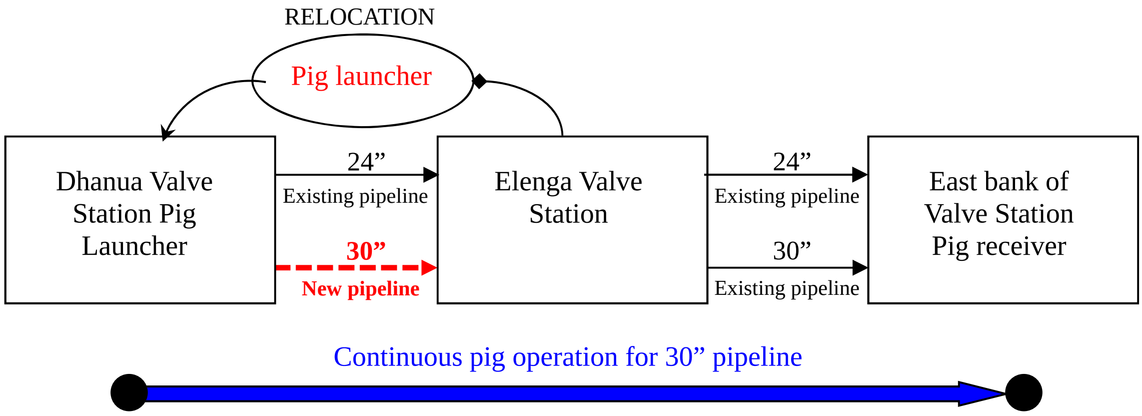
2) Saldah River crossing section (Kalmegha area)

3) Railway crossing (Rajabari area)

4) Site condition around pipeline end point (Elenga Valve Station)

In addition to the above pipeline, a set of pig units such as a pig launcher and receiver are required at both ends of the pipeline for the purpose of cleaning and internal inspection. The pig launcher unit is to be relocated from Elenga Valve Station to Dhanua Valve Station. And the pig receiver unit in Elenga Valve Station does not need to be newly installed because the existing pig receiver in the East Bank of Jamuna Bridge Valve Station will be utilized as it is in the future pig operation.

After relocation of the pig launcher, the pig operation will be able to be carried out continuously from Dhanua VS to the East Bank of Jamuna Bridge VS via Elenga VS. Refer to the Figure 4.2-2.



Source: JICA Survey Team

Figure 4.2-2 Relocation Plan of Pig Launcher Unit

(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.

(5) Approximate Cost of the Project

The project cost consists of materials cost and installation cost. Based on the above table indicating the outline of this pipeline, approximate cost was estimated as shown in the table below.

Description	Pipe Specification					Material Cost	Installation Cost	HDD Cost		Total Cost
	Dia [in]	Thick [mm]	weight [kg/m]	Length [km]	HDD Length [km]	[MM JPY]	[MM JPY]	[km]	[MM JPY]	[MM JPY]
Dhanua – Elenga	30	14.3	263.7	52.0	1.5	2,002.6	1510.5	1.5	224.3	3,737.3

Item	Unit Cost(MMJPY)	Quantity	Amount	Remarks
Material Cost	0.146 /ton	13,711 ton	2,002.6 MMJPY	Unit cost is including transportation fee and is based on recent cost data.
Installation cost	29.9 /km	50.5 km	1,510.5 MMJPY	Pipe laying unit cost used 10USD/in-m, is based on interviews with local contractor and standard unit price in Asian region.
HDD cost	149.6 /km	1.5 km	224.3 MMJPY	HDD unit cost is 1,500USD/m、based on interviews with local contractor and standard unit price in Asian region.

(6) Environmental & Social Considerations

Both EIA and RP (Resettlement Plan that represents RAP/ARAP) were conducted and approved in 2005 as an ADB financed project. This project (and hence the EIA/RP) included a transmission pipeline with a total length of 103 km (30 inches in diameter) having 3 major sectors (Monohordhi – Dhanua, Dhanua – Elenga and Elenga – East Bank of Jamuna Bridge). The construction works on the initial and final sectors of the pipeline were completed in 2009 (ADB financing). Thus, this project is aimed at construction of the remaining mid-sector of the gas transmission pipeline from Dhanua to Elenga with a length of 52 km (30 inches in diameter). The RP report of ADB complied with WB OP 4.12 concerning involuntary resettlement.

Because a long time has elapsed (more than 7 years) following the approved EIA and RP studies in 2005, new EIA and RP studies are necessary in order to duly account for the historical changes in environmental and social conditions along the planned route of the pipeline (ROW) since 2005 including any changes to the originally planned alignment of ROW.

In fact, it has become clear that there has been a significant recent increase in inhabitants (houses) along the originally planned ROW (in 2005) in some areas along the initial 32 km of the pipeline (from Dhanua to Sulgrampur). As such, rerouting of the ROW of the pipeline to the extent possible in order to minimize involuntary resettlement requirements and also straitening of the ROW wherever possible to minimize the overall length of the ROW has just been completed by GTCL (October 2013). The ROW of the pipeline will mostly pass through only vacant and agricultural lands of rice fields for the final 20-km sector from Sulgrampur to Elenga and hence no significant involuntary resettlement would be involved. Still, some resettlement would be necessary near Elenga since there are some inhabitants there.

As a result of re-routing at some locations along the initial 32 km of the ROW, the total population requiring involuntary resettlement has been reduced to 121 people (rerouted ROW accounting for 25 households) from that of 1000 people (original ROW of 2005), thereby resulting in a significant reduction in population targeted for involuntary resettlement.

These changes in the ROW also have to be duly incorporated in the EIA and RAP (ARAP is regarded as adequate since the population resettled is minimized and would not exceed 200 people with rerouting of the ROW) that will be newly carried out. It is noted that all gas pipeline projects fall under the RED category as per the Environmental Conservation Rules of 2007; hence, conducting an EIA is mandatory to obtain an ECC (environmental clearance certificate) from DoE.

It is further noted that there are no protected areas of either national or international significance (like wetland areas of Ramsar Convention) or ecologically significant areas like primeval forests, rain forests or any ecologically valuable natural habitat areas (like mangrove forests for which Sundarban Mangrove Forest as habitat for Bengal Tiger, also a Ramsar Convention area, is internationally well-known) located either along or in the vicinity of the planned ROW of the pipeline. Moreover, there are no historically or culturally significant areas located along the ROW of the pipeline or in its vicinity. This aspect has already been confirmed by the EIA study of 2005 that is regarded as still valid as far as important natural environmental aspects are concerned.

In effect, the ROW of the pipeline passes through areas having long-term human influence like agricultural lands and residential areas (areas of anthropogenic influence). As such, no long-term adverse environmental effects on important natural environmental items consequent to the project is anticipated.

4.2.2 West Bank of Jamuna Bridge – Nalka Pipeline: 30 inch x 14 km

(1) Outline

The contents of the West Bank of Jamuna Bridge – Nalka pipeline project are shown in the table below.

No.	Item	Description
1.	Pipe Diameter	30 inch
2.	Pipeline Length	14 km
3.	Maximum Allowable Operating Pressure	1,130 psig
4.	HDD length (Total)	0 m
5.	Road Crossing Major Ditto Minor	3 points 7 points
6.	Railway Crossing	1 point
7.	Interface Metering Station	1
8.	Valve Station	0
9.	In-take/Off-take Nozzle	5
10.	Pig Launcher/Receiver	1 set
11.	Design Code	ASME B31.8
12.	Pipe Specification	API 5L X60 L-SAW
13.	Pipe wall thickness	14.3 mm, 15.9 mm(HDD)
14.	SCADA	Cable connection at Nalka
15.	Location (District)	Sirajganj

In addition to the pipeline, a set of pig units such as a pig launcher and receiver is to be newly installed at both ends of the pipeline for the purpose of cleaning and internal inspection.

(2) Objective, Necessity and Priority

The objective, necessity and priority of this pipeline are the same as those of the Dhanua – Elenga pipeline. Refer to Section 4.2.1 (2).

(3) Site Condition

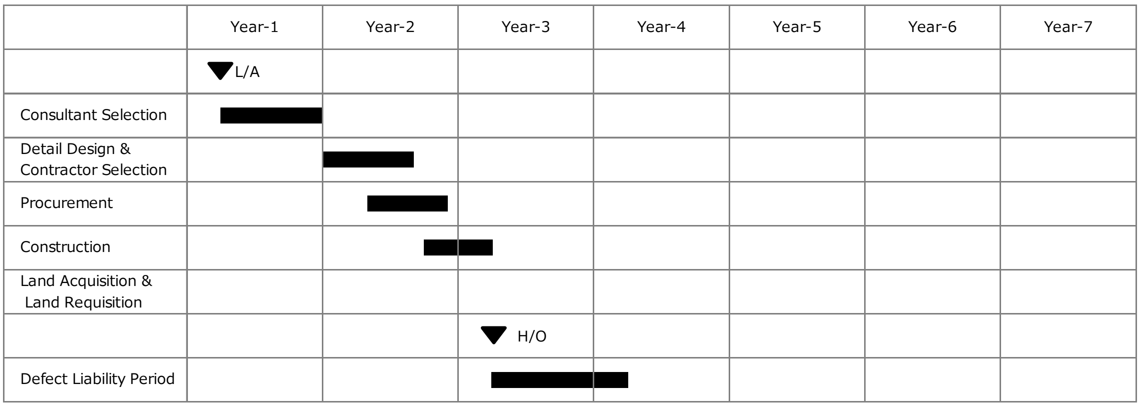
This pipeline is laid alongside of the existing 24-inch pipeline between the West Bank of Jamuna Bridge and Nalka Gas Station. Almost all areas on the pipeline route are paddy fields, grassland and partial swamp area. Pipe laying work will be easy because there are no obstacles. The following photographs show parts of this pipeline route.

1) Site condition around pipeline starting point (West Bank of Jamuna Bridge Valve Station)

2) Site condition around pipeline end point (Nalka Valve Station)

(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

The project cost consists of materials cost and installation cost. Based on the above table indicating the outline of this pipeline, the approximate cost was estimated as shown in the table below.

Description	Pipe Specification					Material Cost	Installation Cost	HDD Cost		Total Cost
	Dia [in]	Thick [mm]	weight [kg/m]	Length [km]	HDD Length [km]	[MM JPY]	[MM JPY]	[km]	[MM JPY]	[MM JPY]
West Bank of Jamuna Bridge – Nalka	30	14.3	263.7	14.0	0.0	539.1	418.7	0.0	0.0	957.9

Item	Unit Cost(MMJPY)	Quantity	Amount	Remarks
Material Cost	0.146 /ton	3,691 ton	539.1 MMJPY	Unit cost is including transportation fee and is based on recent cost data.
Installation cost	29.9 /km	14.0 km	418.7 MMJPY	Pipe laying unit cost used 10USD/in-m, is based on interviews with local contractor and standard unit price in Asian region.

(6) Environmental & Social Considerations

Similar to the Dhanua – Elenga pipeline project discussed in a previous section, both an EIA and RP (Resettlement Plan that represents RAP/ARAP) were conducted and approved in 2005 as an ADB financed project. This project (and hence EIA/RP) covered a transmission pipeline with a total length of 101 km (30 inches in diameter) having 4 major sectors (West Bank of Jamuna Bridge – Nalka, Nalka – Hatikumrul, Hatikumrul – Bonpara and Bonpara – Bheramara). The construction works of all sectors of the pipeline except the initial sector were completed in 2009 (ADB financing). Thus, this project is aimed at construction of the remaining initial sector of the gas transmission pipeline from the West Bank of Jamuna Bridge to Nalka with a length of 14 km (30 inches in diameter). The RP report of ADB complied with WB OP 4.12 concerning involuntary resettlement.

Because a long time has elapsed (more than 7 years) following the approved EIA and RP studies in 2005, a new EIA study is only necessary in order to duly account for the historical changes in environmental and social conditions along the planned route (ROW) since 2005. It is noted that the required ROW has already been acquired by GTCL (with the consent of Jamuna Bridge Authority, the owner of this ROW area) that is located by the side of the road (linking the West Bank of Jamuna Bridge to Nalka) and there are no inhabitants (housing) along this acquired ROW. Accordingly, no significant long-term adverse effect on important natural or social environmental items consequent to the project is anticipated. Moreover, no new RP (RAP/ARAP) study is considered as necessary.

It is noted that all gas pipeline projects fall under the RED category as per the Environmental Conservation Rules of 2007; hence, conducting an EIA is mandatory to obtain an ECC (environmental clearance certificate) from DoE.

4.2.3 Jalalabad – Bibiyana Pipeline: 24 inch x 54 km

(1) Outline

Contents of this pipeline are shown in the table below.

No.	Item	Description
1.	Pipe Diameter	24 inch
2.	Pipeline Length	54 km
3.	Maximum Allowable Operating Pressure	1,130 psig
4.	HDD length (Total) Surma River 570 m Kusiara River 330 m, Kusiara River 525 m	Total 1,425 m
5.	Road Crossing Major Ditto Minor	6 points 5 points
6.	Railway Crossing	1 point
7.	Metering Station	1
8.	Valve Station	2
9.	In-take/Off-take Nozzle	1
10.	Pig Launcher/Receiver	1 set
11.	Location (District)	Sylhet, Sunamganj and Habiganj

(2) Objective, Necessity and Priority

1) Objective

The Jalalabad – Bibiyana pipeline (24” x 54 km) is planned to secure the gas supply to the west part of Bangladesh in consideration of natural gas increase by augmentation of Jalalabad Gas

Field. It is considered that this pipeline can contribute to overcome the regional gap in natural gas supply in the country.

2) Necessity

According to the information of Petrobangla, additional gas production of 300 Million Standard Cubic Feet per day (MMSCFD) is expected in Jalalabad Gas Field by June 2015. Taking this gas increase into consideration, this pipeline will be necessary for future gas transmission for the western part of the country.

However, this gas increase has not been proven at this moment. Moreover, the gas increase may not be expected depending on the result of 3D seismic survey, which is currently underway. In this case, there is a possibility that the necessity and urgency of this pipeline will be extremely low.

(3) Site Condition

Almost all ROW are located in paddy fields, grassland and partial swamp areas. Only the area near Jalalabad is hilly. Pipe laying work will be easy because there are no obstacles. The following photographs show parts of this pipeline route.

1) Site condition around pipeline starting point (Jalalabad Gas Field)

2) Site condition around pipeline end point (Bibiyana Gas Field)

(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.

	Year-1	Year-2	Year-3	Year-4	Year-5	Year-6	Year-7
	▼L/A						
Consultant Selection							
Detail Design & Contractor Selection							
Procurement							
Construction							
Land Acquisition & Land Requisition							
				▼ H/O			
Defect Liability Period							

(5) Approximate Cost of the Project

The project cost consists of materials cost and installation cost. Based on the above table indicating the outline of this pipeline, approximate cost was estimated as shown in the table below.

Description	Pipe Specification					Material Cost	Installation Cost	HDD Cost		Total Cost
	Dia [in]	Thick [mm]	weight [kg/m]	Length [km]	HDD Length [km]	[MM JPY]	[MM JPY]	[km]	[MM JPY]	[MM JPY]
Jalalabad – Bibiyana	24	10.3	152.3	54.0	1.43	1,213.0	1258.0	1.43	213.1	2,684.2

Item	Unit Cost(MMJPY)	Quantity	Amount	Remarks
Material Cost	0.147 /ton	8,225 ton	1,213.0 MMJPY	Unit cost is including transportation fee and is based on recent cost data.
Installation cost	23.9 /km	52.6 km	1,258.0 MMJPY	Pipe laying unit cost used 10USD/in-m, is based on interviews with local contractor and standard unit price in Asian region.
HDD cost	149.6 /km	1.43 km	213.1 MMJPY	HDD unit cost is 1,500USD/m、based on interviews with local contractor and standard unit price in Asian region.

(6) Environmental & Social Considerations

An EIA study was completed recently in November 2012 by GTCL (with self-financing) for this project component that was approved by DoE and the ECC has already been obtained (dated 8th July 2013). It is noted that conducting a detailed RP (RAP/ARAP) study is not mandatory in Bangladesh although an EIA is mandatory for gas pipeline projects since they fall under the RED category as noted in the previous sections.

Still, it is noted that the ROW of this 54-km pipeline (diameter of 24 inches) from Jalalabad to Bibiyana passes through mostly vacant, wooded, seasonally swampy (wetland during rainy season) and agricultural lands (mostly lands of human/anthropogenic influence) and the involuntary resettlement requirement is limited to only 6 households (about 36 people). These aspects on the non-existence of naturally, historically or culturally significant areas (including primeval forests or protected areas of national or international significance) either along or in the vicinity of the planned ROW of this pipeline route (and hence the insignificance of the potential long-term adverse effects on important natural environment items) was also confirmed by the baseline environmental condition study of the EIA Report already approved by DoE.

Moreover, it is regarded that conducting an RAP/ARAP study is not necessary and all resettlement aspects as incorporated in the EIA report (as social aspects) approved by DoE are regarded as adequate in consideration of the very small-scale of resettlement requirement.

4.2.4 Bakhrabad – Chittagong Pipeline: 30 inch x 201 km

(1) Outline

The Bakhrabad – Chittagong pipeline (30 inch x 201 km) is planned to increase the gas supply to the Chittagong area.

(2) Objective, Necessity and Priority

Currently, the Chittagong region suffers from a shortage in gas supply. Gas supply to the Chittagong area is only about 200 mmcfd against a demand of 400 mmcfd.

In order to overcome this situation, a LNG receiving terminal on Moheshkhali Island located south of Chittagong was planned. Because the selection of a contractor for the construction and operation of this terminal is currently delayed, LNG should be imported in the near future to mitigate the energy crisis.

In consideration of such a high possibility of import of LNG that will overcome the gas supply shortage in the Chittagong area, the necessity of this pipeline is considered lower than the transmission pipelines mentioned in the above sections.

(3) Omission of the Component

This project component was excluded from the candidate projects during the 1st survey in Bangladesh for the following reasons:

- Lower necessity and urgency in consideration of the import of LNG that will be realized in the near future.
- It was found that there will be more than 200 inhabitants requiring involuntary resettlement in the Chittagong region. Thus, this project will be classified under Category A of JICA Guidelines for Environmental and Social Considerations and a time-consuming process is required.

4.2.5 Langalband – Maowa Pipeline: 30 inch x 40 km

(1) Outline

The Langalband – Maowa Pipeline (30 inch x 40 km) is planned for gas supply to the Khulna area. The pipeline will run from the southern part of Dhaka to the north bank of the proposed Padma Bridge.

(2) Objective, Necessity and Priority

It is considered that this pipeline can contribute to overcome the regional gap in natural gas supply in the country. However, the necessity and priority of this pipeline is relatively lower because the construction schedule of Padma Bridge is uncertain.

(3) Omission of the Component

This project component was excluded from the candidate projects during the 1st survey in Bangladesh due to the low necessity and priority mentioned above.

4.3 Construction of Distribution Pipelines

4.3.1 River Crossing by HDD at 12 sites (TGTDCL)

(1) Outline

TGTDCL requested the construction of river crossing distribution pipelines located in Dhaka franchise area of TGTDCL by the HDD method at the twelve sites listed below to replace the existing river crossing pipelines.

No.	Location	Pipe Dia.	Length
1	Doteshowori Riv. Munsigan	20”	900m
2	Kaliganga Riv. Manikganj	20”	780m
3	Turag Riv. Ashulia (1st crossing)	20”	300m
4	Turag Riv. Ashulia (2nd crossing)	20”	300m
5	Turag Riv. Karnopara, Savar	20”	200m
6	Buringanga Riv. Zinzira	20”	550m
7	Turag Riv. Jhauchar (Aminbazar-Hazaribagh)	20”	400m
8	Turag Riv. Tongi (Beside Railway Bridge)	20”	200m
9	Buringanga Riv. Singair	16”	640m
10	Turag Riv. Gabtoli, Mirpur	16”	400m
11	Pungli Riv.	20”	450m
12	Baliarpur Riv.	20”	250m

(2) Objective, Necessity and Priority

The existing river crossing pipelines were constructed by a conventional method and a few pipelines have been damaged by the propellers of vessels.

The Bangladesh Inland Water Transportation Authority (BIWTA) instructed that new river crossing pipelines should be constructed by the HDD method and laid 8 metres below the river bottom.

Therefore, the replacement of the existing river crossing pipelines is required.

(3) Site Condition

Photographs taken in parts of the river crossing sections in Section 4.3.1 (1) are shown below:

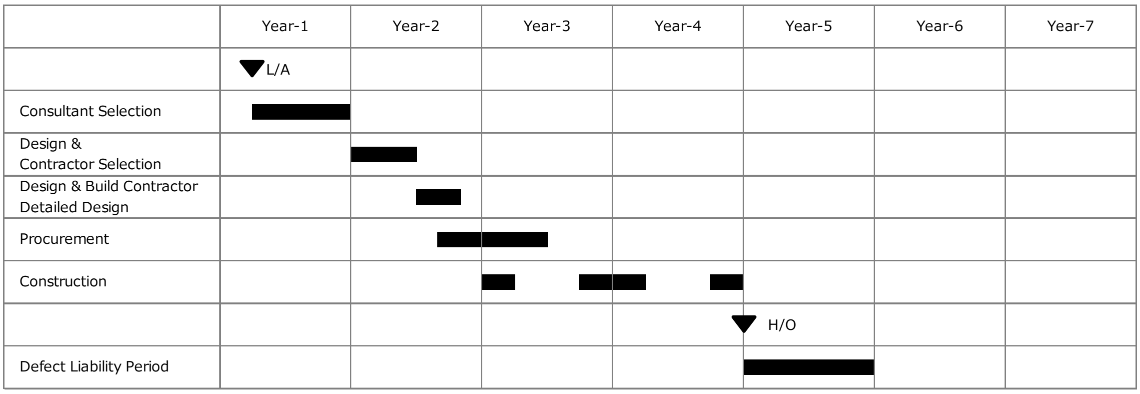
1) Item No. 3 and 4 Turag River Crossing in the Ashulia area

2) Item No. 10 Turag River Crossing in the Gabtoli area (1/2: River crossing portion)

3) Item No. 10 Turag River Crossing in the Gabtoli area (2/2: Gabtoli Bridge)

(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

The project cost consists of materials cost and installation cost. Based on the above table indicating the outline of this pipeline, approximate cost was estimated as shown in the table below.

No	Description	PIPE Specification				Pipe & Valve Cost	Installation Cost	Total Cost
		Dia [in]	Thick [mm]	weight [kg/m]	Length [m]	[MM JPY]	[MM JPY]	[MM JPY]
1	Doteshowori Riv. Munsigan	20	12.7	155.12	900	33.8	135.0	168.8
2	Kariganga Riv. Manikgang	20	12.7	155.12	780	31.4	117.0	148.4
3	Turag Riv. Ashulia(1st)	20	12.7	155.12	300	21.9	45.0	66.9
4	Turag Riv. Ashulia(2nd)	20	12.7	155.12	300	21.9	45.0	66.9
5	Turag Riv. Karnopara,Savar	20	12.7	155.12	200	20.0	30.0	50.0
6	Buringanga Riv. Zinzira	20	12.7	155.12	550	26.9	82.5	109.4
7	Trug Riv.Jhauchar	20	12.7	155.12	400	23.9	60.0	83.9
8	Trug Riv.Tongi	20	12.7	155.12	200	20.0	30.0	50.0
9	Buringanga Riv. Singair	16	12.7	123.3	640	22.9	96.0	118.9
10	Trug Riv. Gabtoli,Mirpur	16	12.7	123.3	400	19.1	60.0	79.1
11	Pungli Riv.	20	12.7	155.12	450	24.9	67.5	92.4
12	Baliarpur Riv.	20	12.7	155.12	250	20.9	37.5	58.4
	Total					287.6	806	1,093.1

(6) Environmental & Social Considerations

A preliminary study on the environmental and social aspects on the targeted 12 HDD river crossing project sites has been recently conducted on an informal basis by TGTDCL. Accordingly, it is reported that there would be no significant long-term adverse effects on the natural environment since there are no significant environmentally sensitive areas like protected areas, primeval forests or historically or culturally important areas in or around the vicinity of these 12 HDD project sites. In fact all these 12 HDD sites are located in areas of long-term human (anthropogenic) influence of urban areas of Dhaka City and its vicinity and hence no significant adverse effects on important natural environmental items is anticipated. Concerning the social aspects, in total, about 30 households (about 150 people) have been identified for involuntary resettlement consequent to the requirement of ROW for all 12 HDD river crossing related works.

It is noted that the 12 HDD sites (gas pipeline project) fall under the RED category as per the Environmental Conservation Rules of 2007; hence, conducting an EIA is mandatory to obtain an ECC (environmental clearance certificate) from DoE.

4.3.2 Rehabilitation of Critical Existing Distribution Pipelines (TGTDCL)

(1) Outline

TGTDCL requested the rehabilitation works for the critical existing distribution pipelines located in Joydebpur and Dhaka city franchise area of TGTDCL listed below.

No.	Location	Size	Length	psig	Remarks
1)	SOD (System Operation Department) – North				
a)	Kadda Bridge to Kaliakoi (North side of Road)	10”	15km	50	These pipelines were buried by the pavement due to road widening, and cannot be maintained.
b)	Kadda Bridge to Kaliakoi (South side of Road)	10”	15km	50	
c)	Joydevpur CGS to Mirzapur	10”	40km	150	
d)	Chandra to Zirani Bazar (BKSP)	12”	4km	50	
		Total	74km		
2)	SOD – Metro Dhaka				
a)	Khilgaon to Sauadabad	6”	4km	50	Pipelines a) ~ d) were buried by the pavement due to road widening, and cannot be maintained. Depth of pipeline e) increased to 25 feet due to repeated road works, and cannot be maintained.
b)	Kollanpur to Azimpur	8”	8km	50	
c)	Donia to Chittagong road	8”	6km	50	
d)	Mirpur Circle-10 to Agrgaon	8”	4km	50	
e)	Pangaon DRS to Zinzira DRS	8”	7.5km	150	
		Total	29.5km		

(2) Objective, Necessity and Priority

1) Pipelines under SOD - North

These pipelines were buried under asphalt pavement due to unexpected road widening works, and maintenance works cannot be done. Therefore, the construction of new pipelines beside the widened road is required.

2) Pipelines under SOD - Metro Dhaka

Details of these pipelines are yet to be provided from TGTDCL.

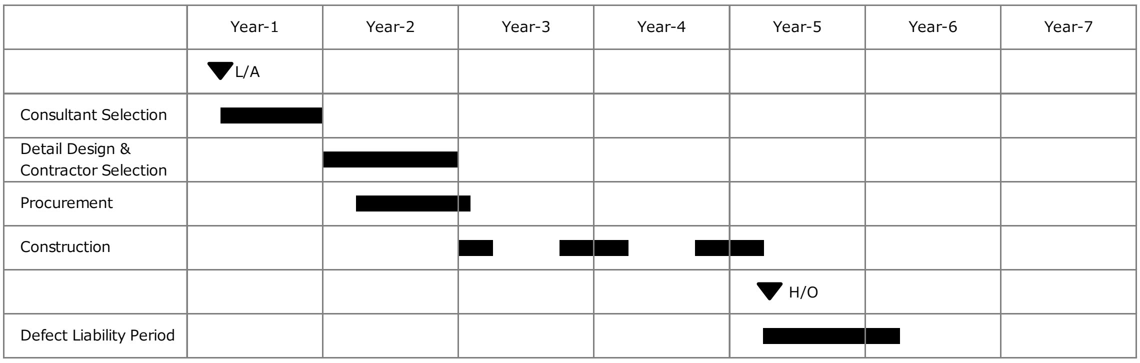
(3) Site Condition

Photographs taken in parts of the rehabilitation pipelines in Section 4.3.2 (1) are shown below:

1) Item No. 1) – a) & b) Kadda Bridge to Kaliakoi

(4) Duration of the Project Implementation

The project schedule is roughly estimated based on the diameters and lengths of pipelines as shown in the figure below.



(5) Approximate Cost of the Project

The project cost consists of materials cost and installation cost. Based on the above table indicating the outline of this pipeline, approximate cost was estimated as shown in the table below.

Description		Pipe Specification				Pipe Cost [MM JPY]	Installation Cost [MM JPY]	Total Cost [MM JPY]
		wall Thick [mm]	weight [kg/m]	Weight [ton]	Length [km]			
1	10"x50psigx15km	6.4	42.09	650.29	15	82.9	161.3	244.2
2	10"x50psigx15km	6.4	42.09	650.29	15	82.9	161.3	244.2
3	10"x150psigx40km	6.4	42.09	1734.11	40	221.1	430.0	651.1
4	12"x50psigx4km	6.4	50.11	206.45	4	26.3	51.0	77.3
5	6"x50psigx4km	5.2	20.91	86.15	4	11.0	26.5	37.5
6	8"x50psigx8km	6.4	33.57	276.62	8	35.3	69.0	104.3
7	8"x50psigx6km	6.4	33.57	207.46	6	26.5	51.8	78.2
8	8"x50psigx4km	6.4	33.57	138.31	4	17.6	34.5	52.1
9	8"x150psigx7.5km	6.4	33.57	259.33	7.5	33.1	64.7	97.8
	Total					536.6	1,049.9	1,586.6

(6) Environmental & Social Considerations

Actions on the conducting of a mandatory EIA study (the project falls under the RED category since it is a gas pipeline project in which new distribution pipelines will be installed as replacement of existing critical pipelines) have yet to be undertaken by TGTDCL. Still, the number of households and relevant population inhabiting the ROW of the pipeline (width of the required ROW is 6 m) and hence requiring involuntary resettlement has been just estimated (on a priority basis) by TGTDCL (in September 2013).

In this respect, it is noted that the project sites are located in two distinct cluster areas of Joydebpur and Central City Area of Dhaka.

As per the survey results (September 2013), it is estimated the total number of such households requiring involuntary resettlement is not that significant for both Joydebpur and Dhaka City areas with a total affected population of only 42 people (7 households) for both areas, with a breakdown of 18 people (3 households) for Joydebpur and 24 people (4 households) for the Central City Area of Dhaka.

Finally it is noted that all project sites are located by the side of urban roads of Dhaka Area (with intense human/anthropogenic influence) and hence there exist no ecologically or culturally significant areas in or around the vicinity of the ROW of the pipeline routes targeted for rehabilitation (replacement). As such, potential adverse effects on important natural environment items are regarded as not significant.

4.3.3 Construction of Distribution Pipeline: 24 inch x 5.5 km (KGDCL)

(1) Outline

KGDCL requested the reinforcement of the Chittagong ring main with the construction of a 24-inch x 5.5 km distribution pipeline including a 1.6 km river crossing by HDD that is parallel to the existing 16-inch pipeline. It spans from Patenga, Chittagong to Shamipur, Anowara, Chittagong.

(2) Objective, Necessity and Priority

KGFCL is suffering from a big change of the gas pressure over the course of a day, which comes from insufficient gas supply (200MMSCFD) against a big gas demand (400MMSCFD). The only solution is to increase gas supply to the ring line with almost the same volume as the gas demand.

After construction of this pipeline the gas transmission capacity of the Chittagong ring main and operational flexibility of the gas pipeline will improve.

Installation of 24in x 5.5km parallel distribution pipeline is not so useful without increasing the gas supply.

For this reason, as long as the construction schedule of the LNG receiving terminal planned for Moheshkhali Island is not finalized, the necessity and priority of this project is not so high.

(3) Site Condition

Photographs taken in parts of the above river crossing pipeline are shown below:

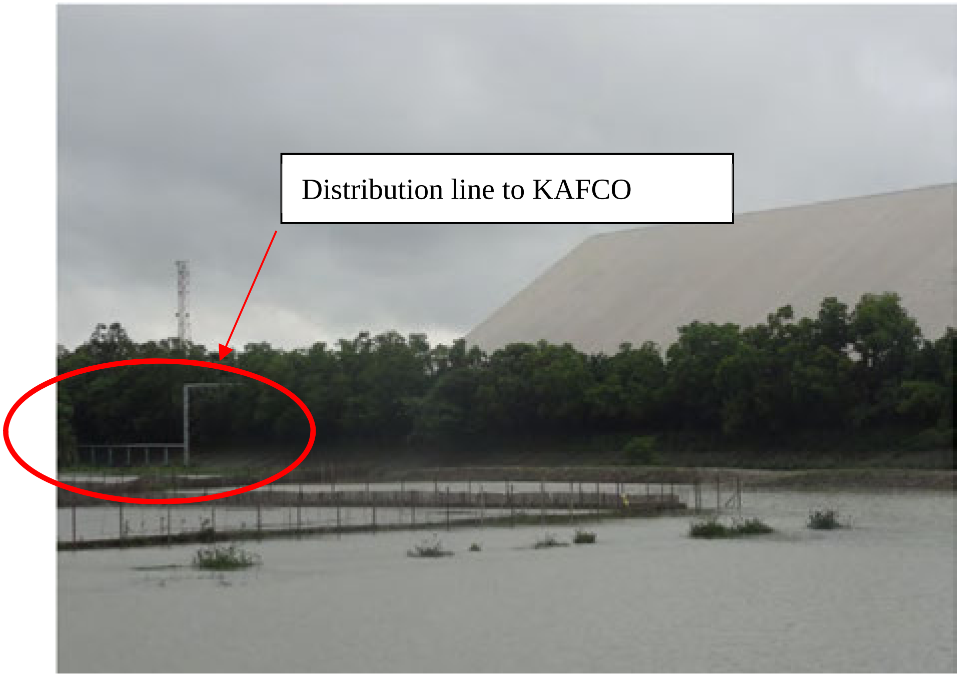
1) Karnaphuli River Crossing

2) Shah mirpur manifold station

3) Shah mirpur manifold station (Tie-in point at East bank of Karnaphuli river)

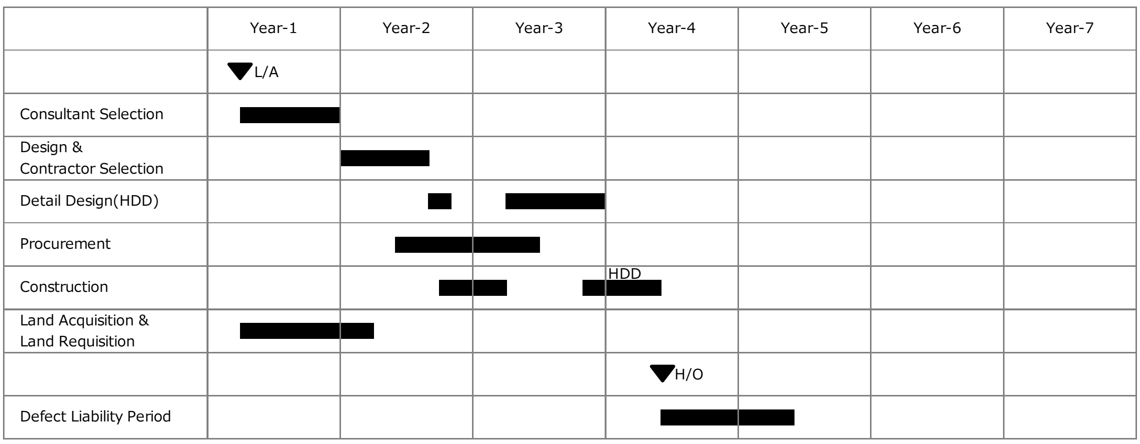
4) Patenga metering station (Tie-in point at West bank of Karnaphuli river)

5) Gas distribution line to KAFCO



(4) Duration of the Project Implementation

The project schedule is estimated as shown in the figure below.



(5) Approximate Cost of the Project

The project cost consists of materials cost and installation cost. Based on the above table indicating the outline of this pipeline, approximate cost was estimated as shown in the table below.

Description	Pipe Specification					Pipe Cost	HDD Cost		Installation Cost	Total Cost
	Dia [in]	Thick [mm]	weight [kg/m]	Length [km]	HDD Length [km]	[MM JPY]	[km]	[MM JPY]	[MM JPY]	[MM JPY]
Construction of distribution pieline	24	10.3	152.3	5.5	1.6	105.4	1.6	227.5	110.9	443.8

(6) Environmental & Social Considerations

Actions on the conducting a mandatory EIA study (project falls under the RED category because it is a gas pipeline project in which a new distribution pipeline, a portion of which is an HDD river crossing, will be installed as a replication/doubling of the existing pipeline) have yet to be undertaken by KGDCL. Still, there are no inhabitants living along the planned ROW of the pipeline that will be laid adjacent to the existing pipeline and the area is basically vacant land with no protected areas, primeval forests or historically/culturally significant areas located along or in the vicinity of the planned ROW of the pipeline. In fact, the area is located in the vicinity of an industrial area of the KAFCO Fertilizer Company. As such, there would be no significant long-term adverse effects on important natural or social environmental items. Moreover, there is no necessity for conducting an RAP/ARAP because no involuntary resettlement is involved.

4.4 Installation of Pre-Paid Gas Meters

4.4.1 Installation of Pre-Paid Gas Meters in Dhaka (TGTDCL)

(1) Outline

TGTDCL requested the installation of 300,000 pre-paid gas meters for domestic customers in the Dhaka metropolitan area.

(2) Objective, Necessity and Priority

Realization of the efficient use of natural gas is one of the major policies of GOB to mitigate the energy crisis due to the depletion of natural gas expected in the future. However, wasting natural gas is chronically prevalent among domestic customers. It has been seen that the pilot flame of cooking burners is kept on to avoid ignition each time and cooking burners are used to dry clothes and/or heat rooms in the winter season. These practices are caused by the low fixed rate adopted for domestic customers.

Under these circumstances, introduction of pre-paid gas meters is recommended because it will contribute to:

- Reduce the waste in natural gas usage
- Environmental conservation
- Improve the energy saving mind set of consumers
- Establish a proper tariff collection system (fixed rate --> measured rate)
- Ensure the correct meter reading

The reasons why "pre-paid" meters are adopted instead of "post-paid" meters are evaluated as follows:

- Prevention of incorrect meter-reading
- Financial merit for executing agency from early tariff collection
- No cost for meter-reading

Therefore the introduction of pre-paid gas meters is indispensable to cope with the recent energy crisis in Bangladesh, and also will contribute to improve energy efficiency that is advocated in NSAPR II as well as the Sixth five year plan 2010-2015 as mentioned in Section 2.4.2.

(3) Numbers of Pre-Paid Meters to be Installed

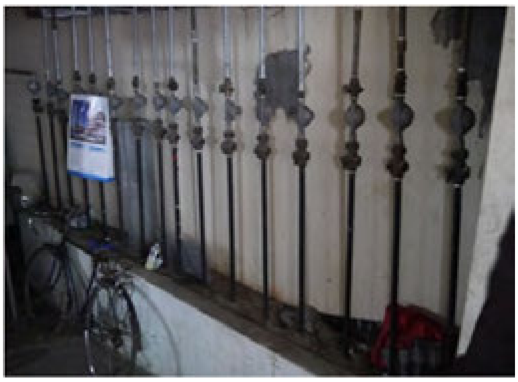
Originally, installation of 300,000 pre-paid meters was requested in Dhaka Metropolitan Area.

The areas planned for the installation of the 300,000 pre-paid meters were surveyed and it was found that there are various conditions for the installation of pre-paid meters. These can be categorized into three cases as shown in the table below.

Table 4.4-1 Existing Conditions for the Installation of Pre-Paid Gas Meters

Case	Building Type	Situation of Riser & Kitchen	Difficulty
Case-A	Apartment building constructed in last 5 years	Separate riser with regulator for each customer (kitchen)	No problem to install meters
Case-B	Apartment building constructed over 5 years ago	One riser with regulator for maximum 8 customers (kitchens) with branch piping from the riser	Difficult. Modification of existing piping is required to install separate risers and meters. This modification will take additional cost and time.
Case-C	Apartment building constructed over 5 years ago in congested area	One riser with regulator for plural customers (kitchens) with branch piping from the riser	Very difficult. Basically no space is available to modify the existing piping for the installation of separate risers and meters.

Source: JICA Survey Team



Case-A: 1 riser to 1 customer (kitchen)

Case B: 1 riser to max. 8 customers (kitchens)

Case-C: 1 riser to multiple customers (kitchens), no space is available for piping modification

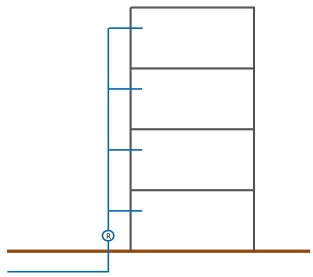
1) Case-A:

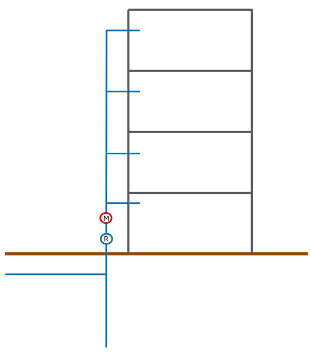
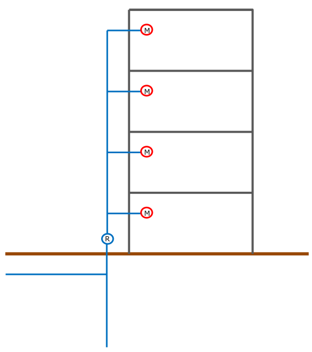
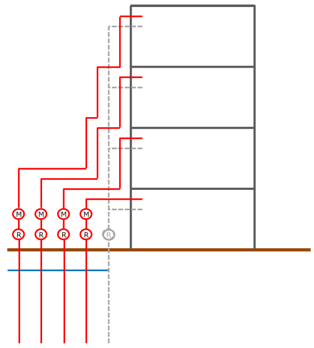
The installation of pre-paid gas meters is recommended in Case-A for the smooth implementation of the project, and it is estimated there are 93,000 installations that would be categorized as Case-A based on the customer data of Dhaka Metropolitan Area provided by TGTDCL.

2) Cases-B & C:

There would be three methods to install pre-paid meters in Cases-B & C as shown in the table below.

CASE-B & C



	Method-1	Method-2	Method-3
Method	 Install one meter for one riser.	 Install one meter in each kitchen.	 Modify piping to have one riser for each kitchen, and install a meter just after each regulator.
Installation Issue	No problem (Case-B). It will be difficult to maintain the security of meters if the riser is located outside the building due to the limited space (Case-C).	Less problem for the meter installation. Minor piping modification will be required inside kitchen.	Piping modification will cause additional time & cost, and tailor-made piping design will be required for each and every building with the consent of residents and/or owner (Case-B). Piping modification will be impossible due to the limited space (Case-C).
Meaintenance Issue	No problem	No free access to meters for the maintenance and emergency service of meters by distribution company.	No problem
Hazardous Issue	No problem	Gas leakage may cause the fire, and unknown circumstances around the meter in the kitchen may cause the unexpected troubles. Automatic functions to prevent these incidents would be required.	No problem
Tariff Collection Issue	Internal management will be required between residents and owner against unfairness.	No problem	Balance of pre-paid amount cannot be monitored in the kitchen.
Property Issue	No problem	Under the current regulation, the customers are responsible for the piping after the regulator. Therefore, the cost of piping modification will be claimed to the customers. This issue would be a major problem to be solved for the smooth project implementation.	Under the current regulation, the customers are responsible for the piping after the regulator. Therefore, the cost of piping modification will be claimed to the customers. This issue would be a major problem to be solved for the smooth project implementation.

Source: JICA Survey Team

Figure 4.4-1 Installation Methods and Issues for Cases B & C

Out of the three methods (Method-1~3) mentioned above, only Method-1 of Case-B can be recommended although an internal arrangement for the fair tariff collection would be required between the residents and the owner.

Method-1 of Case-C and Methods-2 and 3 of Case B & C cannot be recommended due to the red coloured issues in the table above.

The quantity of installations of Method-1 of Case B is estimated at 77,000 based on the customer data of Dhaka Metropolitan Area provided by TGTDCL.

3) Pre-Paid Meters in New Town Areas (Case-A)

According to Rajdhani Unnayan Kartripakkha (RAJUK) and TGTDCL, gas distribution to the following new model town areas is under planning stage.

- Purbachal New Town
  TGTDCL has assigned a project team for gas distribution to this new town.
- Uttara Residential Model Town (phase-III)
  Budget allocation for gas distribution to this model town is planned.
- Jhilmil Residential Area
  There is no concrete plan yet.

These new towns will have an individual riser to each kitchen, therefore the installation condition will be categorized as Case-A.

The quantity of pre-paid meters in these new towns is estimated at 30,000 in consideration of the current development plans of these towns. (Installation of meters in the Jhilmil Residential Area is excluded from this estimation due to uncertainty of the project.)

4) Summary of the Quantity of Pre-Paid Meters

The customer data provided by TGTDCL and used for the analysis mentioned in the above paragraphs 1) & 2) covers approximately 1 million customers (consequently 1 million kitchens) in Dhaka Metropolitan Area, out of approximately 1.5 million customers in the entire TGTDCL franchise area.

As a result of the above analysis, the quantity for the feasible installation of pre-paid meters is estimated at 200,000 (accounts for 20% of 1 million kitchens) as summarized in the table below.

Table 4.4-2 Numbers of Pre-Paid Meters to be Installed for TGTDCL

No.	Area	Quantity	Case	City & Town
1.	Part of Dhaka Metropolitan Area-1 where the installation of pre-paid meters were initially planned by TGTDCL. ※1	36,000 nos. 26,000 nos.	Case-A Case-B	Badda, Gulshan, Banani, Baridhara, Bashundgara, Tejigan Industrial Area, Cantonment, Mirpur, Azampur, Kafrul, Khilkhet, Uttara Khan, Dakkhin Khan, and Uttara.
2.	Part of Dhaka Metropolitan Area-2 other than Area-1 above ※2	57,000 nos. 51,000 nos.	Case-A Case-B	Dhaka Metropolitan Area other than above area.
3.	New Town Area ※3	30,000 nos.	Case-A	Uttara (phase-III), Pulbanchai and Jihilmil (from 2018)
	Total	200,000 nos.		

Source: JICA Survey Team

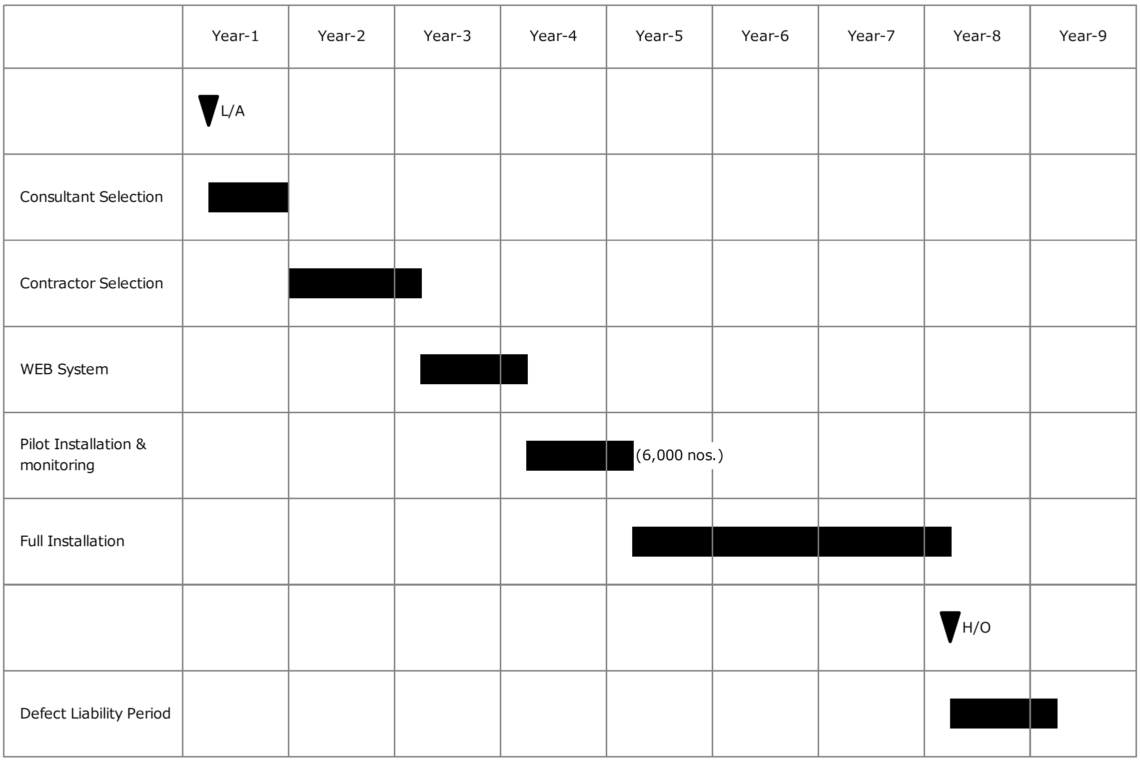
※1: These areas were planned by GOB in March 2013

※2: Exclusive of 4,500 pilot meters installed and 8,600 pilot project meters funded by ADB

※3: According to the RAJUK and TGTDCL information about distribution pipeline possibility, Gas piping arrangement in the New Town Area will be Case-A.

(4) Duration of the Project Implementation

The duration of the project implementation is estimated as shown in the table below.



Pilot installation (6,000 nos.) is recommended for TGTDCL to learn the installation, O&M of the pre-paid gas meters and to determine the problems and their solutions prior to installing all the meters.

(5) Approximate Cost of the Project

The project cost for the installation of 200,000 pre-paid meters is roughly estimated at 4.6 billion yen based on the project scope mentioned below.

- Detail design, installation, commissioning and testing of 200,000 pre-paid gas meters in Dhaka Metropolitan Area and other areas if any[4] with WEB based bill collection management system (WEB system) of the pre-paid card charging system for the gas tariff collection from domestic customers
- Training to the operation team of TGTDCL for the operation and maintenance of the entire system
- Supply of spare parts

(6) Environmental & Social Considerations

The project involves installation of pre-paid gas meters for existing domestic gas customers (gas served households) in Dhaka (TGTDCL franchise area). The project is basically aimed at promoting efficient use of gas by domestic customers with the charges being based on the quantity of gas consumed instead of the current flat charge system that encourages wastage of gas.

As such, the project has no significant adverse environmental effects and has the major beneficial effect of promoting energy efficiency with efficient use of gas, which is a non-renewable natural resource. Moreover, the resettlement aspect is irrelevant to this project component.

Therefore, this project falls under the GREEN category as per the Environmental Conservation Rules of 2007; hence, conducting an EIA is not necessary (Refer to Section 2.7).

(7) Issue and Problems

In order to succeed in the installation of pre-paid meters on a large scale, there are the following issues and problems to be further studied with the executing agency.

- Actual data of current gas consumption without meters is not available. The appropriate method to obtain the actual gas consumption of domestic customers that is necessary to evaluate the effectiveness of pre-paid meters installation needs to be studied.
- Solution for the installation of pre-paid meters in Cases B and C need to be further studied in consideration of the factors described in the previous Figure 4.4-1.

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[4] The area for pre-paid meter installation will be defined as per the customer data from TGTDCL.

- Necessity of capacity building for the smooth management of the system needs to be further studied.

4.4.2 Installation of Pre-Paid Gas Meters in Chittagong (KGDCL)

(1) Outline

KGDCL requested the installation of 20,000 pre-paid gas meters for domestic customers in the Chittagong area.

(2) Objective, Necessity and Priority

Refer to Section 4.4.1 (2).

(3) Numbers of Pre-Paid Meters to be Installed

KGDCL initially requested 20,000 pre-paid gas meters. However, it was found that there are also various conditions for the installation of meters as described in Section 4.4.1 (3).

Based on the customer data of Chittagon City Area provided by KGDCL that covers approximately 0.36 million customers (consequently 0.36 million kitchens), the feasible installation of pre-paid meters is estimated at 60,000 units consisting of 35,000 units of Case-A (approximately 10% of 0.36 million kitchens) and 25,000 units of Case-B (approximately 7% of 0.36 million kitchens) as summarized in the table below.

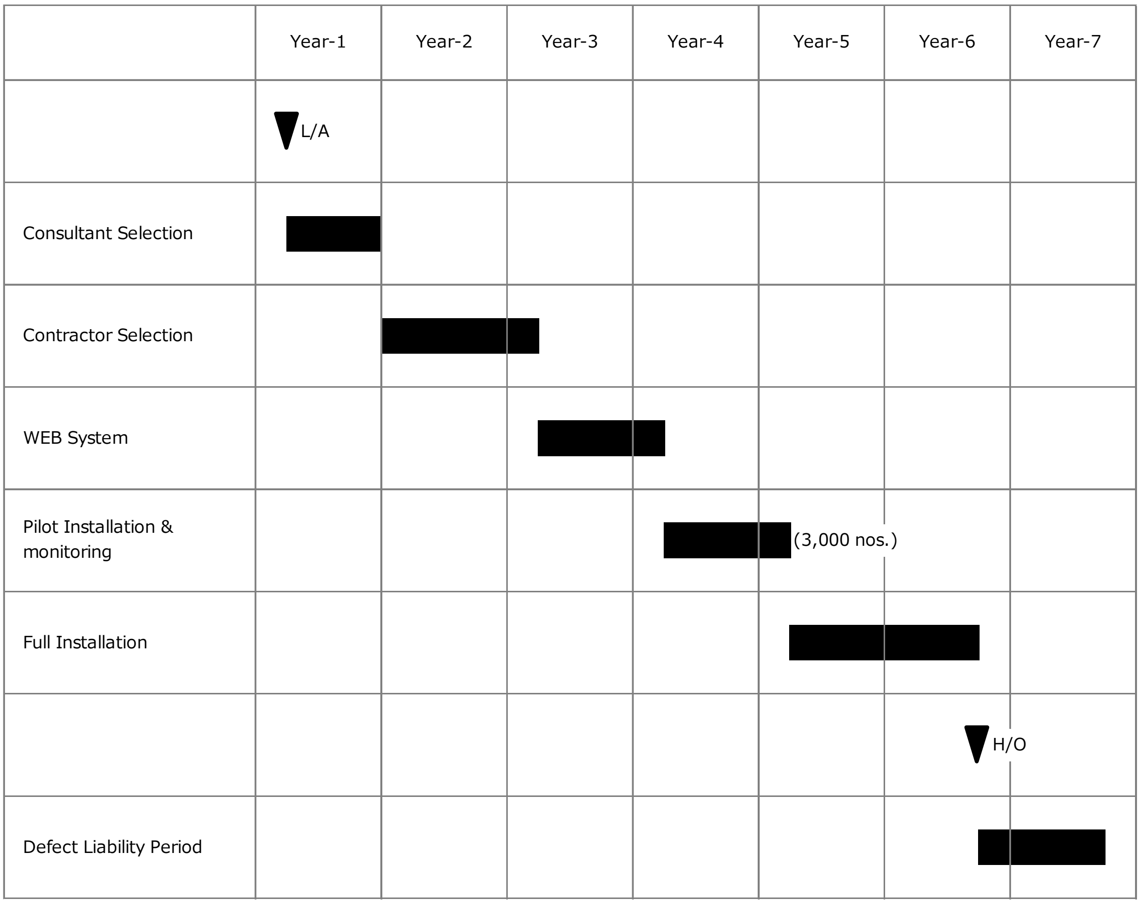
Table 4.4-3 Numbers of Pre-Paid Meters to be Installed for KGDCL

No.	Area	Quantity	Case	City & Town
1.	Part of Chitagong City Area where the installation of pre-paid meters were initially planned by KGDCL.	35,000 nos. 25,000 nos.	Case-A Case-B	Chandanpura, Sorashahar, Bakaliya, Panchlish, Panchilaish, Nasirabad, Muradpur, mahadibag, Chawk bazar, Kazir dewri, Nagar lane, Kotowari, Abashik alaka, Lalkhan Bazar, Jalal khan lane, Char chaktai, Dewan bazar, Andar killa, Halishahar etc,.
	Total	60,000 nos.		

Source: JICA Survey Team

(4) Duration of the Project Implementation

Duration of the project implementation is estimated as shown in the table below.



Since the pre-paid meter system is new to KGDCL, the pilot installation (3,000 units) and monitoring is recommended for KGDCL to learn the installation, O&M of the pre-paid gas meters and to determine the problems and their solutions prior to fully installing the meters.

(5) Approximate Cost of the Project

The project cost for the installation of 60,000 pre-paid meters is approximately estimated at 1.42 billion yen inclusive of the items listed in Section 4.4.1 (5).

(6) Environmental & Social Considerations

The project involves installation of pre-paid gas meters for existing domestic gas customers (gas served households) in Chittagong (KGDCL franchise area). The project is very similar to the project for Dhaka (TGTDCL franchise area) as dealt with under item (7) of the previous Section 4.4.1.

As such, this project falls under the GREEN category as per the Environmental Conservation Rules of 2007; hence, conducting an EIA is not necessary and the resettlement aspect is irrelevant.

(7) Issue and Problems

Refer to Section 4.4.1 (7).

Chapter 5 Selection of the Project Components

5.1 Criteria for the Selection of the Project Components

The following factors are taken into account for the selection of the project components.

- Contribution to energy efficiency
  This project should include the components that will contribute to “energy efficiency” to a certain extent because one of the major strategies for JICA assistance to the energy sector in Bangladesh is “Energy Efficiency and Conservation Promotion.”
- Fewer environmental and social impacts
  Project components that have more than 200 involuntary settlements should be excluded from the selection due to the time-consuming procedures in Japan according to JICA Guidelines for Environmental and Social Considerations.
- Necessity, rationale and priority
  The necessity, rationale and priority of the project components should be justified and prioritized for the selection.

5.2 Recommendations for the Project Component Selection

After careful examination of all survey results of each project component described in Chapter 1, the project components that are feasible and appropriate for a Japanese ODA loan are recommended according to the above criteria as shown in Table 5.3-1.

It should be noted that the installation of compressors in Bakhrabad gas field was initially assessed as the first priority among other project components requested by BGFCL, however, it has been ultimately excluded from the project component selection because GOB decided to utilize the Gas Development Fund (GDF) for the implementation of this project component, due to its urgency.

5.3 Project Cost

The approximate total cost of the project based on these recommendations for the project component selection is estimated at about 24 billion JPY exclusive of the non-eligible portion such as taxes and administration cost for project implementation.

Table 5.3-1 Project Selection Matrix

Exec. Agency	Project Component	Outline	Objective	Necessity & Priority			Environmental and Social Considerations		Energy Efficiency		Selection	Budgetary Cost by EA			Approx. Estimate by JST		Remarks
												MMTk	MMUS$	MMJPY	MMJPY	Note	
BGFCL	Drilling of new well(s) at Bakhrabad gas field	Drilling of new well(s) at Bakhrabad gas field	Contribute to the increase of natural gas supply.	×	Commercialy viable, and GOB decided to use GDF for this component. ↓ Excluded from candidate components during 1st mission.		-	EIA is required.	N/A	Increase of gas production by new well drilling will not contribute to the "Energy Efficiency".	Dropped in 1st mission	0	50	5,000	-	-	
	Installation of gas comporessor(s) at Bakhrabad gas field (1 location)	Design and installation of comporessors for the wells of which pressures are declinning.	Contribute to the sustainability of natural gas supply.	◎	Flowing wellhead pressures (FWHP) of all producing wells are currently lower than a transmission line pressure of 600 psig. The FWHP of BKB well no. 1 is estimated to reach a well abandonment pressure of 200-250 psig in about 2.5 years.	Pr1	○	EIA will not be required and only EMP will be required prvided that the project does not include the additional gas extraction. It has to be confirmed by DoE based on formal request by BGFCL. No resettlement is required because compressors will be installed within existing gas production plants.	△	Efficient extract of natural gas will contribute to the efficient use of available gas reserve.	Request withdrawn by GOB	0	38	3,790	3,303	1. Operating condition of each compressor was decided in accordance with specification planned by BGFCL. 2. Based on stand-by philosophy of two(2) duties and one(1) stand-by, three(3) numbers of compressors are installed at each location. 3. Cost is estimated using software OGM and PEA to be widely utilized in oil & gas industry and 30% of contingency is included in the cost.	the priority for this component was initially assessed as first priority among other components requested by BGFCL, however, it has been ultimately excluded from the project component selection because GOB decided to utilize GDF for this project component due to its urgency.
	Installation of gas compressor(s) at Narsingdi gas field (1 location)			○	Remaining production periods of well No.1 & 2 are estimated at about 6 years and 2.5 years respectively, based on a transmission line pressure of 1000 psig.	Pr2	○		△	Ditto	Selected	0	26	2,570	2,094		
	Installation of gas compressors at Titas gas field (Location-C)			○	FWHPs of Titas well No. 8, 9 and 10, in which gas is produced from "B" and "C" sand, range from 1075 to 1260 psig, and are estimated to reach a transmission line pressure of 1000 psig within about 3 years.	Pr3	○		△	Ditto	Selected	0	62	6,170	5,114		
	Installation of gas compressors at Titas gas field (Location-A)			○	FWHPs of five wells (out of six wells) in Location-C are less than 1500 psig and the FWHPs are estimated to reach a transimission line pressure of 1000 psig within about 2.5-6 years.	Pr4	○		△	Ditto	Not selected due to budgetary reason	0	76	7,610	6,682		
	Installation of gas compressors at Titas gas field (Location-E)			△	Not urgent because all of three wells have a relatively high FWHP of 1500 psig or more.	Pr5	○		△	Ditto	Not recommended	0	38	3,760	3,276		
	Installation of gas compressors at Titas gas field (Location-G)			△	Not urgent because gas production is currently from only one well (well no. 17) with a relatively high FWHP of 1750 psig.	Pr6	○		△	Ditto	Not recommended	0	27	2,670	2,312		
GTCL	Dhanua-Elenga 30 inch x 52 km Parallel to existing pipeline	Loop line to existing pipelines to reinforce gas supply to western part of the country	Contribute to overcome regional gap in natural gas supply	◎	Required to ensure the gas supply to western part of the country with the completion of following on-going/planned activities: 1) Compressor at Ashuganj & Elenga 2) Bibiyana-Dhanua pipeline 3) Augmentation of Bibiyana gas field		△	EIA・RP approved in 2005. New reports are required. 600 inhabitants were found on the route previously planned for ADB project. GTCL reported that it can be reduced to 108 by re-routing of pipeline.	N/A	Reinforcement of transmission pipeline network will not directly contribute to the "Energy Efficiency".	Selected				3,737	Estimate is based on interviews with local contractor and standard unit price in Asian region.	GTCL requests to combine these two components as one component to simplify the necessary process
	West bank of Jamuna brdg-Nalka 30 inch x 14 km Parallel to existing pipeline			◎	Ditto		○	EIA・RP approved in 2005. New EIA report is required. There will be no resettlement because ROW is already acquired.	N/A	Ditto	Selected				958		
	Jalalabad - Bibiyana 24 inch x 54 km New pipeline	Pipeline from Jalalabad gas field and Bibiyana gas field to reinforce gas supply to western part of the country		△	Necessity of this pipeline will be low if the result of 3D-seismic survey for Jalalabad gas field does not recommend the augmentation.		○	EIA clearance was made in June 2013. NRAP is required according to JICA guideline.	N/A	Ditto	Not recommended				2,684		
	Bakhrabad - Chittagong 30 inch x 201 km Parallel to existing pipeline	Pipeline from Bakhrabad to Chittagong ring main to reinforce the gas supply to Chittagong region.		×	Necessity of this pipeline is relatively low since LNG terminal will be constructed and operated in future. ↓ Excluded from candidate components during 1st mission.		×	No environmental study is initiated. More than 200 inhabitants to be resettled in Chittagong region ↓ Category A as per JICA guideline	N/A	Ditto	Dropped in 1st mission	0	342	34,223	-	-	
	Langalbank - Maowa 30 inch x 40 km New pipeline	Pipeline from southern part of Dhaka to northern end of proposed Padma bridge		×	Necessity of this pipeline is relarively low since the construction schedule of Padma bridge is uncertain at this moment. ↓ Excluded from candidate components during 1st mission.		-	No environmental study is initiated.	N/A	Ditto	Dropped in 1st mission	6,886	0	8,952	-	-	
TGTDCL	Pre-paid meters	Installation of 200,000 units of pre-paid gas meters in Dhaka	Contribute to energy efficiency	◎	Pre-paid gas meters will: 1) reduce the waste of natural gas usage of domestic customers 2) improve the energy saving mind of customers 3) contribute to environmental conservation		◎	Green category	◎	Pre-paid gas meters will reduce the waste of natural gas usage of domestic customers.	Selected	0	0	0	4,600	Estimate is based on high durability meters and installation to Case-A and Method-1 of Case-B. (see section 4.4.1.(3) & 4.4.2.(3)	
	HDD (12 river crossing)	Replacement of existing river crossing pipeline by HDD at 12 sites	Avoid damages to river crossing pipelines	○	Existing river crossing pipelines were constructed by conventional method and possible to get damaged by vessels, therefore replacement by HDD method is required.		△	EIA is required. TGTDCL reported that 150 inhabitants to be resettled were found in 12 sites. It should be re-confirmed.	N/A	Reinforcement of distribution pipeline network will not directly contribute to the "Energy Efficiency".	Not selected due to budgetary reason	0	11	1,100	1,093	Estimate is based on interviews with local contractor and standard unit price in Asian region.	
	Rehabilitation of Distribution Pipeline	Rehabilitation of critical existing distribution pipeline (6-12 inch x 103.5 km)	Maintain the existing distribution pipeline network	○	There are some pipelines which were buried by recent road widening and to be replaced.		△	EIA is required. TGTDCL reported that 153~198 ihabitants to be resettled were found. It should be re-confirmed.	N/A	Ditto	Not selected due to budgetary reason	0	16	1,600	1,587		
KGDCL	Pre-paid meters	Installation of 60,000 units of pre-paid gas meters in Chittagong	Contribute to energy efficiency	◎	Pre-paid gas meters will: 1) reduce the waste of natural gas usage of domestic customers 2) improve the energy saving mind of customers 3) contribute to environmental conservation		◎	Green category	◎	Installation of pre-paid gas meters will reduce the waste of natural gas among domestic customers.	Selected	220	0	286	1,422	Estimate is based on high durability meters and installation to Case-A and Method-1 of Case-B. (see section 4.4.1.(3) & 4.4.2.(3)	
	Construction of distribution pipeline (24 inch x 5.5km)	Construction of new 24" loop line parallel to existing 16" pipeline in Chittagong ring main.	Improve the capacity, reliability and flexibility of Chittagong ring main.	△	Necessity of this pipeline is relatively low since the effectiveness of this loop line will be apparent only when gas supply to Chittagong region is increased that is currently uncertain.		○	EIA is required. No inhabitant, no resettlement.	N/A	Reinforcement of distribution pipeline network will not directly contribute to the "Energy Efficiency".	Not selected due to budgetary reason				444	Estimate is based on interviews with local contractor and standard unit price in Asian region.	
														Sub-total of Selected Component	17,925		
														Consulting Services, Dispute Board, Price escalation and Contingency: 30%	5,378		
														Total of Selected Component (Eligible Portion)	23,303		

Source: JICA Survey Team

Chapter 6 Details of Selected Project Components

6.1 Installation of Wellhead Gas Compressors in Narsingdi and Titas Gas Fields

6.1.1 Scope of the Project

As the results of the selection of project components described in Chapter 5, the following two project components were selected as feasible and appropriate projects for a Japanese ODA loan.

- Installation of compressors at Narsingdi Gas Field
- Installation of compressors at Titas Gas Field Location C

Scopes of the projects are summarized in the table below and are applied to both the projects.

No.	Scope of Works	Remarks
1.	Detailed engineering, Procurement, Installation, Commissioning and Testing of Wellhead Compressor units with associated facilities, consisting of the following equipment: ▪ Compressor units x 3 (2 duty & 1 stand-by) ▪ Auxiliary equipment for the compressors ✓ Inlet scrubber x 1 ✓ Outlet scrubber x 1 ✓ After cooler x 1 ▪ Production separator x 1 ▪ Modification work for existing facility ✓ Vent gas system ✓ Drain system ✓ Condensate recovery system ✓ Fuel gas supply system ✓ Electric supply system ✓ Instrument gas system ▪ Installation of shed for compressor unit ▪ Necessary civil and structural works such as levelling, piling, foundation, etc. ▪ All bulk materials required for proposed facility ▪ Relocation works of existing facility (if necessary)	Proposed compressor shall comply with API Standard 617, 618 or 619 and be driven by a gas engine. As auxiliary equipment, the compressor shall have a closed-cycle cooling water system for cooling lube oil and the water jacket of the compressor & gas engine driver.

No.	Scope of Works	Remarks
2.	Operation manual	
3.	Assistance of BGFCL for commissioning and start-up work	
4.	Supply of 1 year spare parts and special tools for proposed compressor facility	As per Manufacturer's standard
5.	Training of operators (before commissioning)	
6.	1 year operation assistance for proposed compressor facility	
7.	Submission of as-built documents	To be submitted within 1 month after facility handover.
8.	Defect Liability Period	12 months

Further details of the project are described in the following sections.

(1) Narsingdi Gas Field

- Three compressor units are to be installed with all necessary auxiliary equipment and materials such as heat exchangers, scrubbers, pressure control devices, etc. In order to boost natural gases produced from each gas field, those compressors work with two in duty and one in stand-by.
- All the materials such as pipe, valves, fittings, electrical/instrument cables, field instruments, etc. required for successful operation of the compressors are to be supplied and installed at the appropriate location.
- Installation works for the above equipment and materials are to be provided.
- One production separator is to be installed upstream of the proposed compressors for the purpose of elimination of foreign substances and mist which may be commingled in the produced gas.
- After start-up of the proposed compressors, one year operation assistance service for the compressors shall be provided by a Contractor. A supervisor to be arranged by the Contractor will educate BGFCL's operators in necessary operation manners and daily maintenance procedures in this period.

(2) Titas Gas Field Location C

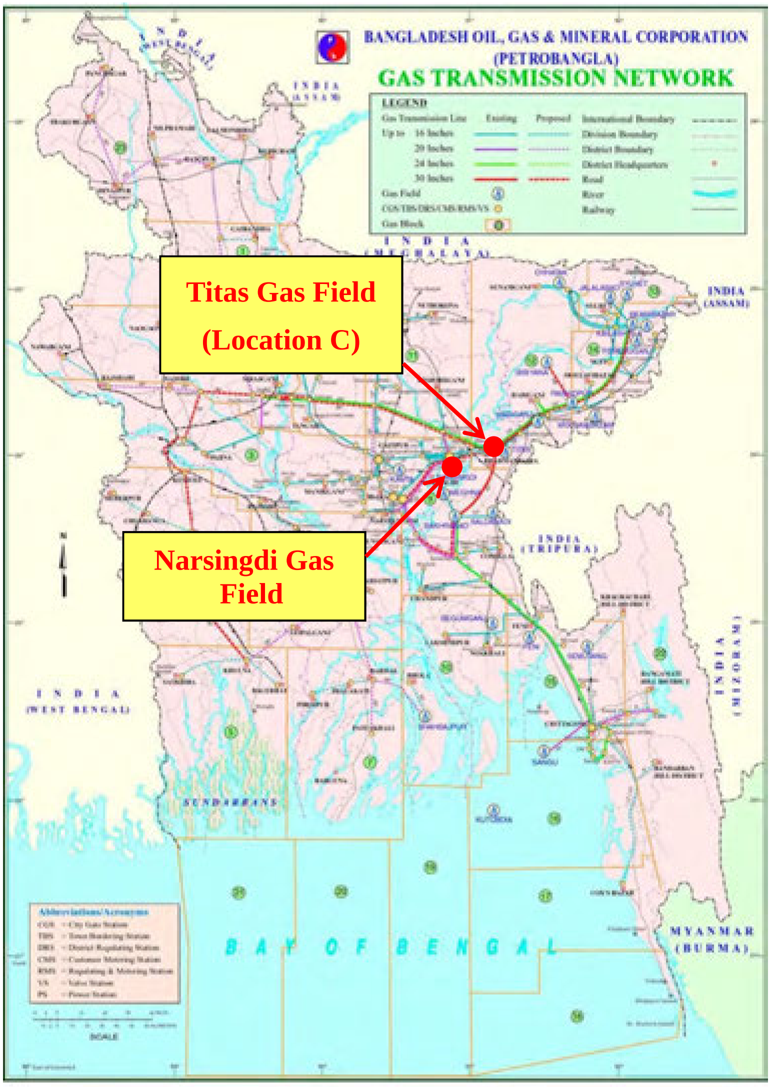
- Three compressor units are to be installed with all necessary auxiliary equipment and materials such as heat exchangers, scrubbers, pressure control devices, etc. In order to boost natural gases produced from gas field, those compressors will work with two in duty and one in stand-by.

- All the materials such as pipe, valves, fittings, electrical/instrument cables, field instruments, etc. required for successful operation of the compressors are to be supplied and installed at the appropriate location.
- Installation works for the above equipment and materials are to be provided.
- One production separator is to be installed upstream of the proposed compressors for the purpose of elimination of foreign substances and mist which may be commingled in the produced gas.
- After start-up of the proposed compressors, one year operation assistance service for the compressors shall be provided by a Contractor. A supervisor to be arranged by the Contractor will educate BGFCL’s operators in necessary operation manners and daily maintenance procedures in this period.

Addresses of project sites are as follows,

<table>
<tr><th>Gas Field</th><th>Village</th><th>Upazilla</th><th>District</th></tr>
<tr><td>Narsingdi Gas Field</td><td>Kamartek</td><td>Shippur</td><td>Narsingdi</td></tr>
<tr><td>Titas Gas Field (Location C)</td><td>Kholapara</td><td colspan="2">Brahmanbaria-3400</td></tr>
</table>

and the location of both gas fields is indicated on the map below.



Source: Petrobangla and JICA Survey Team

Figure 6.1-1 Location Map of Compressor Projects

6.1.2 Status of Related Projects

(1) Overview of the Status of Related Projects

The on-going and planned projects related to the selected projects (components) under BGFCL are summarized in Table 6.1-1.

Table 6.1-1 Related projects/operations under BGFCL

Field	Project	Schedule	Priority
Bakhrabad	Workover of Bakhrabad well no. 5	Expected to start early 2014	2
	Drilling of new well(s)	No specific schedule	
Narsingdi	–	–	
Titas	Drilling of Titas wells no. 19, 20, 21 and 22	To be completed within 1 year	On-going
	Drilling of Titas well no. 27	To be completed by June 2015	1
	Drilling of Titas wells no. 23, 24, 25 and 26	To be completed within 2 years	
	Workover of Titas well no. 10	Expected to start in March 2014	3

Source: JICA Survey Team based on the information from BGFCL

1) Bakhrabad Gas Field

Bakhrabad well no. 5, which has been shut down due to excessive water and sand production, is planned for a workover. The second priority is given to the workover of well no. 5 by BGFCL within their planned projects. A workover of Bakhrabad well no. 5 was recently done, however, no gas was produced from the well.

As a follow-up of Bakhrabad well no. 9, drilling of new development well(s) for enhancing gas production is planned. However, further development planning will be conducted based on the production performance of well no. 9 combined with the results of 3D seismic interpretation which is being currently conducted by BAPEX.

The project component for the installation of wellhead gas compressors in the Bakhrabad Gas Field was finally excluded from the project component selection.

2) Narsingdi Gas Field

No specific plans such as drilling of new well(s) and well workover are prepared yet, although workover of both of the existing wells will be planned in the future.

This plan for well operations in the Narsingdi Gas Field will be taken into account in the planning of the installation of wellhead gas compressors.

3) Titas Gas Field

Titas wells no. 19, 20, 21 and 22 are planned to be drilled by Gazprom. Out of these four wells, well no. 20 has already been drilled and completed at Location A, however, the well did not produce gas due to excessive water production occurred during production testing. Remedial work to stop water production was performed, and then gas production from the well started in late October 2013.

Titas wells no. 19 and 22 are to be drilled at Location C and well no. 21 is to be drilled at Location-A, and these wells are planned to be drilled within one year.

The current production performance of Titas well no. 20 indicates that the well does not need a wellhead compressor because it has a FWHP of about 1,600 psig. Wells no. 19 and 22 at Location C and well no. 21 at Location A will not urgently need wellhead gas compressors because these wells will be expected to have FWHPs high enough to produce gas without wellhead gas compressors.

Drilling of Titas well no. 27 at Location-G is being conducted and is implemented by Gas Development Fund (GDF). The first priority is given to the drilling of well no. 27 within the planned projects under BGFCL and the drilling of well no. 27 started in November 2013.

Titas-23, 24, 25 and 26 wells are planned to be drilled by a drilling contractor chosen through international competitive bidding in 2014 and 2015. This four well drilling project is funded by ADB. At present, procurement activities for drilling materials and a drilling contractor, including all engineering services, are in progress. Titas wells no. 23 and 24 are to be drilled at Location I (new location) and Titas wells no. 25 and 26 are to be drilled at Location J (new location).

Titas wells no. 23, 24, 25, 26 and 27 will also not urgently need wellhead gas compressors because of the same reason as for the case of wells no. 19, 21 and 22 shown above.

Well workover (recompletion in the A sand) is planned for Titas well no. 10 at Location C and the operations will be expected to start in March 2014. Higher priority is also given to the workover of well no. 10 within the planned projects under BGFCL.

This workover plan for well no. 10 will be taken into account in the planning of the installation of wellhead gas compressors.

(2) Necessity and Priority of Selected Projects

The necessity and priority of the selected projects is discussed here in relation to other projects shown above. The Narsingdi Gas Field and Titas Location-C, which correspond to the priorities 2 and 3, respectively, within the six candidates (see 4.1.2 (7)), are finally selected for the installation of wellhead gas compressors[5].

A summary of the Narsingdi Gas Field and Titas Gas Field Location C as of May 2013 is shown in Table 6.1-2. In this table the remaining production periods estimated by the method of production forecast-1 are based on the assumptions that recompletions of some of the producing

[5] The installation of compressors in Bakhrabad gas field was initially assessed as first priority, however, it has been ultimately excluded from the project component selection because GOB decided to utilize GDF for this component due to its urgency.

wells will be conducted if necessary and compressors will be installed in the future. The remaining production periods by production forecast-1 for both of the Narsingdi and Titas Gas Fields show longer than 18 years, and this means that both of the fields will still be producing gas (not depleted) in 2030.

Table 6.1-2 Summary of the Narsingdi Gas Field and Titas Gas Field Location C

Name of Field/Location	Recoverable Reserves (bcf)	Cumulative Production (bcf)	Remaining Reserves (bcf)	Number of Producing Wells	Flow Rate per Well (MMscfd)	Current FWHP (psig)	Remaining Production Period		Remarks
							Production Forecast-1 (yr)	Production Forecast-2 (yr)	
Narsingdi	345	143	202	2	13–17	1220–1499	>18	2.5–6.2	Drilling of new well(s) and workover of the producing wells within a few years are not planned.
Titas Location C	7582	3607	3975	6	8–36	1075–1610	>18	0.3–9.7	Workover (recompletion in the A sand) of well no. 10 is planned.

Notes: 1) Recoverable reserves are based on the HCU's report (2011).
2) Cumulative production data until May 2013 is shown.
3) The recoverable reserves, cumulative production, remaining reserves and remaining production period (production forecast-1) for Titas Location C are based on the field-wise data.
4) Production forecast-1: Based on the production forecast for the gas fields under BGFCL prepared in February 2012 and the updated production forecast for the Narsingdi gas field. These forecasts are prepared by assuming the installation of compressors and the field abandonment pressures of 500 psig for both the Narsingdi and Titas gas fields.
5) Production forecast-2: Based on a review of production profiles on a well-by-well basis. Remaining production periods were estimated based on the present trendlines and **were counted from May 2013 for the Narsingdi gas field, and from August 2012 for the Titas gas field.**

Source: JICA Survey Team based on the information from BGFCL

1) Narsingdi Gas Field

History:

The Narsingdi Gas Field was discovered by Petrobangla in 1990. Total recoverable gas reserves of the field are 345 bcf. Commercial gas production started in July 1996 and 147 bcf of recoverable gas or 42.4% of recoverable reserves has been produced as of 30 September 2013. In September 2013, an average 29 MMscf of gas is being produced daily from the two wells and supplied to the transmission pipeline of TGTDCL after processing through a glycol dehydration process plant. In addition, an average 58 bbl of condensate is also being produced daily as a by-product. Both of the 2 producing wells are completed in the Lower sand.

Drilling and workover plan:

There are only two producing wells in the Narsingdi Gas Field, and drilling of new well(s) and workover in the field are not planned within the next few years, as shown in Table 6.1-2. The existing wells are completed in the Lower sand, and these wells will be recompleted in the Upper sand after production from the Lower sand ceases in the future.

Necessity and priority:

The installation of wellhead gas compressors in the Narsingdi Gas Field is required to avoid a relatively large decrease in the entire field production due to shutdown of Narsingdi well no. 2 when it reaches around the transmission line pressure of 1,000 psig. It is important to maintain the level of the entire field production as high as possible by installing wellhead gas compressors in the Narsingdi Gas Field which will result in the extension of the life of the field. The remaining production period for Narsingdi well no. 2 is estimated to be only about 2.5 years by the method of production forecast-2, although gas production from the well started in February 2007. To maintain the current production levels by the installation of wellhead gas compressors is also a better way for the full utilization of the existing production facilities in the field.

It is also noted that the Narsingdi Gas Field has a rate of about 58 barrels per day (bbl/d) of condensate production as of September 2013, although it is much lower than that of about 386 bbl/d in the Titas Gas Field. However, the average condensate-gas ratio of the Narsingdi Gas Field is 1.99 bbl/MMscf compared to 0.8137 bbl/MMscf of the Titas Gas Field. Therefore, the enhancement of condensate recovery by the installation of wellhead gas compressors in the Narsingdi Gas Field will result in increasing the value (and profitability) of the field (refer to Section 6.1.3 (1)).

Higher priority is given to the Narsingdi Gas Field compared to the Titas Gas Field Location C from the viewpoint of maximizing field-wise production and extending field life even though field-wise recoverable reserves are relatively small.

2) Titas Gas Field Location C

History:

The Titas Gas Field was discovered by Pakistan Shell Oil Company in 1962. Total recoverable gas reserves of the field are 7,582 bcf. Commercial gas production started in 1968 and 3664 bcf of recoverable gas or 48.3% of recoverable reserves have been produced as of 30 September 2013. In September 2013, an average 475 MMscf of gas is being produced daily from 17 wells and supplied to the transmission pipelines of TGTDCL and GTCL after processing through different types of process plants. In addition, about 386 bbl of condensate is also being produced daily as a by-product. Out of 17 producing wells, 3 are completed in the B and C sands and the other wells are in the A sand.

Drilling and workover plan:

Out of the 6 producing wells at Location C, well no. 10, which is completed in the B and C sands, is planned to be recompleted in the A sand in March 2014, and wells no. 19 and 22 which target the A sand are planned to be drilled at Location C within one year, as described in Section 6.1.2 (1).

<u>Necessity and priority</u>

Regarding wells no. 8 and 9, which are also completed in the B and C sands, wellhead gas compressors should be installed before the FWHPs will reach around the level of transmission line pressure of 1,000 psig in order to maximize recovery of gas from the B and C sands. These wells will be recompleted in the A sand when the FWHPs will reach around 1,000 psig, even though wellhead gas compressors will not be installed.

In addition, the remaining production periods of these wells are only 2.8 and 3.2 years, respectively (Table 4.1-3).

As mentioned above, the priority for the installation of wellhead gas compressors in the Titas Gas Field Location C would be low compared to the Narsingdi Gas Field.

6.1.3 Preliminary Design of the Project

Preliminary design work was carried out based on data and information collected in the first and second surveys. In this section, compressor specifications, which were tentatively established in Chapter 4, are reviewed with further details, and principal technical issues for planning proposed compressors are studied as follows:

As described in Chapter 5, the following two (2) project components were selected as feasible and appropriate projects for the Japanese ODA loan.

- Installation of gas compressors at Narsingdi Gas Field
- Installation of gas compressors at Titas Gas Field Location C

In this section, the following technical issues necessary for the selected components are preliminarily studied for the proposed compressor units, including the auxiliary equipment.

- Installation location of proposed compressors
- Outline of proposed facility
- Modification work of existing facility
- Issues to be clarified
- Recommendations

Prior to the above study, the basis and assumptions for the study are established appropriately in accordance with data and information given by BGFCL.

In this study, principal construction items, including installation works of the proposed facilities and modification works of the existing facilities are itemized for future provision. As the result of the study, recommendations and issues to be clarified in the next engineering stage are stated in terms of technical aspects.

The study result of the two (2) projects, i.e. Narsingdi Gas Field Project and Titas Gas Field (Location C) Project, are described in section (2) and section (3), respectively.

(1) Study basis and assumptions

1) Study basis

a) Gas composition

Table 6.1-3 Typical Gas Composition (Narsingdi Gas Field)

Component	mol%
Methane	95.8179
Ethane	2.4161
Propane	0.5438
i-Butane	0.1562
n-Butane	0.1078
i-Pentane	0.0509
n-Pentane	0.0296
Hexane plus (C6+)	0.0128
Nitrogen	0.2477
CO2	0.6172
Total	100.000

Source:BGFCL information

Table 6.1-4 Typical Gas Composition (Titas Gas Field)

Component	mol%
Methane	96.924
Ethane	1.805
Propane	0.361
i-Butane	0.087
n-Butane	0.052
i-Pentane	0.022
n-Pentane	0.017
Hexane	0.039
Heptane	0.018

Component	mol%
Octane	0.000
Nonane	0.000
Decane	0.000
Nitrogen	0.367
CO2	0.308
Total	100.000

Source: BGFCL information

b) Condensate Composition

Table 6.1-5 Typical Condensate Composition

Gas Field	Narsingdi	Titas Location C
Component	mol%	mol%
Ethane	0.25	0.17
Propane	0.36	0.30
i-Butane	0.39	0.25
n-Butane	0.45	0.28
i-Pentane	0.66	0.32
n-Pentane	0.84	0.42
Hexane (C6)	7.83	4.73
n-Heptane	13.78	8.46
n-Octane	17.83	10.98
n-Nonane	6.78	4.43
n-Decane	13.52	10.23
C11	10.36	10.68
C12	8.17	10.99
C13	6.08	10.27
C14	5.09	9.65
C15	3.93	8.31
C16	1.62	4.88
C17	1.08	2.45
C18	0.51	1.43
C19	0.19	0.55
C20+	0.08	0.22

Gas Field	Narsingdi	Titas Location C
Component	mol%	mol%
Total	100.00	100.00

Source: BGFCL information

c) Condensate Gas Ratio of Existing Production

- Narsingdi Gas Field : 2.036 bbl/MMscf
- Titas Gas Field : 0.740 bbl/MMscf

d) Present Wellhead Conditions

The following data are applied at existing wellhead operating conditions in order to make the current simulation models based on the pressure and temperature of sampling points described in the gas analysis report for Narsingdi Gas Field and Titas Gas Field, Location C".

Table 6.1-6 Operating Condition at Wellhead

Gas Field	Narsingdi	Titas Location C
Pressure (psig)	1,781	1,700
Temperature (deg.F)	106	142

e) Utility condition

The following utility conditions are available at the existing gas production facilities in both Narsingdi and Titas Gas Fields (Location C).

- Electric power: 230V, 440V, 1 & 3 Phase, 50 Hz
- Fresh water: Not available on site
- Instrument air: Not available on site
- Fuel gas: Not available at site

2) Study assumptions

a) Gas production rate

- Narsingdi Gas Field

  Based on data given by BGFCL, gas production rate in Narsingdi Gas Field is assumed to be 30 MMSCFD. Refer to Collected Data "GT-3".
- Titas Gas Field (Location C)

  Based on data given by BGFCL, current production rate per each production well in Titas Gas Field (Location C) is as follows:

Well no.	Production rate (MMSCFD)
6	36.4
8	21.6
9	25.035
10	8.0
11	30.0
16	35.3
Total	156.335

Source:BGFCL (Refer to Collected Data “GT-3”)

As shown in the above table, current total production rate is estimated at 156.335 MMSCFD. Furthermore, BGFCL has the following natural gas production enhancement plans related to Titas Gas Field (Location C):

- Future production rate of Well no. 10 will be expected to increase to approx. 30 MMCFD after completion of a workover of this well.
- Produced gas of Well no. 11 will be shifted to Titas Gas Field (Location E) in the near future.
- Production rate of Well no. 19 is expected to be approximately 30 MMSCFD and is produced at Location C with compression by the proposed compressors.

Based on the current total production rate and the above future production enhancement plans, gas production rate in Titas Gas Field (Location C) is assumed to be 180 MMSCFD including production volume of Wells no.6, 8, 9, 10, 16 and 19.

b) Gas production pressure

BGFCL requested installation of 1st stage compressors of which suction pressure is planned at 700 psig in consideration of future wellhead pressure decline. It is assumed that the suction pressure of 700 psig is applied to both Narsingdi and Titas Gas Field case. Later 2nd stage compressors for further wellhead pressure decline will be installed with other donor’s fund or BGFCL own fund.

c) Gas production temperature

It is assumed that the temperature of the produced gas from each well in Narsingdi Gas Field is 139 deg. F based on the production temperature of Wells no. 1 and 2. Refer to Collected Data “GT-4”.

In Titas Gas Field (Location C), it is assumed that the temperature of the produced gas from each well is 149 deg. F based on the production temperature of Wells no. 6, 8, 9, 10, 11 and 16. Refer to Collected Data “GT-4”.

d) Compressed gas temperature

The compressed gas discharged from the proposed compressors in Narsingdi Gas Field and Titas Gas Field (Location C) is hot and contains large quantities of liquid such as condensate and water in vapour form. Therefore, an after cooler (heat exchanger) must be installed downstream of each compressor with a scrubber to separate the liquid that is condensed by the cooling effect. It is assumed that the gas temperature cooled by the after cooler is 120 deg. F.

e) Pressure drop at the existing gas processing facility and operating pressure in adjacent transmission pipeline

In Narsingdi and Titas Gas Field, pressure drop at the existing gas processing facility and operating pressure in the transmission pipeline is assumed as shown in the table below.

Gas Field	Pressure drop at existing gas processing facility (psi)	Operating pressure at transmission pipeline (psig)
Narsingdi	200	1000
Titas Location C	200	1000

Source: BGFCL information

f) Stand-by strategy of proposed compressors

Proposed compressors are to be installed as two (2) on duty and one (1) stand-by in consideration of unexpected shutdown of one (1) running compressor. In case of one (1) running compressor shutdown, the stand-by compressor will be started-up to continue gas production. Simultaneous shutdown of two (2) running compressors and/or trouble with another running compressor during maintenance of one (1) compressor are not to be considered.

g) Necessity of another separator

According to BGFCL policy, another production separator which could be switched on during maintenance of a running separator is not installed because an overhaul has not been conducted for any separator in any of the gas fields in the country through forty years operation.

(2) Narsingdi Gas Field Project

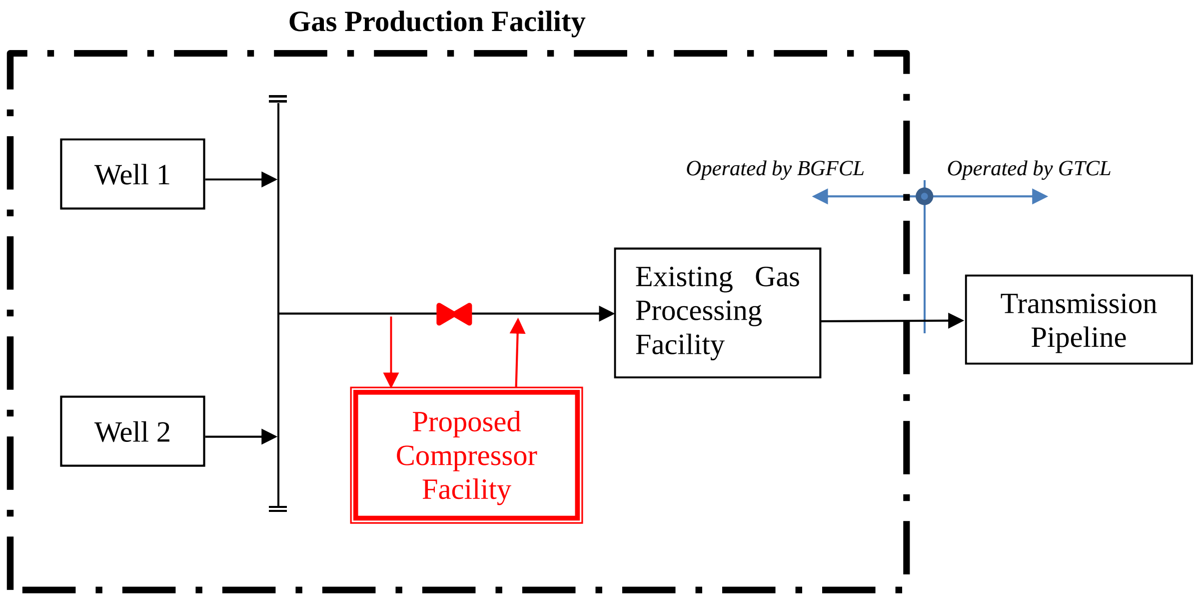
BGFCL is planning to install wellhead gas compressors in Narsingdi Gas Field due to the decline of flowing wellhead pressures (“FWHP”) at each gas production well. In this gas field, the FWHP, whose value currently ranges about 1220~1499 psig, is declining at a rate of approximately 52 to 64 psi per year in recent years. In order to continue to send produced gas into the gas transmission pipeline, the proposed compressors must be installed to overcome the transmission line pressure. Refer to Table 4.1-2.

1) Study for Installation Location of Proposed Compressors

- Installation location

BGFCL is asking for installation of gas compressors upstream of the existing gas processing facility, in order to increase the recoverable condensate volume. After installation of the compressor, insufficient operating pressure in the existing gas processing facility will be improved fully for pressure reduction, which enables operating temperature to be extremely low by Joule-Thomson Effect. It can be expected that the effect will promote gas condensation in the existing gas processing facility.

The installation location of the proposed compressor is shown in Figure 6.1-2.



Source: JICA Survey Team

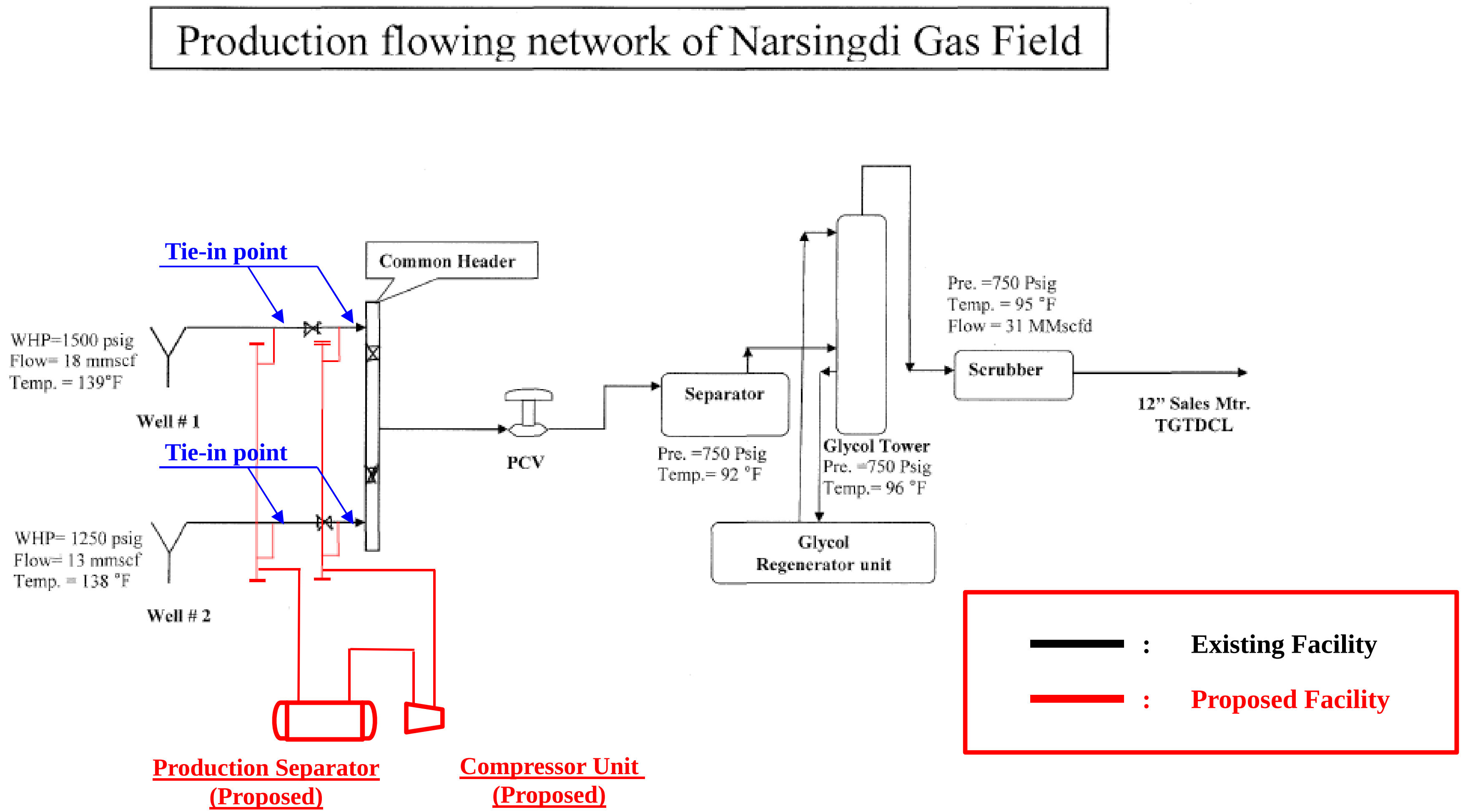
Figure 6.1-2 Block Flow Diagram (Narsingdi Gas Field)

As shown in Figure 6.1-2, the proposed compressor facility marked in red would be newly installed between gas production wells and the existing gas processing facility. In general, most of the produced gas includes several substances such as sand, mud, liquid, and so on, and a compressor unit should be operated in solid- and liquid-free condition.

However, in the case of this compressor location, produced gases coming from production wells flow into the proposed compressor unit directly without any separation of foreign substances and mist, etc. Therefore, it is not preferable to install the proposed compressor at this location, from the viewpoint of stable operation and maintenance.

Accordingly, this study subsequently proceeds on the condition that a production separator, which eliminates such foreign substances in the gas, is additionally installed upstream of the proposed compressor.

Installation location of the proposed compressors with the production separator is shown in Figure 6.1-3.

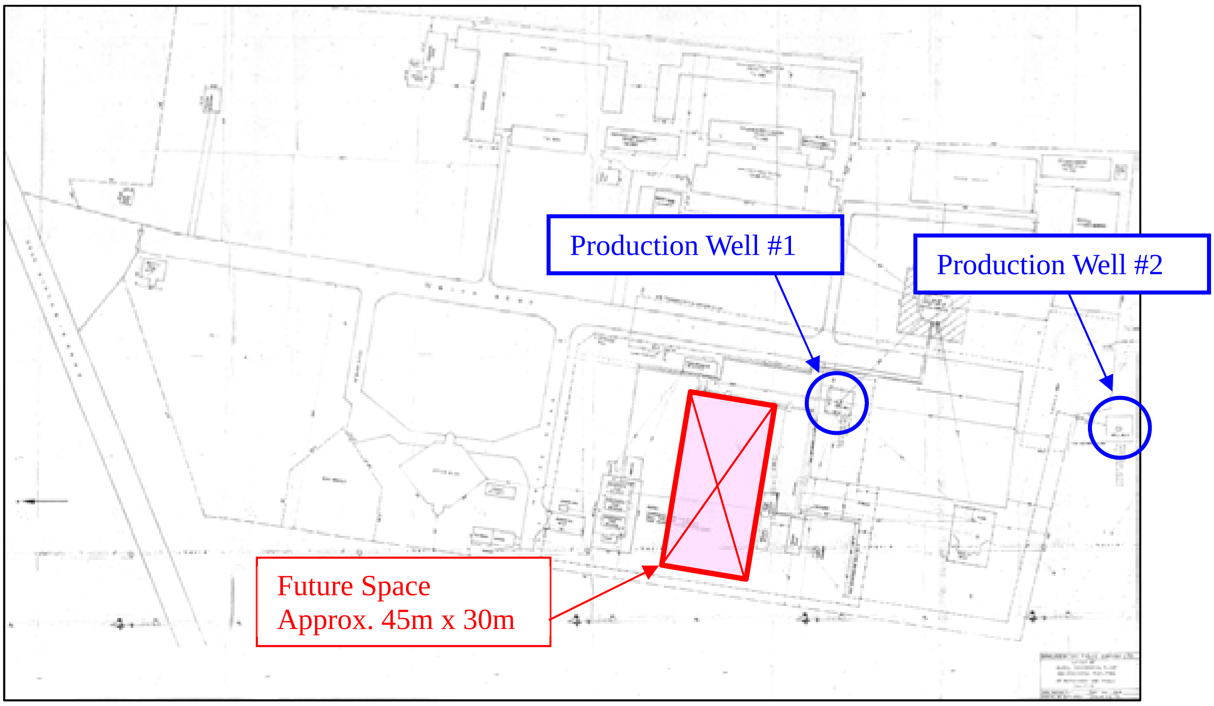


Source: JICA Survey Te

Figure 6.1-3 Installation Location of Proposed Compressor (Narsingdi Gas Field)

■ Future space for proposed compressors

Based on a site survey, the space available for proposed compressors with the auxiliary equipment were discussed with BGFCL and the location was tentatively decided as shown in Figure 6.1-4. The space will be reviewed properly in consideration of operability, accessibility, maintainability, etc., in the next engineering stage.



Source: JICA Survey Team based on BGFCL information

Figure 6.1-4 Future Space for Proposed Compressor Facilities (Narsingdi Gas Field)

2) Study for Recoverable Condensate Volume

a) Confirmation of Condensate Generation

Based on the wellhead gas and condensate compositions described in Section 6.1.3 (1), 1), a) and b), the composition of wellhead fluid is calculated as follows:

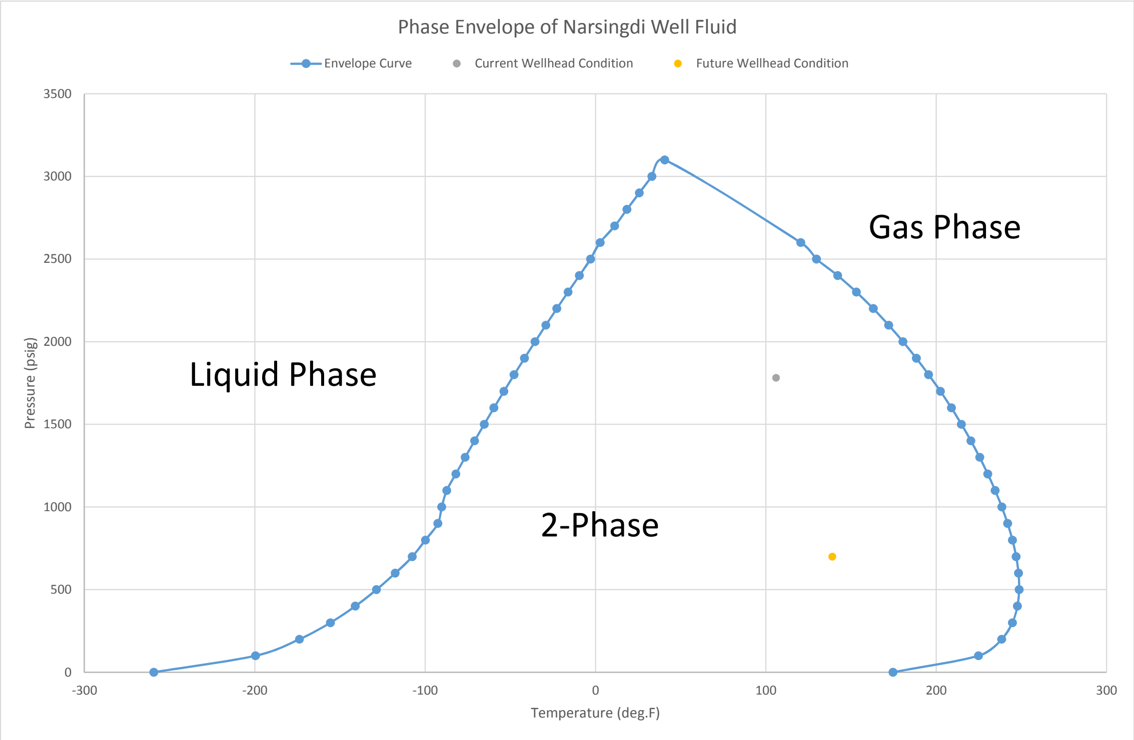
Table 6.1-7 Wellhead Fluid Composition (Narsingdi Gas Field)

Composition	mol%
Nitrogen	0.25
CO2	0.62
Methane	95.51
Ethane	2.41
Propane	0.54
i-Butane	0.16
n-Butane	0.11
i-Pentane	0.05
n-Pentane	0.03
n-Hexane	0.03
n-Heptane	0.03
n-Octane	0.04
n-Nonane	0.01
n-Decane plus	0.10
H2O	0.12
Total	100.00

Source: JICA Survey Team

Based on the calculated wellhead composition, it will be confirmed by development of a phase envelope whether condensate can be recovered. The phase envelope is prepared by using an Aspen HYSYS (version 8.2) process simulator, which is widely utilized in the oil and gas industry.

As a result of drawing the phase envelope, both current and future wellhead operating points are and will be located within the envelope curve. Therefore, it is expected that some amount of condensate will be recovered from the produced well fluid in both current and future operating condition. Refer to Figure 6.1-5 "Envelope of Narsingdi Well Fluid."



Source: JICA Survey Team

Figure 6.1-5 Envelope of Narsingdi Well Fluid

b) Recoverable Condensate Volume

BGFCL intends to increase condensate recovery volume by installation of a new compressor at the upstream location of the existing gas processing facility. In this section, recoverable condensate volume expected in future operation is roughly evaluated versus current operating conditions. As for future operation, both cases—“with compressor” and “without compressor”—are evaluated in order to confirm the effect of the compressor.

Recoverable condensate volumes expected in current and future operating conditions are calculated as shown in the table below.

Table 6.1-8 Comparison Table for Recoverable Condensate Volume (Narsingdi Gas Field)

Situation		Wellhead Condition		Produced Gas Rate (MMSCFD)	Recovery Condensate Volume (bbl/day)
		Pressure (psig)	Temperature (deg.F)		
Current		1,781	106	30.2	61.3
Future	w/o Compressor	700	139	30.0	42.9
	w/ Compressor	700	139	30.0	53.8

Source: JICA Survey Team

Where,

Operating conditions of compressor unit are assumed as follows,

Suction pressure / temperature: 700psig / 139 Degrees Fahrenheit (deg. F)

Discharge pressure / temperature: 1,200psig / 120 deg.F

In this simulation, the set value of secondary pressure of the existing PCV equipped upstream of the existing Separator in its future condition is assumed to be same as that of the current conditions of 750psig and 92deg.F.

As a result of the simulation, recoverable condensate volume after installation of the proposed compressor will be less than that in current operation. However, the volume will be more than that of “without compressor case”. Refer to Table 6.1-8.

3) Outline of Proposed Facility

a) Process Description

Natural gas of 30MMscfd from the existing Wells No.1 and No.2 in Narsingdi gas field is produced at the pressure of 700psig and the temperature of 139deg.F, and collected at the existing Common Header.

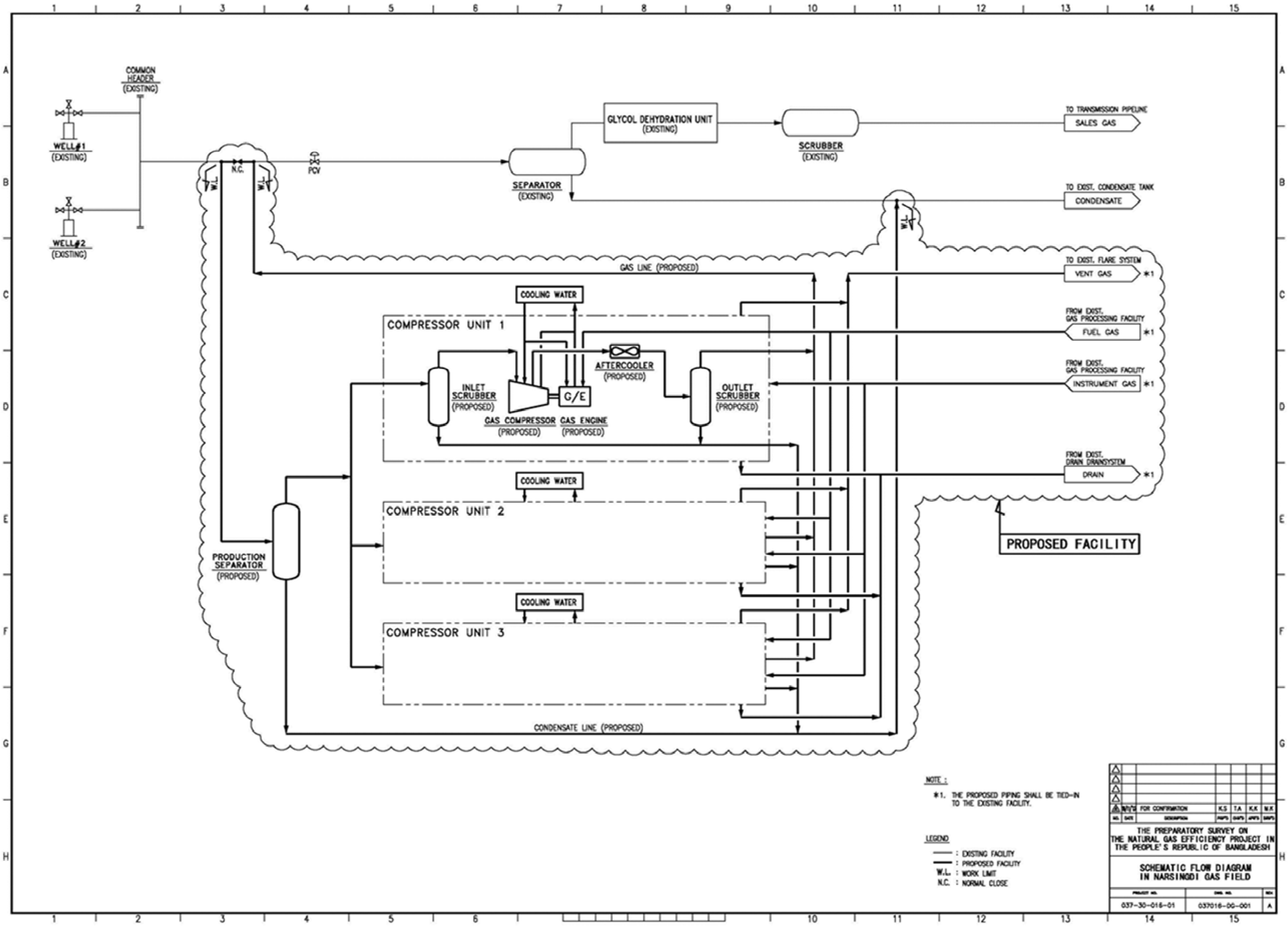
The collected natural gas is sent to the proposed Production Separator to separate the liquid and gas. The separated gas flows into the proposed Compressor units. Three (3) units will be installed; two (2) units in operation and one (1) unit on standby. The capacity of the compressor is planned at 15MMscfd per unit.

In each Compressor Unit, the gas from the proposed Production Separator is fed to the Inlet Scrubber to remove the solid impurities and condensed liquid, and sent to the proposed Gas Compressor, which is the reciprocating type and driven by the proposed Gas Engine. The gas is compressed by the compressor up to a pressure of 1,210psig. Since the gas reaches high temperature through the compression process, the gas is cooled to 120deg.F by the proposed Aftercooler, by which pressure loss is estimated at 10psig in this study. The cooled gas, including some condensate, is sent to the proposed Outlet Scrubber to remove the condensate. After removing condensate, the gas from each Compressor Unit is gathered and sent to the upstream of the existing PCV. The gathered gas passes through to the existing gas processing facility.

On the other hand, the condensates separated from the proposed Production Separator and each Compressor Unit are collected and sent to the existing Condensate Tank. In addition to the above, the cooling water units are installed at each proposed Gas Compressor Unit in order to cool the lubricant, compressor’s jackets and gas engines.

The gas engine fuel to run the compressor and the instrument gas are supplied from the existing gas processing facility.

Refer to Schematic Flow Diagram (Dwg. No.: 037016-DG-001).


COMMON HEADER (EXISTING)
WELL#1 (EXISTING)
WELL#2 (EXISTING)
W.L.
N.C.
PCV
SEPARATOR (EXISTING)
GLYCOL DEHYDRATION UNIT (EXISTING)
SCRUBBER (EXISTING)
TO TRANSMISSION PIPELINE
SALES GAS
TO EXIST. CONDENSATE TANK
CONDENSATE
GAS LINE (PROPOSED)
TO EXIST. FLARE SYSTEM
VENT GAS *1
COOLING WATER
COMPRESSOR UNIT 1
FROM EXIST. GAS PROCESSING FACILITY
FUEL GAS *1
AFTERCOOLER (PROPOSED)
INLET SCRUBBER (PROPOSED)
G/E
OUTLET SCRUBBER (PROPOSED)
FROM EXIST. GAS PROCESSING FACILITY
INSTRUMENT GAS *1
GAS COMPRESSOR (PROPOSED)
GAS ENGINE (PROPOSED)
FROM EXIST. DRAIN DRAINSYSTEM
DRAIN *1
COMPRESSOR UNIT 2
PROPOSED FACILITY
PRODUCTION SEPARATOR (PROPOSED)
COMPRESSOR UNIT 3
CONDENSATE LINE (PROPOSED)
NOTE :
*1. THE PROPOSED PIPING SHALL BE TIED-IN TO THE EXISTING FACILITY.
LEGEND
: EXISTING FACILITY
: PROPOSED FACILITY
W.L. : WORK LIMIT
N.C. : NORMAL CLOSE
FOR CONFIRMATION
K.S
T.A
K.K
M.K
THE PREPARATORY SURVEY ON THE NATURAL GAS EFFICIENCY PROJECT IN THE PEOPLE'S REPUBLIC OF BANGLADESH
SCHEMATIC FLOW DIAGRAM IN NARSINGDI GAS FIELD
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b) Production Separator Specification

The following specifications are applied to the proposed production separator into which produced gas flows directly:

- Capacity

  Based on a gas production rate of 30 MMSCFD in Narsingdi Gas Field, the capacity of the production separator shall be 30 MMSCFD. Refer to Section 6.1.3 (1), 2), a) "Gas production rate".

- Operating pressure and temperature

  Operating pressure and temperature at the proposed separator are almost equal to inlet operating conditions at the proposed compressors. Based on the gas production pressure and gas production temperature described in Section 6.1.3 (1), 2), b) and c), the operating pressure and temperature at the proposed production separator shall be 700 psig and 139 deg.F, respectively.

c) Compressor Specifications

Based on discussion with BGFCL, the following specifications are applied to proposed compressors:

- Flow rate

  Based on Section 6.1.3 (1), 2), a) "Gas production rate", flow rate of 15 MMSCFD per unit is applied to proposed compressors.

- Suction pressure

  Based on Section 6.1.3 (1), 2), b) "Gas production pressure", since production wells are connected to compressor suction line via separator, suction pressure of 700 psig is applied to proposed compressors.

- Discharge pressure

  Based on operating pressure at transmission pipeline and pressure drop expected at existing gas processing facility described in Section 6.1.3 (1), 2), e), discharge pressure of 1200 psig is applied to proposed compressors as shown in the table below.

Gas Field	Pressure drop at existing gas processing facility (a) [psi]	Operating pressure at transmission pipeline (b) [psig]	Compressor discharge pressure (a+b) [psig]
Narsingdi	200	1000	1200

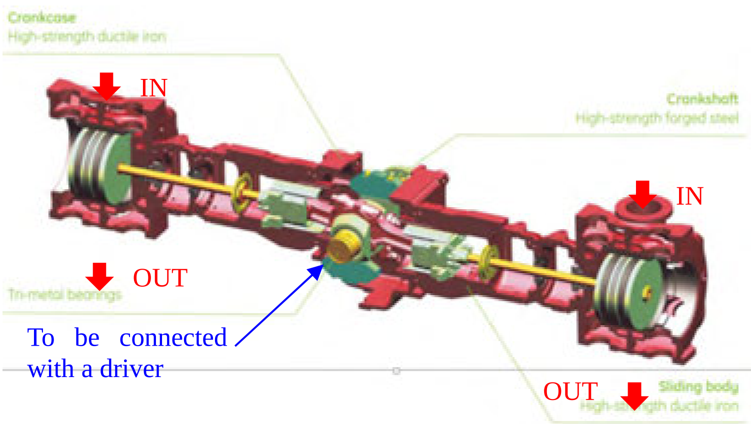
- Inlet and outlet temperature

  According to the gas production and compressed temperature described in Section 6.1.3 (1), 2), c) and d), inlet and outlet temperatures of 139 and 120 deg.F are applied to proposed compressors, respectively.

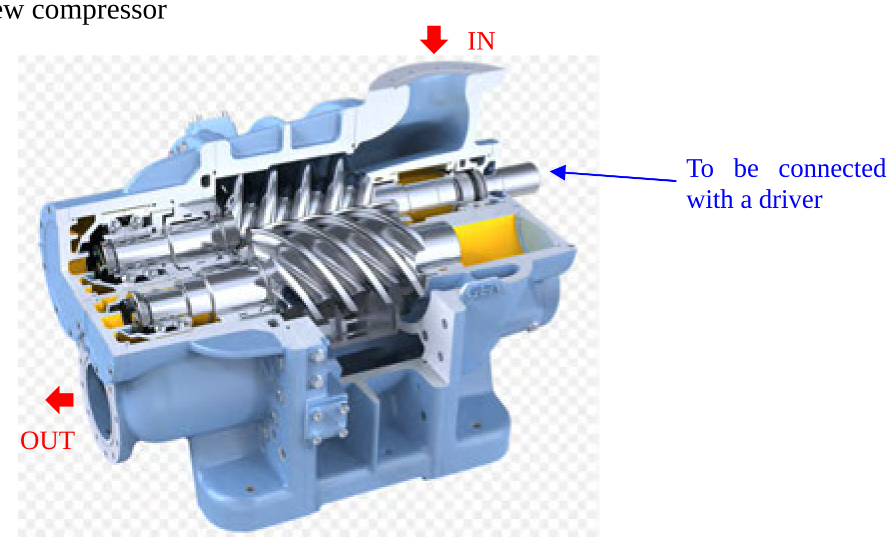
- Type of compressor

  Based on the compressor specifications described above, a market survey of Japanese compressor manufacturers who have certainly many delivery experiences of process gas compressors in the oil and gas industry was conducted for selection of a compressor suitable for the Narsingdi Project. As the result of the survey, it was confirmed that reciprocating and screw type compressors complying to API (American Petroleum Institute) Standard are to be suitable in terms of conformance to specifications and cost competitiveness, etc. It seems that centrifugal compressors are also appropriate, however, priority of the type is relatively lower than the former two (2) types. The following pictures show the mechanism and characteristics of the three (3) types of compressors.

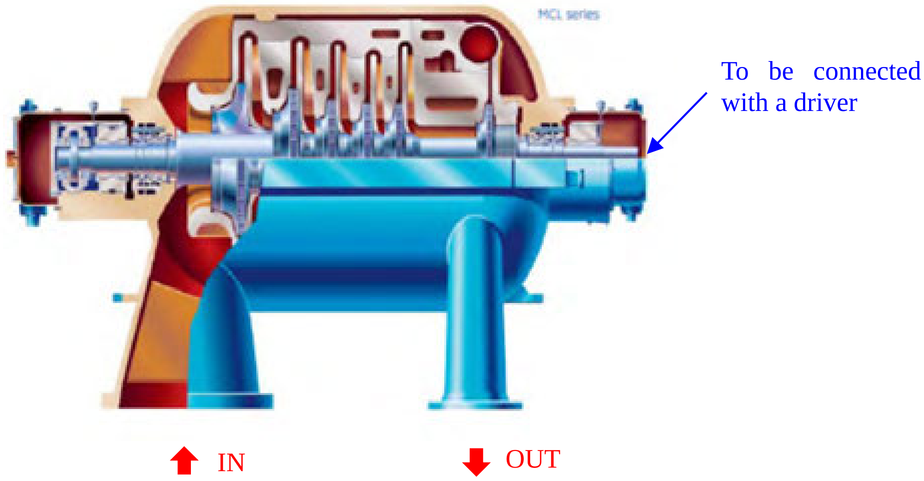
➢ Reciprocating compressor



➢ Screw compressor



➢ Centrifugal compressor



- Type of compressor driver

  In general, gas engines, gas turbines, steam turbines and electric motors are utilized for driving a compressor.

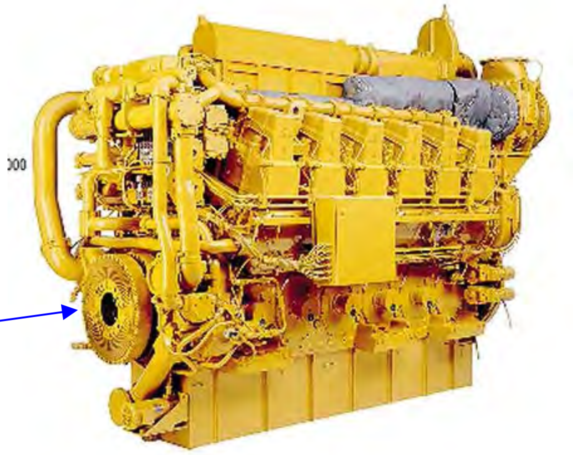
  As for a steam turbine, a large amount of steam is required for driving its turbine. However, such steam is not available at the site. In this case, a boiler facility should be additionally installed and it costs a lot.

  In the case of an electric motor, substantial electric power necessary for the driver is not available at the site. And also, it is difficult to stably receive such substantial electric power in the country due to the tight electricity situation. Accordingly, an electric motor is not suitable for the proposed compressor's driver.

On the other hand, gas engines and gas turbines are reasonable and rational for the application in terms of OPEX (Operating Expenditure) as natural gas produced in the gas field can be used for it. Taking operability and maintainability into consideration, a gas engine has an advantage over a gas turbine. Moreover, its CAPEX (Capital Expenditure) is also less expensive than a gas turbine, if both types of driver have the same horsepower.

Accordingly, a gas engine should be applied to the compressor's driver. The following pictures show a typical model of a gas engine.

To be connected with a compressor



According to the above, specifications of proposed compressors are set as follows:

No.	Description	Specification
1.	Number of compressors	3
2.	Flow rate	15 MMSCFD/unit
3.	Suction pressure	700 psig
4.	Discharge pressure	1200 psig
5.	Inlet temperature	139 deg.F
6.	Outlet temperature	120 deg.F
7.	Type of driver	Gas engine driven

d) Auxiliary Equipment for Proposed Compressor

Auxiliary equipment such as inlet/outlet scrubbers, aftercooler, etc., will be required for the operation of the proposed compressor. In the case of a multistage compressor, an interstage cooler and scrubber are additionally required between the discharge of one cylinder and intake of the next cylinder. The above said auxiliary equipment in single stage compressor case is shown in the Schematic Flow Diagram (DWG. No.: 037016-DG-001).

Moreover, in order to operate and maintain several functions of the proposed compressor facilities, a lube oil system, cooling water system, vent system and drain system are required, and those systems will be installed in the vicinity of the compressor unit. Facility configuration of those systems is described as follows:

- Lube oil system

  An oil lubrication system is required to maintain moving parts in the compressor such as bearings, cranks, cylinders, etc. In general, this system mainly consists of pump, strainer, piping and field instruments, etc.
- Cooling water system

  A cooling water system is required for cooling lube oil and jacket water that is supplied to the compressor. However, as fresh water is not available at the site, a closed cycle cooling water system will be applied to the compressor. In general, this system mainly consists of pump, strainer, piping and field instruments, etc.
- Vent system

  A gas vent system is required for emergency blowdown and purging of flammable gas from the separator and the compressor unit. The vent gas should be collected and sent to existing gas vent line or flare line. In general, this system mainly consists of pressure safety valve, piping and necessary field instruments, etc.
- Drain system

  Oily drains are generated from the compressor unit during operation or at the time of maintenance. Since it is not preferable to dispose of it into the ground without any treatment from the viewpoint of environmental protection, the oily drain should be collected and sent to the existing wastewater treatment facility to remove the oil content. In general, this system mainly consists of pump, piping, oil/water separator and field instruments, etc.
- Condensate recovery system

  Condensate is recovered at the separator and the compressor unit. The condensate should be recovered and sent to the existing condensate tank. In general, this system mainly consists of piping and field instruments, etc.

e) Utility Facilities

Utility facilities such as the fuel gas system, electric power system and instrument system are required for the proposed compressors. Facility configuration of those systems is described as follows:

- Fuel gas system

  Fuel gas will be supplied for the gas engine, which drives a compressor. The fuel gas will be taken from a point in the existing gas processing facility and received at a new pressure vessel. In general, this system mainly consists of pressure vessel, piping and pressure control valve, etc.
- Electric power system

  An electric-driven pump will be applied to the lube oil pump and the water circulation pump mentioned above, taking the required horsepower into consideration. In addition to electric power for the pumps, electric power will also be required for several field instruments and devices. Based on the expected power consumption, the total power capacity of the existing power supply system should be verified in the next engineering stage.
- Instrument system

  An instrument air system, which is preferable for control of field instruments, is not available at the site. Accordingly, a part of sales gas will be utilized for the instrument system in the proposed compressor facility. In general, this system mainly consists of pressure vessel, pressure control valve, piping and field instruments, etc.

4) Construction of Proposed Facility

According to the “Outline of Proposed Facility” described in the above 3), principal construction works for the proposed facility and necessary modification works of existing facility are itemized below.

a) Installation Works of Proposed Facility

- Installation of three (3) compressor units, including auxiliary equipment such as inlet scrubber, outlet scrubber and aftercooler for each compressor unit
- Installation of shed for proposed compressors
- Installation of one (1) production separator
- Installation of fuel gas system for compressor driver (pressure vessel, control valve, etc.)
- Installation of the following piping works
  - Gas line for compressor and separator
  - Condensate recovery line for compressor and separator
  - Drain line for compressor
  - Fuel gas supply line for compressor
  - Gas vent line for compressor and separator
  - Instrument gas line for compressor

- Installation of electrical/instrument cables for the above proposed facilities

b) Modification Works of Existing Facility

- Tie-in works of piping mentioned in the above section a)
- Tie-in works of electrical/instrument cables mentioned in the above section a)

In addition to the above items, relocation works of existing facility, such as buried objects, etc., may be required, according to further considerations to be conducted in the next phase.

5) Recommendations and Issues to be Clarified

a) Recommendations

- Compressor specifications

  Based on the future gas production profile of all production wells, compressor specifications mentioned in the above section 3)-c) shall be reviewed in the next basic engineering stage. Moreover, it is recommended that the specifications should also be reviewed and finalized upon commencement of the construction stage.

- Production separator specifications

  A production separator shall be newly installed upstream of the proposed compressors to eliminate foreign substances and mist in the produced gas. Based on the future gas production profile of all production wells, the specifications mentioned in the above section 3)-b) shall be reviewed in the next basic engineering stage.

- Disposal of wastes

  Several wastes such as oily drain, vent gas, cooling water drain and lube oil discharged from the proposed separator and compressor unit should be collected and treated in an appropriate treatment facility, from the viewpoint of both safety and environmental protection. All the wastes shall not be disposed into the environment without treatment. In case such treatment facilities have not been installed in the existing facility, it is recommended that a proper treatment facility is newly installed for future operation.

  In addition to the above, the capacity of all the existing facilities to be tied-in from the waste lines shall certainly be checked in the next engineering phase.

b) Issues to be clarified

- Review of specifications for proposed facility

  As described in the above section 5)-a), all the specifications for the proposed compressors and separator, such as flow rate, inlet/outlet pressure and temperature, gas composition, etc., shall be reviewed in the next basic engineering stage, based on the operating condition expected in the future. The production forecast of each well shall be fully evaluated to establish the proper specifications.

- Review of pressure drop at existing gas processing facility

  It seems that the assumed pressure drop of 200 psi at the existing gas processing facility in Narsingdi Gas Field is a little bit small. It shall be reviewed in the next engineering phase in order to decide the compressor discharge pressure required for sending the gas into the transmission pipeline.

- Verification of condensate recovery volume

  As mentioned in the above section 2), it was confirmed that recoverable condensate volume will tend to increase with the installation of the proposed compressors, compared with no compressor operation. Since the recovery volume varies significantly depending on gas composition of the produced gas to be sampled, it shall be carefully verified in the next engineering phase using gas to be sampled upstream of the existing separator.

- Check of electric power capacity

  In the next engineering phase, electric power capacity of the existing facility shall be checked in consideration of additional power consumptions that will be used in lube oil pump, water circulation pump and other field instruments.

(3) Titas Gas Field (Location C) Project

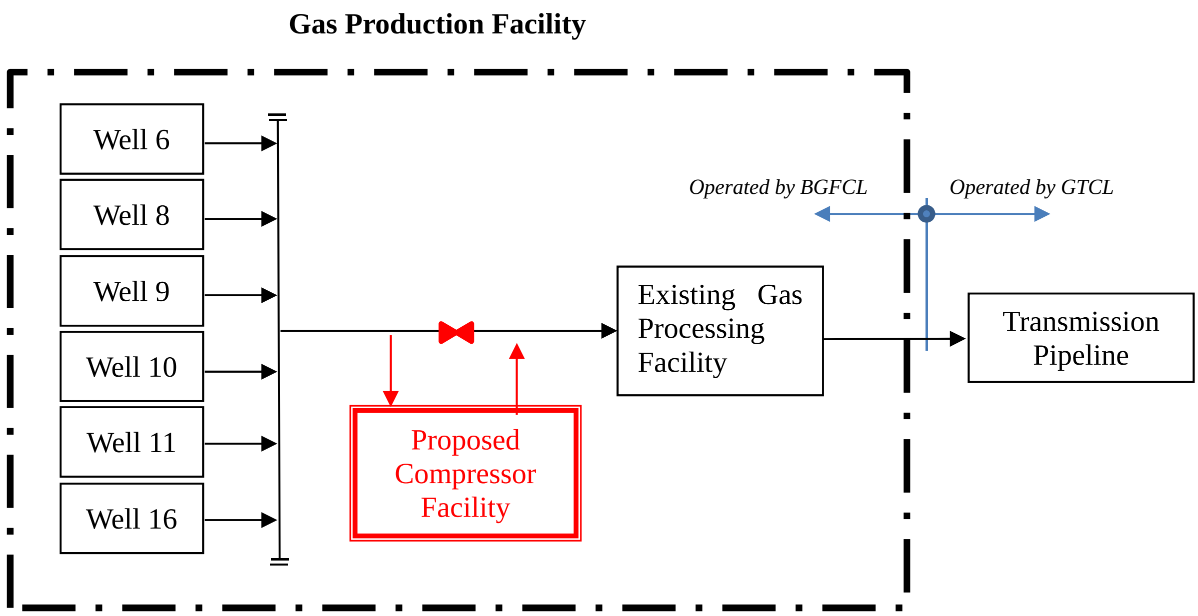
BGFCL is planning to install wellhead gas compressors in Titas Gas Field (Location C) due to a decline of flowing wellhead pressures (“FWHP”) at each gas production well. In this gas field, FWHP, which currently ranges about 1075~1610 psig, is declining at a rate of approximately 72 to 98 psi per year in recent years. In order to continue to send produced gas into the gas transmission pipeline, proposed compressors must be installed so as to overcome the transmission line pressure problem. Refer to Table 4.1-3.

1) Study for Installation Location of Proposed Compressors

- Installation location

Similar to Narsingdi Gas Field Project, BGFCL is asking for installation of gas compressors upstream of the existing gas processing facility for the purpose of increasing recoverable condensate volume.

The installation location of the proposed compressor is shown in Figure 6.1-6.



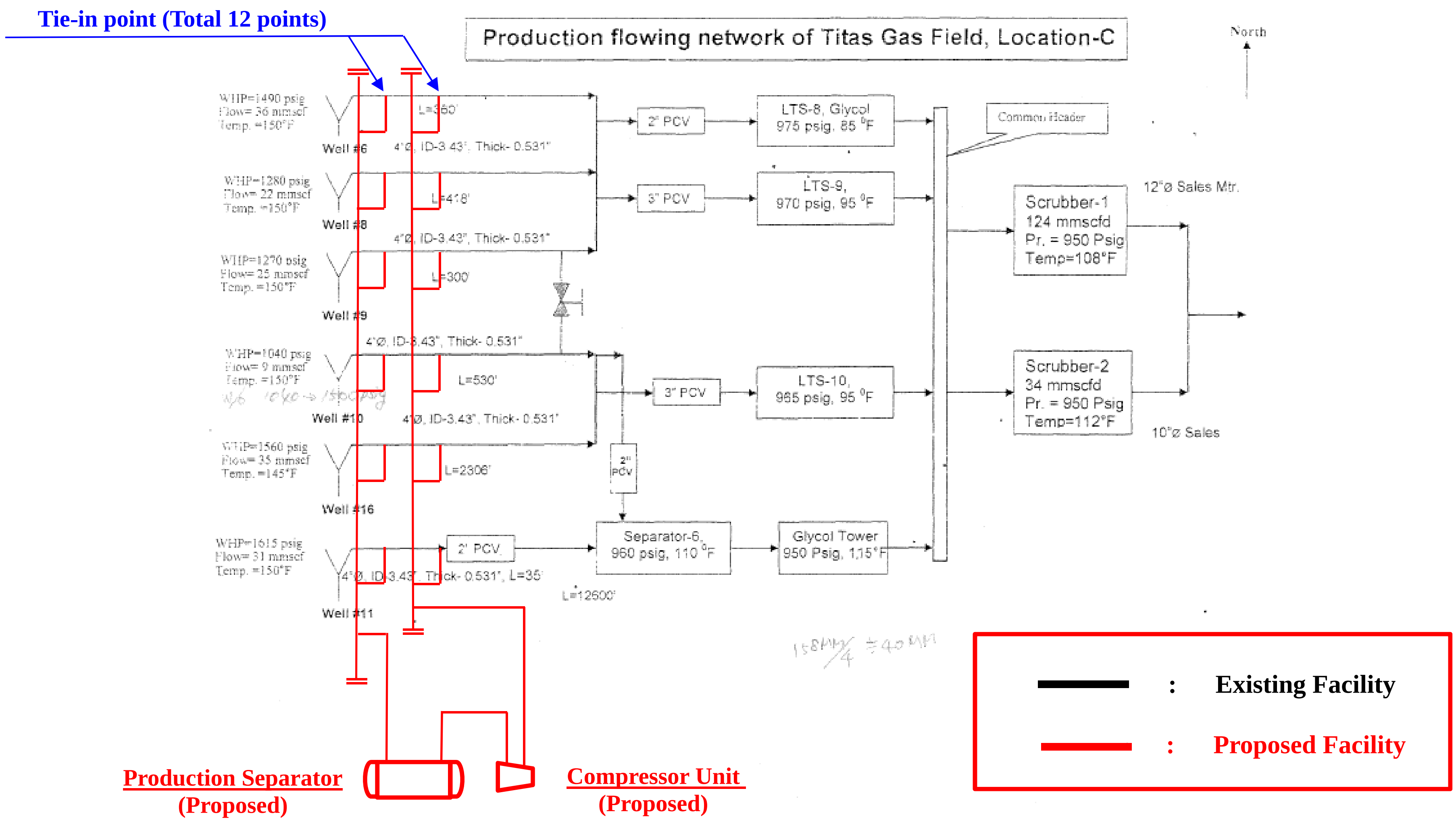
Source: JICA Survey Team

Figure 6.1-6 Block Flow Diagram (Titas Gas Field Location C)

As shown in Figure 6.1-6, the proposed compressor facility marked in red is newly installed between gas production wells and the existing gas processing facility.

Due to several foreign substances such as sand, mud, condensate, and so on, this study subsequently proceeds on the condition that a production separator which eliminates such foreign substances in the gas is additionally installed upstream of the proposed compressor.

According to the above, the installation location of the proposed compressors with the production separator is shown in Figure 6.1-7.

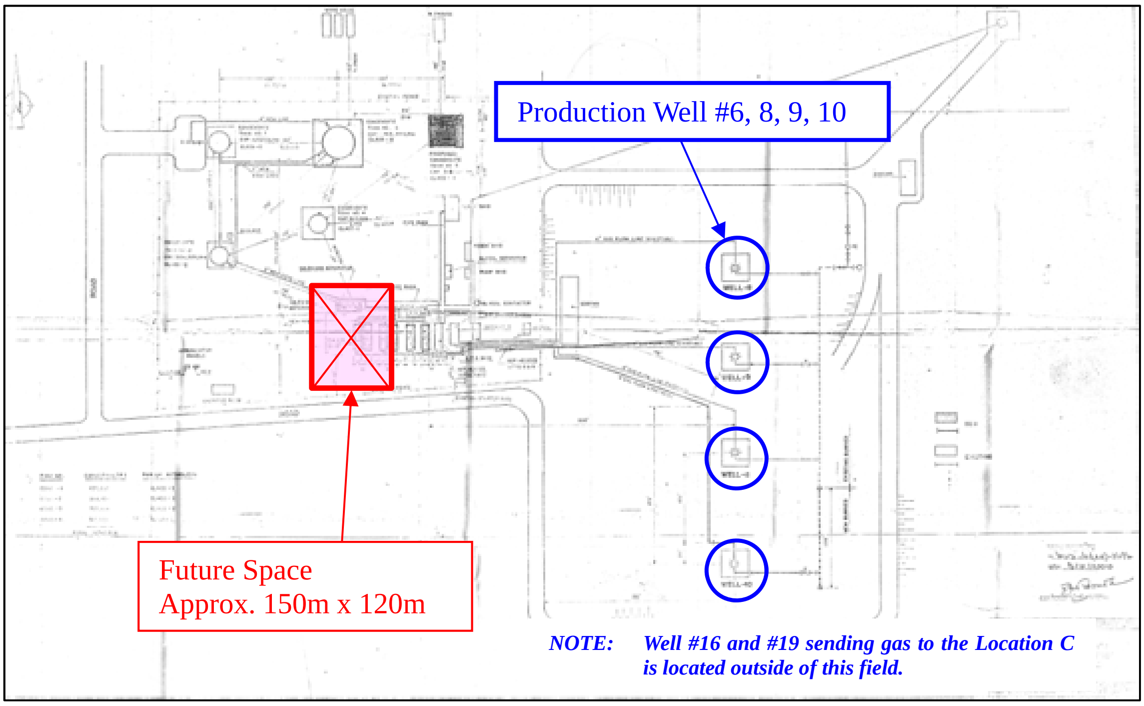


Sourve: JICA Survey Team

Figure 6.1-7 Installation Location of Proposed Compressor (Titas Gas Field, Location C)

■ Future space for proposed compressors

Through a site survey, the space available for proposed compressors with the auxiliary equipment was discussed with BGFCL and tentatively decided as shown in Figure 6.1-8. The space will be reviewed properly in consideration of operability, accessibility, maintainability, etc., in the next engineering stage.



Source:JICA Survey Team based on BGFCL information

Figure 6.1-8 Future Space for Proposed Compressor Facilities (Titas Gas Field, Location C)

2) Study for Recoverable Condensate Volume

a) Confirmation of Condensate Generation

Based on the wellhead gas and condensate compositions described in Section 6.1.3 (1), 1), a) and b), the composition of wellhead fluid is calculated as follows:

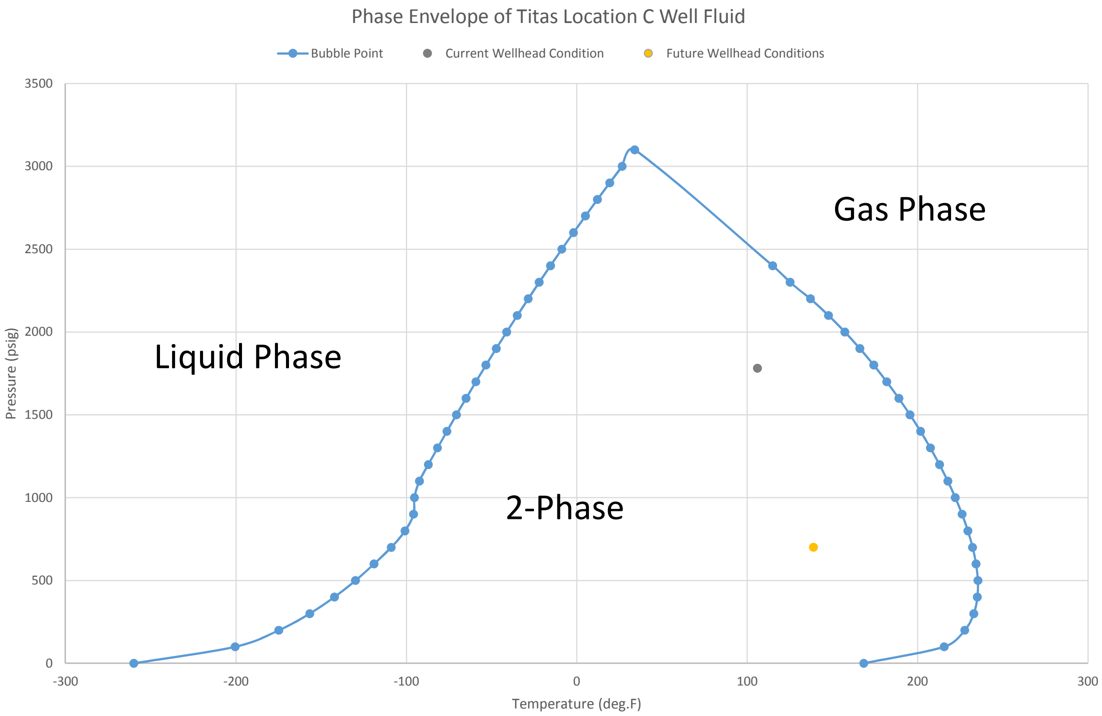
Table 6.1-9 Wellhead Fluid Composition (Titas Gas Field, Location C)

Composition	mol%
Nitrogen	0.37
CO2	0.31
Methane	96.76
Ethane	1.80
Propane	0.36
i-Butane	0.09
n-Butane	0.05
i-Pentane	0.02
n-Pentane	0.02
n-Hexane	0.04
n-Heptane	0.02
n-Octane	0.01
n-Nonane	0.00
n-Decane plus	0.04
H2O	0.11
Total	100.00

Source: JICA Survey Team

Based on the calculated wellhead composition, it will be confirmed by development of a phase envelope whether condensate can be recovered. The phase envelope is prepared by using an Aspen HYSYS (version 8.2) process simulator, which is widely utilized in the oil the gas industry.

As a result of drawing the phase envelope, both current and future wellhead operating points are and will be located within the envelope curve. Therefore, it is expected that some amount of condensate will be recovered from the produced well fluid in both current and future operating condition Refer to Figure 6.1-9 “Envelope of Titas Location C Well Fluid.”



Source: JICA Survey Team

Figure 6.1-9 Envelope of Titas Location C Well Fluid

b) Recoverable Condensate Volume

BGFCL intends to increase condensate recovery volume by installation of a new compressor at the upstream location of the existing gas processing facility. In this section, the recoverable condensate volume expected in future operation is roughly evaluated versus current operating conditions. As for future operation, both cases—"with compressor" and "without compressor"—are evaluated in order to confirm the effect of the compressor.

Recoverable condensate volumes expected in current and future operating conditions are calculated as shown in the table below.

Table 6.1-10 Comparison Table for Recoverable Condensate Volume (Titas Gas Field, Location C)

Situation		Wellhead Condition		Produced Gas Rate (MMSCFD)	Recovery Condensate Volume (bbl/day)
		Pressure (psig)	Temperature (deg.F)		
Current		1,376	150	157.7	116.7
Future	w/o Compressor	700	149	180.0	93.6
	w/ Compressor	700	149	180.0	115.2

Source: JICA Survey Team

Where,

Operating conditions of compressor unit are assumed as follows,

Suction pressure / temperature: 700psig / 149 deg.F

Discharge pressure / temperature: 1,200psig / 120 deg.F

In this simulation, the set value of secondary pressure of the existing PCV equipped at the upstream of the existing Separator in its future condition is assumed to be same as that of current conditions of approx. 970psig and 95deg.F.

As a result of the simulation, recoverable condensate volume after installation of the proposed compressor will be less than that in current operation. However, the volume will be more than that of "without compressor case." Refer to Table 6.1-10.

3) Outline of Proposed Facility

a) Process Description

Natural gas of 180MMscfd from the existing Wells No. 6, 8, 9, 10, 11 and 16 of Location C in Titas gas field is produced at the pressure of 700psig, and the temperature of 149deg.F.

The gas produced from each well is taken out upstream of the block valve newly installed upstream of the existing common headers and sent to the proposed Production Separator to separate the liquid and gas. The separated gas flows into the proposed Compressor units. Three (3) units will be installed; two (2) units in operation and one (1) unit on standby. The capacity of the compressor is planned at 90MMscfd per unit.

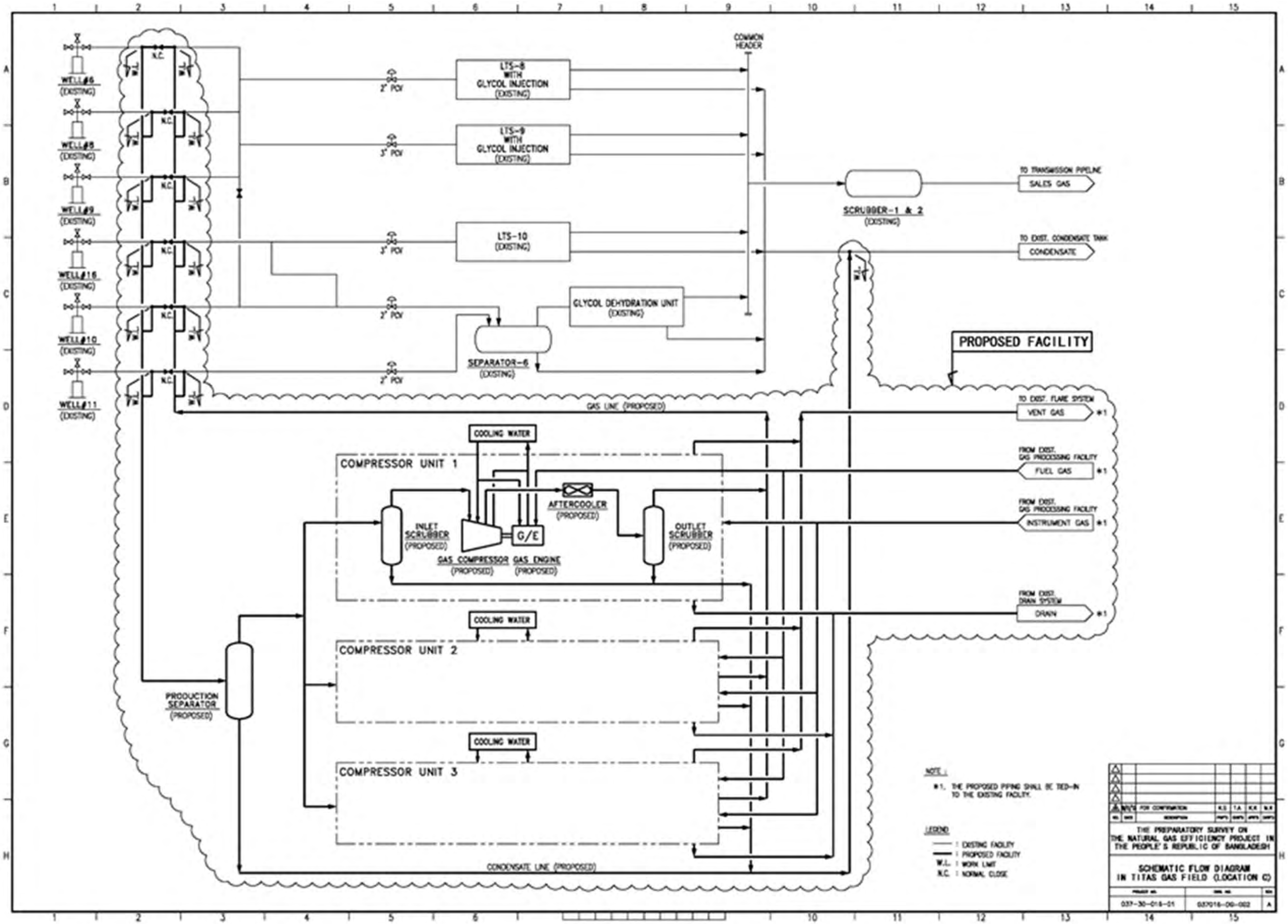
In each Compressor Unit, the gas from the proposed Production Separator is fed to the Inlet Scrubber to remove the solid impurities and condensed liquid, and sent to the proposed Gas

Compressor, which is the reciprocating type and driven by the proposed Gas Engine. The gas is compressed to a pressure of 1210psig by the compressor. Since the gas becomes high temperature by the compression process, the gas is cooled until 120deg.F by the proposed Aftercooler, whose pressure loss is estimated at 10psig in this study. The cooled gas, including some condensate, is sent to the proposed Outlet Scrubber to remove the condensate. After removing condensate, the gas from each Compressor Unit is gathered and sent downstream of the respective newly installed block valves mentioned above and processed by the existing gas processing facility, having four (4) train dehydration units. Almost the same volume of compressed gas flows into each dehydration unit equally and is treated for sending the gas into the transmission pipeline.

On the other hand, the condensates separated from the proposed Production Separator and each Compressor Unit are collected and sent to the existing Condensate Tank. In addition to the above, the cooling water units are installed at each proposed Gas Compressor Unit in order to cool the lubricant and compressor jackets and gas engines.

The gas engine fuel to run the compressor and the instrument gas are supplied from the existing gas processing facility.

Refer to the Schematic Flow Diagram (Dwg. No.: 037016-DG-002).


WELL#6 (EXISTING)
WELL#8 (EXISTING)
WELL#9 (EXISTING)
WELL#16 (EXISTING)
WELL#10 (EXISTING)
WELL#11 (EXISTING)
N.C.
W.L.
2" PCV
3" PCV
LTS-8 WITH GLYCOL INJECTION (EXISTING)
LTS-9 WITH GLYCOL INJECTION (EXISTING)
LTS-10 (EXISTING)
GLYCOL DEHYDRATION UNIT (EXISTING)
SEPARATOR-6 (EXISTING)
COMMON HEADER
SCRUBBER-1 & 2 (EXISTING)
TO TRANSMISSION PIPELINE
SALES GAS
TO EXIST. CONDENSATE TANK
CONDENSATE
PROPOSED FACILITY
GAS LINE (PROPOSED)
TO EXIST. FLARE SYSTEM
VENT GAS
*1
FROM EXIST. GAS PROCESSING FACILITY
FUEL GAS
INSTRUMENT GAS
FROM EXIST. DRAIN SYSTEM
DRAIN
COOLING WATER
COMPRESSOR UNIT 1
COMPRESSOR UNIT 2
COMPRESSOR UNIT 3
INLET SCRUBBER (PROPOSED)
GAS COMPRESSOR (PROPOSED)
G/E
GAS ENGINE (PROPOSED)
AFTERCOOLER (PROPOSED)
OUTLET SCRUBBER (PROPOSED)
PRODUCTION SEPARATOR (PROPOSED)
CONDENSATE LINE (PROPOSED)
NOTE :
*1. THE PROPOSED PIPING SHALL BE TIED-IN TO THE EXISTING FACILITY.
LEGEND
: EXISTING FACILITY
: PROPOSED FACILITY
W.L. : WORK LIMIT
N.C. : NORMAL CLOSE
FOR CONFIRMATION
THE PREPARATORY SURVEY ON THE NATURAL GAS EFFICIENCY PROJECT IN THE PEOPLE'S REPUBLIC OF BANGLADESH
SCHEMATIC FLOW DIAGRAM IN TITAS GAS FIELD (LOCATION C)
037-30-016-01
037016-00-002
A

b) Production Separator Specifications

The following specifications are applied to the proposed production separator into which produced gas directly flows:

- Capacity

  Based on a gas production rate of 180 MMSCFD in Titas Gas Field (Location C), capacity of the production separator is decided at 180 MMSCFD. Refer to Section 6.1.3 (1), 2), a) “Gas production rate”.

- Operating pressure and temperature

  Operating pressure and temperature at the proposed separator are almost equal to inlet operating conditions at the proposed compressors. Based on the gas production pressure and temperature described in Section 6.1.3 (1), 2), b) and c), the operating pressure and temperature at the proposed production separator shall be 700 psig and 149 deg.F, respectively.

c) Compressor specifications

Based on discussion with BGFCL, the following specifications are applied to proposed compressors:

- Flow rate

  Based on Section 6.1.3 (1), 2), a) “Gas production rate”, flow rate of 90 MMSCFD per unit is applied to proposed compressors.

- Suction pressure

  Based on Section 6.1.3 (1), 2), b) “Gas production pressure”, since production wells are connected to the compressor suction line via separator, suction pressure of 700 psig is applied to proposed compressors.

- Discharge pressure

  Based on operating pressure at transmission pipeline and pressure drop expected at existing gas processing facility described in Section 6.1.3 (1), 2), e), discharge pressure of 1200 psig is applied to proposed compressors as shown in the table below.

Gas Field	Pressure drop at existing gas processing facility (a) [psi]	Operating pressure at transmission pipeline (b) [psig]	Compressor discharge pressure (a+b) [psig]
Titas Location C	200	1000	1200

- Inlet and outlet temperature

  According to gas production and compressed temperature described in Section 6.1.3 (1), 2), c) and d), inlet and outlet temperatures of 149 and 120 deg.F are applied to proposed compressors, respectively.

- Type of compressor

  Similar to the Narsingdi Project, reciprocating type compressors are also suitable for the Titas Gas Field (Location C) Project, in terms of conformance to the specifications and cost competitiveness, etc.

- Type of compressor driver

  A gas engine should be applied to the compressor's driver for the same reason as the Narsingdi Project.

  According to the above, specifications of proposed compressors are set as follows:

No.	Description	Specification
1.	Number of compressor	3
2.	Flow rate	90 MMSCFD/unit
3.	Suction pressure	700 psig
4.	Discharge pressure	1200 psig
5.	Inlet temperature	149 deg.F
6.	Outlet temperature	120 deg.F
7.	Type of driver	Gas engine driven

d) Auxiliary Equipment for Proposed Compressor

Similar to the Narsingdi Project, auxiliary equipment such as inlet/outlet scrubbers, aftercooler, etc., will be required for the reason of process requirement. The auxiliary equipment in single stage compressor case is shown in Schematic Flow Diagram (DWG. No.: 037016-DG-002).

In addition to the above, a lube oil system, cooling water system, vent system, drain system and condensate recovery system for proposed compressor facilities will be installed in the vicinity of the compressor in common with the Narsingdi Project.

e) Utility Facilities

The following three (3) utility facilities are required for proposed compressors. Facility configuration of those systems is provided as below, in common with Narsingdi Project.

- Fuel gas system for gas engine

- Electric power system
- Instrument system

4) Construction of Proposed Facility

According to “Outline of Proposed Facility” described in the above section 3), principal construction works for the proposed facility and necessary modification works of the existing facility are itemized below.

a) Installation Works of Proposed Facility

- Installation of three (3) compressor units, including auxiliary equipment such as inlet scrubber, outlet scrubber and aftercooler for each compressor unit
- Installation of shed for proposed compressors
- Installation of one (1) production separator
- Installation of fuel gas system for compressor driver (pressure vessel, control valve, etc.)
- Installation of the following piping works
  - Gas line for compressor and separator
  - Condensate recovery line for compressor and separator
  - Drain line for compressor
  - Gas vent line for compressor and separator
  - Fuel gas supply line for compressor
  - Instrument gas line for compressor
- Installation of electrical/instrument cables for the above proposed facilities

b) Modification Works of Existing Facility

- Tie-in works of piping mentioned in the above section a)
- Tie-in works of electrical/instrument cables mentioned in the above section a)

In addition to the above items, relocation works of existing facility such as buried objects, etc., may be required according to further considerations to be conducted in the next phase.

5) Recommendations and Issues to be Clarified

a) Recommendations

- Compressor specifications

  Based on the future gas production profile of all production wells, compressor specifications mentioned in the above section 3)-c) shall be reviewed in the next basic engineering stage. Moreover, it is recommended that the specifications should also be reviewed and finalized upon commencement of the construction stage.

- Production separator specifications

  A production separator shall be newly installed upstream of the proposed compressors to eliminate foreign substances and mist in the produced gas. Based on the future gas production profile of all production wells, the specifications mentioned in the above 3)-b) shall be reviewed in the next basic engineering stage.

- Disposal of wastes

  Several wastes such as oily drain, vent gas, cooling water drain and lube oil discharged from the proposed separator and compressor unit should be collected and treated in an appropriate treatment facility, from the viewpoint of both safety and environmental protection. All the wastes shall not be disposed into the environment without treatment. In case such treatment facilities have not been installed in the existing facility, it is recommended that a proper treatment facility is newly installed for future operation.

  In addition to the above, the capacity of all the existing facilities to be tied-in from the waste lines shall certainly be checked in the next engineering phase.

b) Issues to be Clarified

- Review of specifications for proposed facility

  As described in the above section 5)-a), all the specifications for the proposed compressors and separator, such as flow rate, inlet/outlet pressure and temperature, gas composition, etc., shall be reviewed in the next basic engineering stage, based on the operating condition expected in future. The production forecast of each well shall be fully evaluated to establish the proper specifications.

- Review of pressure drop at existing gas processing facility

  It seems that the assumed pressure drop of 200 psi at the existing gas processing facility in Narsingdi Gas Field is a little bit small. It shall be reviewed in the next engineering phase in order to decide the compressor discharge pressure required for sales gas transmission.

- Verification of condensate recovery volume

  As mentioned in the above section 2), it was confirmed that recoverable condensate volume will tend to increase with the installation of the proposed compressors, compared with no compressor operation. Since the recovery volume varies significantly depending on gas composition of the produced gas to be sampled, it shall be carefully verified in the next engineering phase using gas to be sampled upstream of the existing separator.

- Check of electric power capacity
  In the next engineering phase, electric power capacity of the existing facility shall be checked in consideration of additional power consumptions, that will be used in lube oil pump, water circulation pump and other field instruments.

6.1.4 Construction Plan

(1) Access to Site

Both Narsingdi and Titas Gas Field (Location C) face national roads having a width of approximately 6 meters or more, and all the roads have already been paved with asphalt. Also, it seems that the access roads are adequate for mobilization of heavy equipment such as self-propelled cranes, conveyance of other construction equipment and so on. Therefore, it is possible to transport equipment, materials and construction equipment without any difficulty. However, the necessary care to maintain the condition of the access roads should be arranged by the Contractor during implementation of the Project.

(2) Recommended Construction Season

In both Narsingdi and Titas Gas Field (Location C), field construction works can be carried out through all seasons. However, all civil works in the rainy season are inefficient because of accumulation of rain water.

In addition to the above, it is preferable that welding and painting works should be carried out in the dry season taking work efficiency into consideration. Appropriate measures necessary for rainfall should be taken during the rainy season.

(3) Application for Permission

As to the application for permission to construct compressor facilities and the auxiliary equipment including modification works of existing facilities, no application is especially required because all the facilities can be installed in existing plant areas. This issue is common with both gas fields.

(4) Safety Plan

Some of the most common types of Gas compressor installation accidents are crane accidents, electrical accidents, trench collapse, fire and explosions, and welding accidents.

To prevent such accidents, a safety plan should be prepared by the contractor for BGFCL's approval prior to the installation works. This plan should include the contractor's safety scheme, safety measures, communication network in case of accident, etc.

Then, during the construction stage, periodic and also random safety patrols will be carried out by BGFCL and/or the contractor in order to ensure that all works are carried out in safe manner according to the said safety plan with a PDCA (Plan-Do-Check-Act) method.

1) Responsibilities of the implementation agency for safe construction are as follows.

a) Dissemination of Information

- Details of the Project
- Condition of the project site, etc.

b) Confirmation and approval (Evaluates and approves)

- Construction plan by contractor
- Construction schedule by contractor

2) A list of possible disasters and counter measures that are predicted during the construction period.

a) Use safety equipment at all times and wear appropriate protection, such as:

- Safety helmet properly fastened
- Safety Shoes
- Gloves
- Ear protectors
- Dust glasses
- Safety belt and rope

Keep safety equipment properly maintained and in good condition after use.

b) Pay attention to the following:

- Do not run or jump
- Watch your step
- Watch against bumping your head.
- Turn your head when walking backwards.
- Avoid lifting too heavy materials.

3) Construction Accident and Control Measures

Gas compressor installation

Construction Accident	Control Measures
Crane Accidents	・Keep within the cargo weight limit. ・Select the suitable type of crane based on the Crane Specification ・Keep workers out of the crane working area. ・Set outrigger to avoid upsetting the crane. ・Arrange decking to keep the crane from sinking. ・Set the crane level on the ground. ・Attach a assist rope for long material. ・Don't get below the cargo ・Appoint a signalman and signal instructions for the operator.
Electrical Accidents	・Have all electric equipment checked regularly by a qualified electrician. ・All equipment must be in good condition and shall be grounded properly. ・Carry out cable insulating properly. ・Avoid submerging electric cable under water except use insulated cable when necessary. ・Do not use any electric equipment in poor condition or in wet condition. ・Electric hand tools shall be protected by earth leakage or similar safety cut out switches which activate immediately in case of sudden increase in current.
Welding Accidents	・Before work starts, check equipment as follows: ·Acetylene welder – ensure absence of leakage along the hose to be used. ·Electric welder – ensure all insulating systems are in good condition ・Always wear appropriate safety equipment: ·For welding: wear helmet, eye protector, gloves, safety shoes, etc. ・Use grounding for the welding machine ・Provide adequate air circulation such as blower during welding . ・Never perform welding near inflammable objects.
Falls	・Edges of excavations should be protected with substantial barriers where people are liable to fall into them. ・Barricade hazardous areas
Trench Collapses	・The need for adequate support will depend on the type of excavation, the nature of the ground and the ground water conditions. ・Keep machinery, material and soil piles at sufficient distance to avoid collapse of the sides of the excavation ・After rain, check ground condition and report immediately any presence

Construction Accident	Control Measures
	of cracks. ・Keep water out of trench
Fires	・Open fires are prohibited ・Know where firefighting equipment is located and be trained on how to use it. ・Never perform welding near inflammable objects. ・All site personnel are enforced to confirm that there are no live fires left behind before leaving their work place.

Safety activities of BGFCL, the executing agency of the gas compressor project are controlled by the Environmental and Safety Section.

(5) Lessons from previous projects

Currently, wellhead compressors are only operated in Bakhrabad gas field, on the downstream side of the gas process unit. According to BGFCL information, no trouble in regard to installation or operation occurred in this field. And also, special consideration is not required for introduction of the proposed compressors.

However, reliable project management and fostering of operator and maintenance staffs are indispensable for avoiding problems and accidents on execution of the Project. Therefore, expected project risks should be considered and appropriate measures should be taken thoroughly. Refer to Section 6.1.13 “Associated Risks under the Project”.

6.1.5 Package for the Procurement of the Project

BGFCL intends to implement the installation of all compressors required in Narsingdi and Titas Gas Field Location C as one contract package. BGFCL, JICA and the Survey TEAM agreed to the procurement package for the project as described below.

Contract Package	Selection Method
(1) Consulting Service	Short Listing, *QBS JICA Standard Request for Proposal(SRFP) [Consultants]
(2) Compressor Installation	International Competitive Bid (ICB) with PQ, 2 envelope 1 stage JICA Standard Bidding Document (SBD) [Plant]

(1) Consulting Service Contract

The consultant will be selected according to the following guidelines and standard documents for bidding prepared by JICA.

- Guidelines for the Employment of Consultants under Japanese ODA loans
- Standard Request For Proposals Under Japanese ODA Loans
  for Selection of Consultants (October 2012)

Selection procedure of Consultant is as follows;

1) Preparation of Terms of Reference (refer to Appendix 2)

2) Preparation of Short List of Consultants

   - The consultants have satisfactory overseas experience of the consulting services concerned (e.g., detailed design, supervision)
   - Consultants must have experience in a developing country
   - The number of the short-listed consultants is 3 to 5

3) Preparation of Letter Of Invitation

4) Sending of the Letter Of Invitation to consultants

5) Evaluation of Proposals

   - Evaluation of Consultants' proposals will be executed based on the evaluation criteria.
   - Final result should be approved by the Board and JICA's concurrence.
   - Contract Negotiation
   - Informing Unsuccessful Consultants

Compressor technologies have already been established in technical standards such as the American Petroleum Institute (API) and International Organization for Standardization (ISO), etc., and these are generally recognized in the worldwide oil and gas industry. Accordingly, highly specialized technologies related to manufacturing of compressors are not required for the consultant, however, the consultant must have sufficient knowledge to securely carry out complicated basic engineering executed by seven (7) experts (process, civil, mechanical, piping, electrical, instrument and the environment) and the result of the basic engineering essentially affects the detail engineering. And also, since the Project is done in existing plant areas that are currently handling combustible oil and gas, work procedures and necessary safety measures for the construction must be carefully reviewed based on the practical expertise of the Consultant.

Therefore, the Quality-Based Selection ("QBS") method is recommended for the consultant selection. In this case, the proposals should be evaluated based on only the quality of the technical proposal and subsequent negotiation of financial terms.

(2) Design and Build Contract

It is recommended that BGFCL enter into a Design and Build contract with the selected contractor.

- Procurement of the Design and Build contractor should be carried out in accordance with JICA "Standard Bidding Documents under Japanese ODA Loans- Procurement of Plant Design, Supply and Installation (SBDP)"
- International Competitive Bidding (ICB) will be performed.
- Single-Stage Two-Envelope Bidding is recommended for this Project.

The Design and Build contract includes the following items:

1) Narsingdi Gas Field

- Detailed engineering for the compressor project
- Procurement and installation of three compressor units with all necessary auxiliary equipment and materials including fuel gas supply system for the gas engines
- Supply and installation of all the materials such as pipe, valves, fittings, electrical /instrument cables, field instruments, compressor's shed, etc. to be required for successful operation of the compressors
- Preparation of construction equipment, utilities, material stock yard and site office, etc. to be necessary for related construction
- Schedule and quality control
- Submission of monthly progress report
- Supply of 1 year spare parts and special tools
- Preparation of operation manual
- Training of operators
- Assistance of BGFCL for commissioning and start-up work
- One (1) year operation assistance for proposed compressor facility
- Submission of EHS management program
- Submission of as-built document
- Defect liability period of twelve (12) months

2) Titas Gas Field Location C

- Detailed engineering for the compressor project
- Procurement and installation of three compressor units with all necessary auxiliary equipment and materials including fuel gas supply system for gas engines
- Supply and installation of all the materials such as pipe, valves, fittings, electrical/instrument cables, field instruments, etc. to be required for successful operation of the compressors

- Preparation of construction equipment, utilities, material stock yard and site office, etc. to be necessary for related construction
- Procurement and installation of one production separator (only Titas Gas Field Location C)
- Preparation of construction equipment, utilities, material stock yard and site office, etc. to be necessary for related construction
- Schedule and quality control
- Submission of monthly progress report
- Supply of 1 year spare parts and special tools
- Preparation of operation manual
- Training of operators
- Assistance of BGFCL for commissioning and start-up work
- One (1) year operation assistance for proposed compressor facility
- Submission of EHS management program
- Submission of as-built document
- Defect liability period of twelve (12) months

(3) Possibility for the Utilization of Local Consultants and Contractor

As for Design and Build contract for the compressor installation, it may be difficult for local contractors to carry out all works for the engineering, procurement and installation of compressors.

Regarding Consulting Service, there is some possibility to join the project together with international consultants, since they have experts such as mechanical engineers, electrical engineers, etc.

(4) Recommended Requirements for the Consultant

It is recommended that the Consultant satisfy the following conditions for successful project implementation.

- The Consulting Firm shall be a company specializing oil and gas sector - upstream and have ample experiences in engineering and consulting services for development of worldwide oil and gas fields.
- The Consulting Firm shall have experience in engineering works for installation of process gas compressors in the past 20 years.
- The Consulting Firm shall have experience in project management, procurement assistance, engineering and supervision of construction for oil & gas projects that were funded by JICA, WB or ADB.

- The Consulting Firm shall have experience in project management, procurement assistance, engineering and supervision of construction for projects in Bangladesh that were funded by JICA, WB or ADB.
- Acquisition of ISO 9001

(5) Recommended Requirement for the Contractor

It is recommended that the following factors should be incorporated at the time of Prequalification (PQ) for procurement of the contractor.

- Sufficient construction experiences in oil and gas industry
- Acquisition of ISO 9001

(6) Recommended Requirement for Manufacturer of Compressor

It is recommended that the following capacity and experience should be incorporated at the time of PQ notice.

- More than 30 years manufacturing experience of the process gas compressor.
- Capable to comply with the latest edition of API Standard 617, 618 or 619
- Technology to couple a gas engine with the process gas compressor
- Experience for an overseas supply of the process gas compressor no less than five (5) projects
- Capable to dispatch service engineer to the site of Bangladesh within 72 hours of the notification during the operation
- Acquisition of ISO9001

6.1.6 Consulting Services

The Consultant will keep BGFCL and JICA fully informed on all matters relating to the Services and the Project during the period of the Services. This can be done through oral communications and will be confirmed by the submission of letters, monthly, weekly and other reports in writing, all as appropriate for the purpose.

(1) Scope of Service

The Consulting services are to be sequentially provided by the selected Consultant according to the following three (3) stages:

- Services for Pre-Construction Stage
- Services for Construction Stage
- Services for Post Construction Stage

And the Consulting services at each stage include the following major works necessary for implementation of the Project including but not limited to, the works described below. Details of each work are described in Section 5 (2) of Appendix 2 "*Terms of Reference (TOR) of Engineering Consultancy Services for the Project of Installation of Compressors at Narsingdi and Titas Location C Gas Fields - BGFCL*".

1) Services for Pre-Construction Stage
   a) Review of conceptual study documents
   b) Basic Engineering
   c) Preparation of Documents for Pre-qualification and Bidding
   d) Assistance for Pre-qualification and Tender
   e) Institutional Development

2) Services for Construction Stage
   a) Design Review Work for Detailed Engineering
   b) Check of the Contractor's Procurement
   c) Supervision of Field Construction Works
   d) Assistance for Pre-commissioning and Commissioning
   e) Check of the Plan for One (1) Year Operation Assistance for Proposed Compressor Facility
   f) Institutional Development
   g) Environmental Management Activity

3) Services for Post Construction Stage
   a) Final Acceptance
   b) Project Completion Report

(2) Reports and Documents

The consultant shall prepare the following documents and reports and submit them to BGFCL.

1) Inception Report (including schedule)
2) Engineering Report (including basic design report)
3) Construction schedule and cost estimate
4) Draft of pre-qualification documents

5) Draft of Bid documents
6) Draft of evaluation criteria and method of pre-qualification
7) Draft of evaluation report of pre-qualification
8) Draft of evaluation criteria and method of international competitive bidding
9) Draft of evaluation report of international competitive bidding
10) Monthly progress report
11) Quarterly progress report
12) Project completion report

(3) Expertise Requirement

The consulting services shall be provided by foreign and local consultants, which shall include but not be limited to the following:

Foreign Staff

1) Project Manager (Team Leader)
2) Engineering Manager (Basic Design, Check & Review of Detail Design)
3) Mechanical Engineer (Compressor, Gas Engine)
4) Electrical Engineer
5) Instrument Engineer
6) Civil Engineer (Foundations)
7) Process Engineer (Compressor, Process unit)
8) Piping Engineer
9) Contract Engineer
10) EHS Engineer
11) Environmental Engineer
12) QA/QC Manager

Local Staff

1) Deputy Project Manager (Local Team Leader)
2) Process Engineer (Compressor, Process Unit)
3) Environmental Engineer
4) QC Engineer
5) Mechanical Engineer (Compressor, Gas Engine)
6) Structural Engineer (Compressor shade etc.)
7) Civil Engineer
8) Electrical Engineer
9) Instrument Engineer

(4) Duration of Service

The consulting service shall cover the duration of 44-62 months, starting from the commencement of consultant services to the completion of the project. Duration and manning schedule of the consulting service is shown in Figure 6.1-12 "Project Implementation Schedule for Gas Compressors" and Section 8 of Appendix 2 (TOR of Engineering Consultancy Services for the Project of Installation of Compressors at Narsingdi and Titas Location C Gas Field – BGFCL).

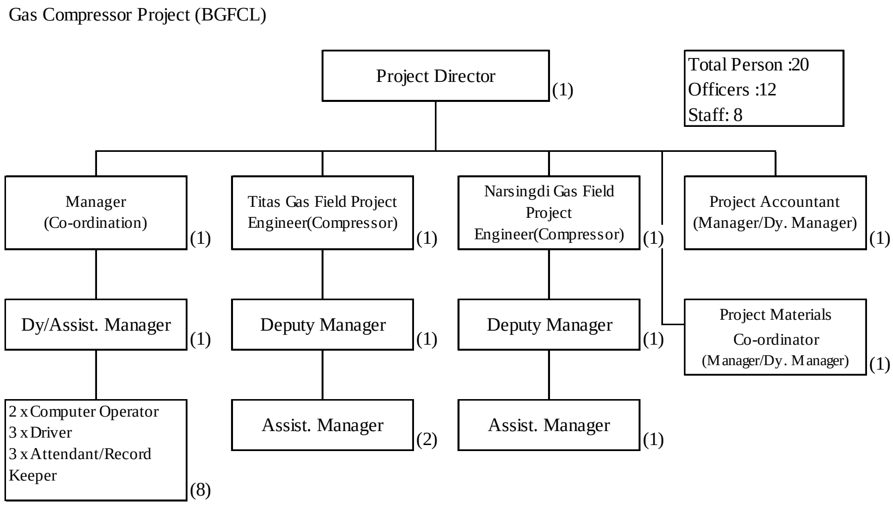
1)	Basic Design & Tender Documents Preparation Stage	:	6	months
2)	PQ and Tender Stage	:	7	months
3)	Evaluation, Negotiation and Contract Stage	:	8.5	months
4)	Detailed Design by Contractor	:	6	months
5)	Procurement of Compressor and Associated Equipment	:	22	months
6)	Construction/Installation Stage	:	16	months
7)	Defect Liability Period	:	12	months
8)	Foreign Consultant	:	200	Man-Months
9)	Local Consultant	:	205	Man-Months

The detail terms of reference (TOR) for the Engineering Consultancy Services are given in Appendix 2 of this Report.

6.1.7 Organization for the Project Implementation and O&M

BGFCL intends to implement the installation of compressors in two gas fields (Narsingdi and Titas) as one package project in order to effectively manage the projects in terms of schedule and quality control aspects. The organization charts for the implementation and O&M for the said integrated project are proposed as shown below.

(1) Implementation



- General Manager (Planning &Development) will be the head of project monitoring unit.
- The Project will also be monitored by Ministry, IMED &Petrobangla
- Requirement of manpower for execution of the project will be met from Company set-up. No extra manpower will be recruited.

Source: BGFCL

Figure 6.1-10 Organization Chart for the Project Implementation

Personnel numbers and responsibilities are as shown below.

Work responsibility schedule for the Project Implementation of Gas Compressor Project

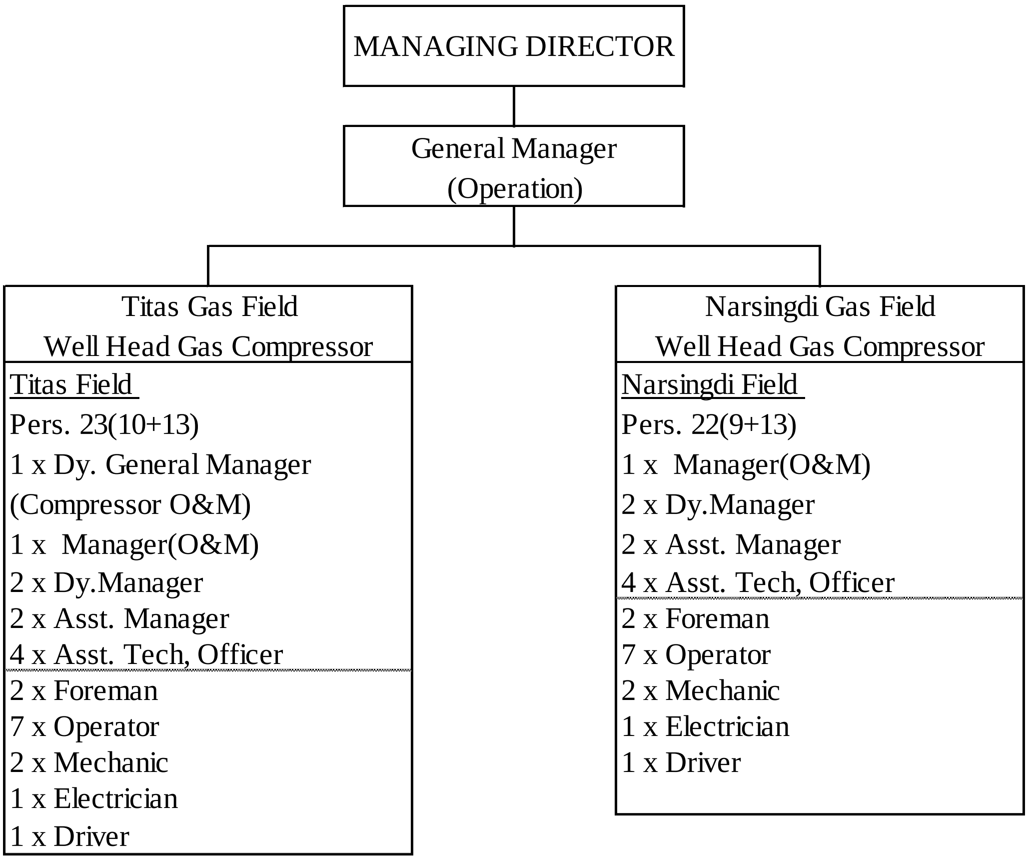
Position	Number	Responsibility	Assignment Before
Project Director	1	Provide effective line management on the implementation of the project.	DPP preparation
Project Eng. (Titas"C")	1	Provide effective line management on the implementation of the project in Titas C field.	Construction
Project Eng. (Narsingdi)	1	Provide effective line management on the implementation of the project in Narsingdi field.	Construction
Deputy Manager	2	Will work under respective Manager/Project Engineer and to assist his reporting officer for doing the responsibilities assigned as mentioned above.To act as Environment, Health and Safety（EHS）Manager in this Project.	DPP preparation
Assit. Manager	3	-ditto-	Consultant Section
Manager (Co-ordination)	1	To co-ordinate all activities of Project Manager's (PM) office.	Contractor Selection
Deputy Assist. Manager	1	-ditto-	Detail Design (by Contractor)
Project Accountant	1	Prepare all the reports related to the financial information of the project.	Contractor Selection
Project Material coordinator	1	Assist for preparing compressors/goods schedule to be procured.	Construction
Others	8	Computer Operator, Driver, Record keeper	As required
TOTAL	20		

・Requirement of manpower for execution of the project will be met from Company set-up.
・No extra manpower will be recruited.

- Manpower requirements for execution of the project will be arranged from the existing manpower of BGFCL. No extra manpower will be recruited.
- It is recommended that the Project Director and Deputy Manager are assigned from the DPP preparation stage and other members are assigned as shown in the above table basically. But the other staffs will be assigned according to the progress of the project.
- Key members will be assigned from the detail design stage
- A steering committee may not be required, however, a weekly coordination meeting among BGFCL, the Consultant and the Contractor, monthly meetings to report to JICA, ad hoc meetings to solve some important subject etc. should be held timely among project members.

(2) Operation & Maintenance

Gas Compressor Project (BGFCL)



Source: BGFCL

Figure 6.1-11 Organization Chart for O&M

Personnel number and responsibilities are as shown below.

Work responsibility schedule for O&M of Gas Compressor Project

Position	Number		Responsibility
	Titas	Narsingdi	
Deputy GM (Titas)	1		To ensure operation & maintenance of all Compressors, Gas engine (related to compressors) of the respective field.
Manager	1	1	Responsible to Dy. General Manager. To order and ensure timely receipt of all spares, materials, equipment etc. required for the maintenance of Compressors of the respective field.
Deputy Manager	2	2	Responsible to Manager. To prepare maintenance program and to ensure that program is followed
Assist. Manager	2	2	Responsible to Deputy Mgr. To assist his reporting officer for doing the responsibilities assigned as mentioned above.
Assist. Tech. Officer	4	4	Supervise the operation & maintenance work for Compressor
Foreman	2	2	To manage Compressor operation and maintenance.
Operator	7	7	Operation & maintenance work for Compressors & Gas engines
Mechanic	2	2	Mechanical maintenance work for Compressors and related facilities
Electrician	1	1	Electrical maintenance work for Compressors and related facilities
Driver	1	1	
Total	23	22	

- Manpower requirements for execution of the project will be arranged from the existing manpower of BGFCL. No extra manpower will be recruited.
- A dedicated team for the operation and maintenance of compressors at each location (Titas Location C and Narsindi) will be organized, and all members will work full-time.
- Training will be mainly executed by means of On the Job Training (OJT)
- Operation and maintenance staff that are new to gas compressor operation will be dispatched to the manufacturer's factory before start-up of the compressors to learn about the compressors. Expected period necessary for the learning course can be estimated at about four (4) days including three (3) days for technical lectures and one (1) day for hands-on exercise. It is recommended that the staffs learn and acquire the following knowledge and skills at least:
    - Compressor components
    - Compression theory
    - Sealing mechanism
    - Lubrication system
    - Cooling system
    - Operational guidelines
    - Start-up check items
    - Failure analysis
    - Maintenance and inspection procedure
    - Major trouble shooting

- Operation and maintenance staff will study operation procedure based on the start up manual and operation manual provided by the Contractor during the commissioning stage.
- Operation and maintenance staff will be trained for one year under the supervision of the Contractor in accordance with the supervisor's instruction for daily maintenance procedures and the operation manual. They should record operating conditions every day, and also keep a periodic inspection record and a maintenance record of principal equipment in the proposed compressor units.

6.1.8 Project Implementation Schedule

The Project Implementation Schedule is estimated as shown in the Figure 6.1-12, and the schedule of the Projects is comprehensively explained below.

(1) Preparatory Phase

BGFCL should prepare a DPP (Development Project Proposal) and obtain approval from the government prior to the loan agreement.

(2) Implementation Phase-1 (Procurement)

1) Selection of Consultant

After the loan agreement, BGFCL will select a consultant. Approximately nine months will be needed for the selection of a consultant in consideration of the necessary processes such as preparation of the terms of reference ("TOR"), tender, evaluation, negotiation and contract, etc.

2) Selection of Contractor

Basic engineering including a review of the feasibility study document will be commenced from the beginning of 2015 by the Consultant based on the contract. Tender documents of the construction will be prepared along with executing the basic engineering work. The construction tender will be launched for construction contractors with the basic engineering document. After the launch of the tender, a Design and Build contract will be signed after necessary steps such as pre-qualification, tender, evaluation of bid documents and negotiations. Approximately eighteen months is required from the start of basic engineering to decision of the contractor.

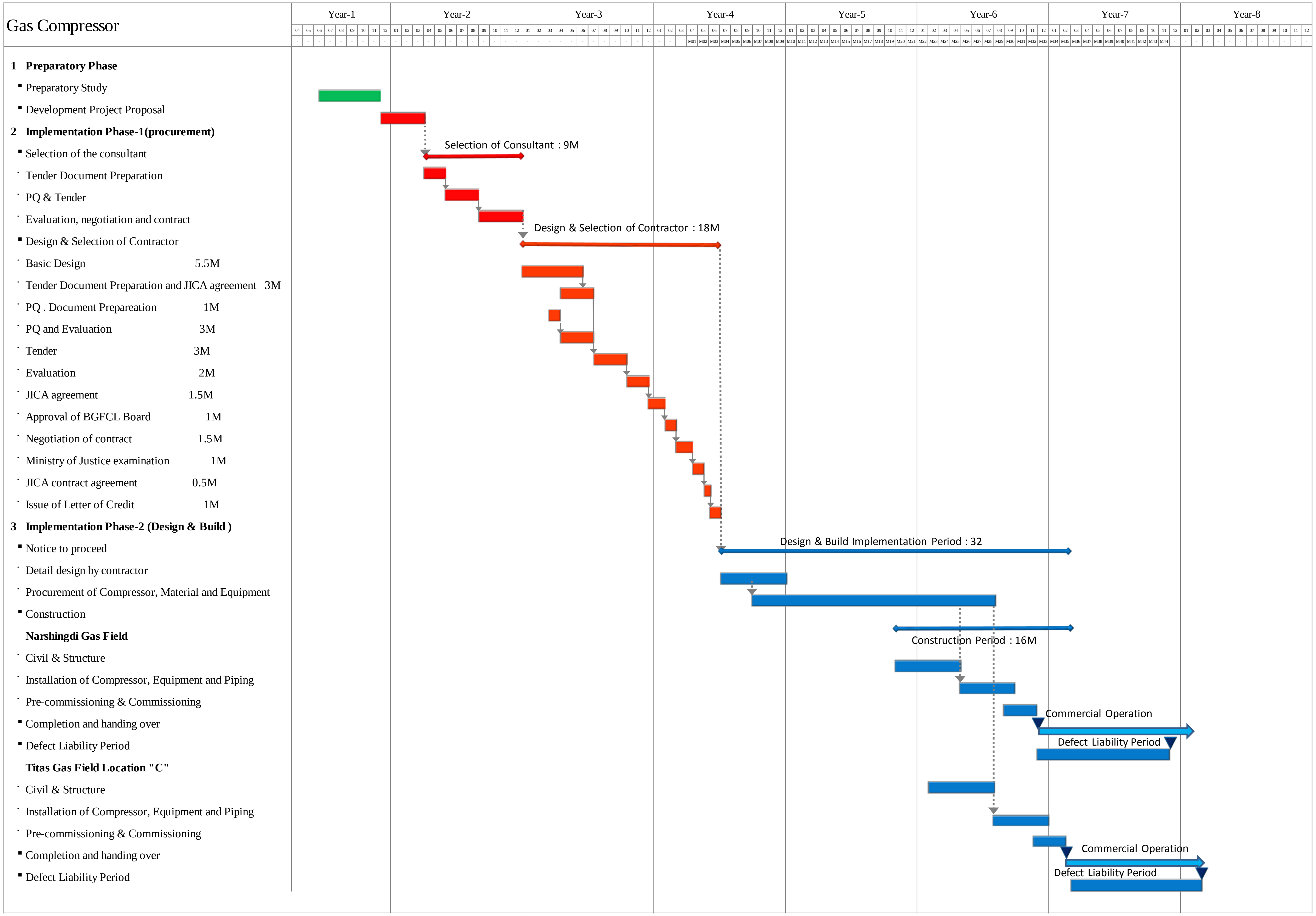
(3) Implementation Phase-2 (Detail Design & Installation)

Based on the contract with the contractor, detailed engineering will be commenced by the contractor. After three months from start of the detailed engineering, the design of the longest lead item, i.e. compressors will be finalized and the purchase order will be issued on October 2016.

Field construction work in Narsingdi Gas Field will be started in November 2017. Civil work has to be completed up to delivery of the longest lead item. Subsequently, installation work of major equipment such as compressor units, heat exchangers scrubbers and so on will be started and piping, electrical, and instrumentation systems will be installed after installation of the major equipment. The total installation duration of the proposed facilities is estimated at five months.

Start of commercial operation of the proposed compressors is scheduled on December 2018 after commissioning of all the compressor units including related existing facilities.

As for field construction work in Titas Gas Field Location C, civil works will be started in February 2018. All the subsequent field construction works in Titas Gas Field Location C will be implemented approximately three months behind that of Narsingdi Gas Field. The overall project schedule for the proposed compressor projects is as indicated in Figure 6.1-12.



Source: JICA Survey Team

Figure 6.1-12 Project Implementation Schedule for Gas Compressors

6.1.9 Project Cost

(1) Review of Preliminary Cost Estimation

The preliminary construction cost for the proposed compressor projects was approximately estimated in Section 4.1.4 (5) and Section 4.1.6 (5) as follows.

No.	Project	Approximate Project Cost
1)	Gas Compressor Project (Narsingdi Gas Field)	2,094 million JPY
2)	Gas Compressor Project (Titas Gas Field Location C)	5,114 million JPY

In this section, the said preliminary cost was reviewed based on the result of technical study for the compressors, and the project cost is re-estimated accordingly.

(2) Project Cost Estimate (preliminary)

Based on the above Item (1), project cost is estimated in this section. The Project Cost is composed of following items:

Table 6.1-11 Composition of Project Cost for Wellhead Gas Compressors

No.	Item	Remarks
A	Eligible for ODA loan	
1)	Construction cost of Gas Compressor (Design and Build cost)	
2)	Project management cost (cost for consulting service)	
3)	Dispute Board Fee	
B	Non-eligible for ODA loan	
1)	BGFCL's administration cost	
2)	Bank charge cost	
3)	VAT and Custom duties	

The following rates are adopted in this estimate based on the survey and recent project data in Bangladesh.

Table 6.1-12 Precondition of Cost Estimate for Wellhead Gas Compressors

No.	Item	Rate
1.	Price escalation (Foreign Portion)	1.3%
	Price escalation (Local Portion)	3.4%
2.	Physical Contingency	5%
3.	Interest during construction	0.01%
4.	TAX	25% (VAT: 15% + AIT: 10%)
5.	Custom Duty	7.1% on Cost Freight Value
6.	Administration cost	4% of the Project cost
7.	Bank charge cost	1% of the Project cost

The exchange rates used in this estimate are as follows:

1)	1 USD = 99.7 JPY
2)	1 USD = 77.8 BDT
3)	1 BDT = 1.28 JPY

According to the above composition and preconditions, the total Project cost is estimated based on the Project implementation schedule “Figure 6.1-12” in Section 6.1.8 as well as the results of studies described in other chapters. Table 6.1-13 is the summary sheet of the total Project cost estimate.

Table 6.1-13 Project Cost of Wellhead Gas Compressors (BGFCL)

	Item	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local
			[1,000 JPY]			[1,000 BDT]			[1,000 USD]	
	Eligible Portion									
a	Gas Compressor (a1+a2+a3)	7,380,460	5,506,380	1,874,080	5,765,984	4,301,859	1,464,125	74,027	55,229	18,797
a1	Installation of Gas Compressor (Narsingdi)	2,122,988	1,578,548	544,440	1,658,584	1,233,241	425,344	21,294	15,833	5,461
a2	Installation of Gas Compressor (Titas_C)	5,142,988	3,813,348	1,329,640	4,017,959	2,979,178	1,038,781	51,585	38,248	13,336
a3	Dispute Board	114,484	114,484		89,441	89,441		1,148	1,148	
BDT	Contingency (b1+b2)	1,110,489	661,576	448,913	867,569	516,856	350,713	11,138	6,636	4,503
b1	Price Contingency on A F 1.3% L 3.4%	706,158	367,863	338,294	551,686	287,393	264,292	7,083	3,690	3,393
b2	Physical Contingency on A 5.0%	404,331	293,712	110,619	315,884	229,463	86,421	4,055	2,946	1,110
c	Consulting Service	751,995	558,856	193,139	587,496	436,606	150,890	7,543	5,605	1,937
d	Contingency (d1+d2)	91,857	55,420	36,437	71,763	43,297	28,466	921	556	365
d1	Price Contingency on C F 1.3% L 3.4%	51,673	26,169	25,505	40,370	20,444	19,926	518	262	256
d2	Physical Contingency on C 5.0%	40,183	29,251	10,932	31,393	22,853	8,541	403	293	110
A	**Total of Eligible Portion (a+b+c+d)**	9,334,801	6,782,231	2,552,569	7,292,813	5,298,618	1,994,195	93,629	68,026	25,603
	Non Eligible Portion									
e	Administration Cost (including Bank Charge 1%) 5%	466,740		466,740	364,641		364,641	4,681		4,681
f	Custom Duties、 VAT and AIT (f1+f2)	2,734,943		2,734,943	2,136,675		2,136,675	27,432		27,432
f1	VAT : 15% & AIT: 10%	2,333,700		2,333,700	1,823,203		1,823,203	23,407		23,407
f2	Custom Duties on Foreign Portion of A 7.1%	401,243		401,243	313,471		313,471	4,025		4,025
g	Interest During Construction 0.01%	2,922	2,922		2,283	2,283		29	29	
B	**Total of Non Eligible Portion (e+f+g)**	3,204,606	2,922	3,201,683	2,503,598	2,283	2,501,315	32,142	29	32,113
	Grand Total (A+B)	12,539,406	6,785,154	5,754,253	9,796,411	5,300,901	4,495,510	125,771	68,056	57,716

Source: JICA Survey Team

6.1.10 Economic and Financial Analyses

(1) Outline of Economic and Financial Analyses of the Project

The evaluation and computation of the financial internal rate of return (FIRR) and economic internal rate of return (EIRR) including sensitivity analysis were carried out for the Project on an incremental basis of the comparison between "with project" and "without project" scenarios. The cash flow is projected and the financial and economic viability of the Project are examined.

(2) Key Assumptions Used for Financial Analysis

1) Inflation

- Price escalation for the foreign currency components: 1.3 % per annum
- Price escalation for the domestic currency components: 3.4 % per annum

2) Increase of gas price

It is assumed that the gas price will have increased for the project implementation at 9% every year, as the average increase rate in gas price to all sectors for last 32 years[6] has been 9%.

[6] It is considered that the period when gas price increases is 35 years, because project priod is 35 years. However, the data of gas sales volume for last 35 years was not collected so that such data for last 32 years was utilized

3) With-project and Without-project Scenarios

The financial analysis considered only the incremental revenues and costs directly associated with each project component. Therefore, the revenues and costs of existing systems are not considered.

4) Financing

It is assumed that the majority of the total initial investment cost including interest during construction (IDC) will be financed with a yen-denominated soft loan from JICA, which is sublet to executing agencies from GOB on the basis of the Subsidiary Loan Agreement. These loan conditions are given below:

a) Yen-denominated soft loan

- Interest rate: 0.01 % per annum
- Repayment period: 40 years including 10 year grace period (The grace period starts in the year of the first disbursement of the loan.)

b) Subsidiary Loan to each executing agency from MOF

Conditions of Subsidiary Loan Agreement (SLA) such as interest rate, repayment period including grace period and debt equity ratio for each executing agency are described in the Section on the financial analysis for the Project.

(3) Key Assumptions Used for Economic Analysis

1) Economic costs

In the economic analysis, we use true economic prices instead of often-distorted financial or market prices. For this purpose, we disregard all transfer payments within the country, such as taxes and duties. Then, we convert distorted market prices into economic prices by multiplying them by conversion factors. As far as the Project is concerned, while no "border distortion" is assumed, domestic currency components of the initial capital investment are expected to be subject to domestic distortion. In particular, wage rates of unskilled labour tend to exceed "opportunity-cost" wages. For simplicity, we use the standard conversion factor of 0.97[7] in our calculations, to be applied to market prices of all domestic currency components.

[7] The standard conversion factor of 0.97 is used, referring to ADB report, "Third Natural Gas Development Project"

2) Economic Discount Rate

A 12% economic discount rate[8] is used as a cut-off rate of the Project to evaluate whether the Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

(4) Financial Analysis for Wellhead Gas Compressors

For the BGFCL, the installation of wellhead gas compressors is primarily designed to relieve downstream supply constraints and to maintain sustainable gas production.

1) Initial Investment Costs

As described earlier in this report, the total cost of the eligible portion for the wellhead gas compressors including consulting service is estimated at approximately US$ 94 million. With administration cost, VAT & AIT and custom duties, the total initial investment cost (excluding IDC) is estimated at approximately US$ 126 million. Table 6.1-13 in Section 6.1.9 shows the estimate of initial investment costs.

2) O&M Costs

The estimated amount necessary for O&M works for the Project, excluding price escalation, will be around BDT 32 million per year. Approximate operating expenditures include personnel positioning, staff assignment, vehicles and maintenance fees. The breakdown of O&M costs is as follows:

Table 6.1-14 Breakdown of O&M Costs for Gas Compressors

(Unit: 1,000 BDT/year)

Work Item	Annual Cost
Personnel positioning and staff assignment	8,000
Vehicles	6,000
Maintenance fee & consumable parts	17,800
Total	31,800

Source: JICA Survey Team

3) Conditions of SLA

- Interest rate: 4% per annum
- Repayment period 15 years including 5 years grace period
- Currency: Bangladesh Taka
- Debt equity ratio: 60 : 40[9]

[8] The 12% economic discount rate is used, referring to ADB report, “Natural Gas Access Improvement Project”

4) Others

Other key assumptions used in our analysis are as follows:

- Depreciation: 20-year straight line
- Corporate income tax: 37.5%

Property taxes or working capital requirements are not considered in projecting the cash outflow stream. Potential revenues other than sales revenue, such as interest earnings, are not taken into account either, since they will be comparatively small.

5) Recovery Volume of Gas Supply

The installation of wellhead gas compressors contributes to relieving downstream supply constraints and maintaining sustainable gas production. The recovery gas volume that is supplied as a result of the investments will be 187 MMSCFD in total and the details are as follows:

- Narshingdi Gas Field: 30 MMSCFD
- Titas Gas Field C: 157 MMSCFD

6) Revenue

The BGFCLC derives its revenue from wellhead margin on gas volumes and condensate volumes transported. For analysis a purposed rate of US$0.10/MCF[10] for BGFCL's margin is used.

7) Weighted Average Cost of Capital

Once the FIRR is calculated, the FIRR is to be compared with the weighted average cost of capital (WACC) to verify whether the FIRR calculated is sufficiently covering the cost of the funds including the equity and borrowed funds. WACC is calculated by using the following formula:

WACC (before tax) = [Equity Cost (after tax)／(1 - corporate tax rate) x Equity／(Equity + Debt)] + [Debt Cost X Debt／(Equity + Debt)]

The project FIRR, the tool for the financial analysis, is to be calculated on the basis of the cost and benefit before incorporating taxes into the benefit and costs. We, therefore, use the WACC (before tax) for the analysis.

The following are the assumptions that are laid down for the project:

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[9] This is the information referring to MoF's "Lending and Relending Terms of Local/Foreign Currency Loans" for Petrobangla.

[10] In accordance with an answer from BGFCL to the questionnaire, this value was obtained.

- Cost of Equity[11] = 17% p.a. (before tax)
- Equity／(Equity + Debt) = 10%
- Debt Cost = 4% p.a.
- Debt／(Equity + Debt) = 90%
- Corporate Tax Rate = 37.5%

Those assumed figures are inserted into the formulae to draw the output rates for WACC as follows;

WACC = 6.37%

As a result of the above exercise, the weighted average of capital costs is 6.37% on the basis of before tax. We conclude this section by confirming that the project is to be deemed viable when the project FIRR will be found above the WACC of 6.37%.

(5) FIRR on the Total Investment Cost (Project FIRR)

To confirm the underlying financial viability or the true soundness of the Project, the financial internal rate of return (FIRR) of the Project was calculated. The revenue and costs for wellhead gas compressors are summarized in the below table.

Table 6.1-15 Costs and Revenue of Gas Compressors for Financial Analysis

Costs:	Construction cost of gas compressors, project management cost, dispute board fee, BGFCL's administration cost, taxes, IDC and operation & maintenance
Revenue:	Gas revenue (wellhead margins) from recovery volume of gas production/supply due to the installation of compressors.

Source: JICA Survey Team

The result of the calculation of the FIRR is as follows: (See Table 6.1-16)

FIRR: 10.67%

The FIRR is at 10.67%, which exceeds 6.37%, WACC. Therefore, the Project is regarded as financially viable.

11 The risk-free rate for Bangladesh is government-guaranteed 10-year bonds, for which the interest rate is 12%. The risk premium is 5% (refer to "ADB, Report and Recommendation of the President (RRP: BAN 35242)"). Beta factor is assumed to be 1, as public sector such as gas supply would be stable. The cost of equity will be 17%.

Table 6.1-16 Project FIRR for Compressors

(Thousand USD)

Project Year	Project Life	Cash Inflow: Owned Capital	Cash Inflow: Foreign Loan	Cash Inflow: Domestic Loan	Cash Inflow: Operating Revenue	Cash Inflow: Total Revenue	Cash Outflow: Capital Costs	Cash Outflow: O&M Costs	Cash Outflow: Interest Foreign Loan	Cash Outflow: Interest Domestic Loan	Cash Outflow: Repay Foreign Loan	Cash Outflow: Repay Domestic Loan	Cash Outflow: Total Cost	Net Cash Flow for: Cash Balance	Net Cash Flow for: Project IRR	Net Cash Flow for: Cumulative Cash Balance
3		334	2,437	502	0	3,273	3,273						3,273	0	-3,273	0
4		322	2,349	483	0	3,155	3,155						3,155	0	-3,155	0
5		191	1,390	286	0	1,867	1,867						1,867	0	-1,867	0
6	1	11,829	86,218	17,744	130	115,920	115,790	9	0	0	0	0	115,799	122	-115,669	122
7	2	159	1,157	238	9,270	10,825	1,554	499	0	0	0	0	2,054	8,771	7,216	8,892
8	3	10	72	15	11,083	11,180	97	516	4,235	872	7,059	1,453	14,232	-3,051	10,470	5,841
9	4				11,691	11,691		534	3,953	813	7,059	1,453	13,811	-2,120	11,158	3,721
10	5				12,300	12,300		552	3,670	755	7,059	1,453	13,489	-1,189	11,748	2,532
11	6				12,908	12,908		571	3,388	697	7,059	1,453	13,167	-260	12,337	2,272
12	7				13,516	13,516		590	3,106	639	7,059	1,453	12,846	670	12,926	2,942
13	8				14,124	14,124		610	2,823	581	7,059	1,453	12,526	1,598	13,514	4,540
14	9				14,733	14,733		631	2,541	523	7,059	1,453	12,206	2,526	14,102	7,067
15	10				15,341	15,341		653	2,259	465	7,059	1,453	11,887	3,454	14,688	10,520
16	11				15,949	15,949		675	1,976	407	7,059	1,453	11,569	4,380	15,274	14,900
17	12				16,557	16,557		698	1,694	349	7,059	1,453	11,252	5,306	15,860	20,206
18	13				17,166	17,166		721	1,412	291	7,059	1,453	10,935	6,231	16,444	26,437
19	14				17,774	17,774		746	1,129	232	7,059	1,453	10,619	7,155	17,028	33,592
20	15				18,382	18,382		771	847	174	7,059	1,453	10,304	8,078	17,611	41,670
21	16				18,990	18,990		797	565	116	7,059	1,453	9,990	9,001	18,193	50,671
22	17				19,599	19,599		825	282	58	7,059	1,453	9,676	9,922	18,774	60,593
23	18				20,207	20,207		853	0	0	0	0	853	19,354	19,354	79,947
24	19				20,815	20,815		882	0	0	0	0	882	19,933	19,933	99,881
25	20				21,423	21,423		912	0	0	0	0	912	20,512	20,512	120,392
26	21				22,032	22,032		943	0	0	0	0	943	21,089	21,089	141,481
27	22				22,640	22,640		975	0	0	0	0	975	21,665	21,665	163,147
28	23				23,248	23,248		1,008	0	0	0	0	1,008	22,240	22,240	185,387
29	24				23,856	23,856		1,042	0	0	0	0	1,042	22,814	22,814	208,201
30	25				24,464	24,464		1,077	0	0	0	0	1,077	23,387	23,387	231,588
31	26				25,073	25,073		1,114	0	0	0	0	1,114	23,959	23,959	255,547
32	27				23,856	23,856		1,042	0	0	0	0	1,042	22,814	22,814	278,361
33	28				23,856	23,856		1,191	0	0	0	0	1,191	22,665	22,665	301,026
34	29				26,897	26,897		1,232	0	0	0	0	1,232	25,666	25,666	326,692
35	30				27,506	27,506		1,273	0	0	0	0	1,273	26,232	26,232	352,924
Total		12,845	93,624	19,268	545,387	671,124	125,737	23,940	33,881	6,973	105,879	21,790	318,200	**352,924**	395,709	
FIRR															**10.67%**	

Source: JICA Survey Team

(6) Sensitivity to FIRRs

Separate analyses were carried out to examine the sensitivity of projected financial returns to adverse changes in key variables. The risks involved in the Project in terms of financial viability are the future uncertainty of the initial investment cost and the exchange rate between the local currency and the US dollar.

a) 10% higher cost of eligible portion in initial investment cost

b) 20% higher cost of eligible portion in initial investment cost

c) 10% lower exchange rate than assumed, i.e., 85.58 BDT/USD and thus 0.09 USD/MCF of income from wellhead margin

d) 20% lower exchange rate than assumed, i.e., 93.36 BDT/USD and thus 0.08 USD/MCF of income from wellhead margin

The results of the above sensitivity test are summarized below:

Table 6.1-17 Results of Sensitivity Analysis on FIRR for Compressors

	Item	Project FIRR
1	10% higher cost of eligible portion in initial investment cost	9.73%
2	20% higher cost of eligible portion in initial investment cost	8.91%
3	10% lower exchange rate	9.58%
4	20% lower exchange rate	8.43%
5	Combination of the above 1 and 3	8.69%
6	Combination of the above 1 and 4	7.59%
7	Combination of the above 2 and 3	7.92%
8	Combination of the above 2 and 4	6.86%

Source: JICA Survey Team

The above sensitivity analysis indicates that all the FIRRs show over 6.37%, which is over the WACC cut-off rate. Therefore, the financial feasibility of the Project is deemed to be high.

(7) Conclusion on Financial Viability

The project FIRR of the base case is at 10.67%, which exceeds 6.37 %, the WACC. Therefore, the Project is regarded as financially viable and a sound investment. With regards to the sensitivity to FIRRs, all the FIRRs are higher than the cut-off rate. Therefore, the financial feasibility of the Project is deemed to be high, considering the result of sensitivity analysis. To sum up, it is deemed that the Project is financially feasible.

(8) Economic Analysis for Wellhead Gas Compressors

The economic analysis of a project is concerned with all the costs and benefits incurred or generated by the project to the society as a whole, while the financial analysis is concerned with those to the project owner only. In order to assess the economic feasibility of the Project, i.e., whether or not the Project generates a sufficient net benefit to the country so that investment for its implementation can be justified, we estimate EIRR of the Project, as discussed below.

(9) Economic benefit

It is assumed that the recovery volume of gas production is equal to that of gas supply. This gas supply due to the installation of compressors contributes to increase supply to the society, compared to the without project scenario. Thus, the increase in revenue brought by gas supply due to the installation of compressors is regarded as the main economic benefit.

(10) EIRR

The benefit and costs for wellhead gas compressors are summarized in the below table.

Table 6.1-18 Costs and Benefit of Gas Compressors for Economic Analysis

Costs:	Construction cost of gas compressors, project management cost, dispute board fee, BGFCL's administration cost and operation & maintenance (excluding taxes and IDC)
Benefit:	The recovery volume of gas production/supply due to the installation of compressors contributes to incremental supply toward the society, compared to "without project" scenario. Thus, the incremental revenue brought by gas supply due to the installation of compressors is regarded as a main economic benefit.

Source: JICA Survey Team

Table 6.1-19 exhibits the calculation of the EIRR of the Project based on the economic benefits and costs discussed earlier. The EIRR is calculated at 13.49%, which clearly supports the economic viability of the Project, because the 13.49% EIRR is above 12%, cut off rate of the evaluation criteria for economic analysis.

Table 6.1-19 EIRR of the Project for Compressors

(Thousand USD)

Project Year	Project Life	Cash Inflow		Cash Outflow			Net Cash Flow for	
		Benefits	Total Benefit	Capital Costs	O&M Costs	Total Cost	Cash Balance	Cumulative Cash Balance
3		0	0	2,621		2,621	-2,621	-2,621
4		0	0	2,529		2,529	-2,529	-5,150
5		0	0	1,478		1,478	-1,478	-6,627
6	1	130	130	89,506	9	89,515	-89,384	-96,012
7	2	9,270	9,270	1,196	499	1,696	7,575	-88,437
8	3	11,083	11,083	0	516	516	10,567	-77,870
9	4	11,691	11,691	0	534	534	11,158	-66,713
10	5	12,300	12,300	0	552	552	11,748	-54,965
11	6	12,908	12,908		571	571	12,337	-42,628
12	7	13,516	13,516		590	590	12,926	-29,702
13	8	14,124	14,124		610	610	13,514	-16,188
14	9	14,733	14,733		631	631	14,102	-2,086
15	10	15,341	15,341		653	653	14,688	12,602
16	11	15,949	15,949		675	675	15,274	27,876
17	12	16,557	16,557		698	698	15,860	43,736
18	13	17,166	17,166		721	721	16,444	60,180
19	14	17,774	17,774		746	746	17,028	77,208
20	15	18,382	18,382		771	771	17,611	94,819
21	16	18,990	18,990		797	797	18,193	113,012
22	17	19,599	19,599		825	825	18,774	131,786
23	18	20,207	20,207		853	853	19,354	151,140
24	19	20,815	20,815		882	882	19,933	171,074
25	20	21,423	21,423		912	912	20,512	191,585
26	21	22,032	22,032		943	943	21,089	212,674
27	22	22,640	22,640		975	975	21,665	234,340
28	23	23,248	23,248		1,008	1,008	22,240	256,580
29	24	23,856	23,856		1,042	1,042	22,814	279,394
30	25	24,464	24,464		1,077	1,077	23,387	302,781
31	26	25,073	25,073		1,114	1,114	23,959	326,740
32	27	25,681	25,681		1,152	1,152	24,529	351,269
33	28	26,289	26,289		1,191	1,191	25,098	376,367
34	29	26,897	26,897		1,232	1,232	25,666	402,033
35	30	27,506	27,506		1,273	1,273	26,232	428,265
Total		549,645	549,645	97,329	24,050	121,380	**428,265**	
EIRR							**13.49%**	

Source: JICA Survey Team

(11) Sensitivity Analysis to EIRRs

A sensitivity test was performed on the EIRR for the initial investment cost only, which is the largest foreign cost component. The results of the test are as follows:

Table 6.1-20 Results of EIRR Sensitivity Analysis

	Scenario	EIRR of the Project
1	10% higher initial investment cost	12.40%
2	20% higher initial investment cost	10.67%

Source: JICA Survey Team

Generally, higher EIRRs are expected for energy projects, whereas a substantial cost overrun of the initial investment cost could undermine the Project's viability. As a result of this sensitivity analysis, the EIRR is over 12% in case of a 10 % higher initial investment. On the other hand, EIRR is lower than 12% in case of a 20% higher initial investment. Thus, it can be said that the Project is economically viable in the case of the expected basic initial investment cost and a 10% higher initial investment.

(12) Conclusion on Economic Feasibility

It can be concluded that the Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

6.1.11 Operation and Effect Indicators

(1) Operation Indicator

As an operation indicator at two years after compressor start-up, outage hours caused by compressor trouble and/or human errors in the two years of operation is the most preferable to evaluate its degree of achievement. Basically, the proposed compressors should be operated without any outage time because one stand-by compressor is installed for the purpose of back-up at the time of periodic maintenance, unexpected shutdown, etc. Accordingly, the original and target value are set as indicated in Table 6.1-21.

Table 6.1-21 Operation Indictor for Compressor Projects

Gas Field	Operation Indicator	Original (as of 2013)	Target (as of 2020)
Narsingdi & Titas Gas Field (Location C)	Outage hours by compressor trouble (hour)	N/A	0
	Outage hours by human errors (hour)	N/A	0

Source: JICA Survey Team

(2) Effect Indicator

As an effect indicator at two years after compressor start-up, total gas production volume in two years operation is the most preferable to evaluate its degree of achievement. Accordingly, "Cumulative Gas Production Volume" in the two years operation is to be applied as the "Effective Indicator".

As for the "Cumulative Gas Production Volume", since daily gas production volume at each gas field is recorded on daily production reports by BGFCL, the total gas production volume for the two years can be checked based on the sales record. And the "Cumulative Gas Production Volume" should be estimated by deducting plant shutdown periods caused by several problems in wellheads, gas processing plant and transmission pipeline and so on. If a total shutdown period of 30 days is assumed per year, the gas production period will be 335 days per year. In this case, the "Effect Indicator" in Narsingdi and Titas Gas Field (Location C) is estimated as follows:

- Narsingdi Gas Field
  Effect Indicator = 30.0 MMSCFD x 335 day/year x 2 year

  = 20,100MMSCF

- Titas Gas Field (Location C)
  Effect Indicator = 157 MMSCFD x 335 day/year x 2 year

  = 105,190 MMSCF

As the targeted effect indicator, it is preferable that the targeted value will be equal to or more than that of the "Cumulative gas production volume" estimated above. The original and target value are set as indicated in Table 6.1-22.

However, since the future gas production rate of each well may vary due to characteristics of the wells, the targeted value should be reviewed properly based on the related production profiles of the wells at the time of the compressor start-up.

Table 6.1-22 Effective Indictor for Compressor Projects

Gas Field	Effective Indicator	Original (as of 2013)	Target (as of 2020)
Narsingdi Gas Field	Cumulative gas production volume (MMSCF)	20,100	≧20,100
Titas Gas Field (Location C)	Cumulative gas production volume (MMSCF)	105,190	≧105,190

Source: JICA Survey Team

6.1.12 Environmental and Social Considerations

The projects in both gas fields (Narsingdi and Location C of Titas) are aimed at reinforcement of the transmission of gas produced in existing gas fields so that the gas produced could be compressed to meet the design pressure requirement of the gas transmission pipelines. There would be no additional gas extraction/production consequent to the operation of the compressors. It is noted that any additional gas extraction (consequent to the operation of the compressor) would require a mandatory EIA study because such an industrial project would fall under the RED category (as per the environmental conservation rule of DoE (1997).

Moreover, compressors will be installed within the existing gas fields (industrial areas) and there is no land acquisition or resettlement requirement. As such, only an EMP (environmental management plan) focussed on the required environmental mitigation, management and monitoring for the project implementation and subsequent operation will be necessary to be formulated and submitted by the project proponent, BGFCL, for review and approval by DoE, and hence the issuance of ECC. Agreement on this requirement of the formulation of the EMP has already been reached between DoE and BGFCL. Accordingly these Sector-1 Projects are regarded as categorized into Amber-B by DoE, with the IEE being replaced with the EMP in the flowchart shown in Figure 2.7-1 of Chapter 2 for the Amber-B category projects, considering the already operational status of the project areas (existing industrial areas of gas fields).

The Environment and Safety Department under the Planning and Development Division of BGFCL (responsible unit of BGFCL for environmental aspects) has already formulated the EMP for review and approval by DoE. The submission of EMP to DoE by BGFCL is expected to be done by the end of February 2014. Accordingly, approval of EMP and hence issuance of ECC by DoE is expected at the latest by the end of March 2014.

(1) Existing Status as Operational Gas Fields (Industrial Area)

The compressors will be installed in the existing operational gas fields of Narsingdi and Location C of Titas (industrial areas). The compressor system is intended to compress the gas produced to the design pressure requirements of the gas transmission pipelines and will not result in any additional extraction of gas from the gas fields.

Justification on the insignificance of potential adverse effects on both important natural and social environment items consequent to the installation and operation of compressors in the 2 selected gas fields of the project, namely, Narsingdi and Titas Location C, is illustrated under Item (6) of respective sections (Section 4.1.4 for Narsingdi and 4.1.6 for Titas-Location C) of Chapter 4.

In essence, compressors will be installed in existing operational gas fields (industrial areas and there would be no adverse effects on the natural environment) belonging to BGFCL and there will be no additional extraction of gas consequent to the operation of the compressors. Moreover, there is no need for any land acquisition or involuntary resettlement, and construction/installation and operation of the compressors would not require use of a significant quantity of water to result in generation of any significant quantity of wastewater/sludge.

As such, conducting an EIA study is not necessary and ECC (Environmental Clearance Certificate) from DoE could be obtained with the conducting (and submission) of an EMP (Environmental Management Plan) by the project proponent, BGFCL, focused on required environmental mitigation and monitoring measures (EHS aspects) separated between project construction/installation (short-term) and operation (long-term) stages as noted above.

These aspects are justified in the following sections starting from alternative consideration of the projects followed with environmental scoping, management, mitigation, and monitoring measures in accordance with the JICA Guidelines on Category B projects.

(2) Alternative Considerations including Zero Option

1) Alternatives

The locations for installation of the compressors are confined to existing operational gas fields having potential for decline in line pressure of extracted gas from the well fields. Such low line pressure would mitigate input of gas into the transmission pipelines with high design pressure. So there is no alternative to the project location other than the selection of existing operational gas fields having potential to result in declining line pressure as have been technically assessed in Section 4.1.2 followed with project selection dealt with in Chapter 5. In effect, the compressor system is basically reinforcement for the existing operational gas fields to facilitate effective and efficient operation of the overall system.

Based on such technical assessment and priority considerations, the 2 operational gas fields of Narsingdi and Location C of Titas were selected for the installation of gas compressor systems. It is noted that all gas fields are industrial areas belonging to BGFCL with similar environmental and social characteristics and hence project alternative consideration will be governed by technical and financial aspects only (environmental and social aspects have no bearing) and were used in the selection of these 2 project sites for the installation of natural gas compressor systems.

2) Zero option

Zero option will always be a viable and at times inevitable option for the installation of compressors in any gas field if the necessary funding (and the subsequent installation works) for the provision of compressor is not secured in a timely manner. Such a condition with declining line pressure in produced gas would result in inefficient operation of the gas fields in which a large investment has already been made in the development of such gas field wells.

Inefficient use of such an important natural resource of Bangladesh, considering the fact that natural gas is a cleaner source of energy with less CO_2 emission in comparison to other liquid based petroleum sources that still have to be imported, is regarded as unacceptable from both energy and environmental viewpoints as well. Accordingly, due provision of compressor systems for the existing gas fields with potential declining line pressure is regarded as a necessary and wise option to pursue in comparison to deliberately targeted zero option (no action option).

(3) Environmental Scoping and TOR for EMP

Scoping for significant environmental and social aspects for the projects in this survey, all projects basically belonging to industrial sector, was conducted based on the typical environmental and social components relevant to the industrial sector.

Such relevant components are broadly classified into 3 environmental groups, namely, Environmental quality and pollution control, Natural environment and Social environment and used as the basis for scoping of all 3 sector selected projects, compressors, gas transmission pipelines and prepaid gas meters for domestic customers.

Classification and the relevant environmental (and social) elements selected for scoping are summarized below.

	Classification of Environment	Environmental (and social) elements
1	Environmental quality and pollution control	Air quality Water quality Noise/vibration Waste Soil Climate change factors
2	Natural environment	Topography Geology Hydrology Ecosystem Biodiversity Protected areas Area of environmental/ecological significance
3	Social environment	Local economy Resettlement Indigenous people Cultural heritage Health and safety

The results of scoping with evaluation separated between positive (beneficial) and negative (adverse) effects with 4 ranking grades of A, B, C and D along with due reasoning for such ranking are given in Table 6.1-23.

Table 6.1-23 Environmental Scoping for Installation of Compressors in Narsingdi and Titas-Location C Gas Fields of BGFCL

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
Environmental quality and pollution control	Air quality	B-	D	During construction, air pollutants are expected from land clearance, movement of heavy equipment and trucks, which would generate mostly dust and to some extent exhaust gaseous emission (CO, NO_x, SO_x and others). During O&M, no significant air pollutant emission is expected even with the operation of natural gas fuelled electricity generator since natural gas is a cleaner fuel.
	Water quality	D	D	Work activities of the compressor are confined within the gas field area (industrial area) and there are no significant surface water bodies. So no adverse effect on water quality consequent to the project is anticipated.
	Noise/vibration	B-	B-/D	Noise and vibration during construction/installation of the compressors can not be entirely eliminated. Still, since the compressor installation site is an existing industrial area (gas field) it is regarded that a relatively high tolerance level for noise/vibration is admissible, in particular considering the short term nature of the adverse effect. Moreover, work prone to potentially high noise/vibration could also be scheduled for day-time only. Operation of compressors driven by gas engines during the operation stage is noise and vibration prone. In this regard sound proofing could be adopted as a long-term mitigation measure
	Waste	B-	D	Waste generation during construction activities, sanitary and solid waste generation due to working personnel and other construction related works. Waste generated directly due to the operation of the gas compressor is not that significant.
	Soil	D	D	No significant adverse effect on soil is anticipated since the work involves predominantly overland installation of natural gas compressors in an industrial area.
	Climate change Factors	D	D	Natural gas results in less CO_2 emission in comparison to other liquid petroleum sources. As such, a natural gas compressor system facilitates the use of cleaner fuel Still, overall, any such beneficial effects on overall climate change factors is regarded as not that significant.

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
Natural Environment	Topography	D	D	The project is not that large-scale to significantly affect topography.
	Geology	D	D	Similar to the topography case above, the project is not that large-scale to significantly affect geology.
	Hydrology	D	D	Similar to the topography case above, the project is not that large-scale to significantly affect hydrology.
	Ecosystem	D	D	Installation and operation of compressors will be confined to an existing industrial area. So no adverse effect on the ecosystem is anticipated.
	Biodiversity	D	D	Similar to the ecosystem case above, since the project location is an existing industrial area so no significant adverse effect on biodiversity due to compressor installation and operation is anticipated.
	Protected areas	D	D	There are no protected areas located in or around the vicinity of the planned compressor installation area (industrial area).
	Areas of environmental /ecological significance	D	D	There are no environmentally or ecologically significant, critical or vulnerable areas located in or around the vicinity of the planned compressor installation area (industrial area).
Social Environment	Local Economy	B+	B+	Compressor installation work would generate some employment opportunity for the local labourers, including unskilled labour thereby contributing to the local economy. This is also possible to some extent during the operation stage as well, for operation, maintenance, and security of the compressor system.
	Resettlement	D	D	The compressor installation site is an existing operational gas field area (industrial area) belonging to BGFCL and requirement for resettlement is irrelevant.
	Indigenous people	D	D	Installation of compressors within the existing operational gas field belonging to BGFCL is not expected exert any effects on indigenous people, if any, though there are no indigenous people living around the vicinity of these 2 gas fields.
	Cultural Heritage	D	D	There are no cultural heritage sites located within the gas fields.

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
	Health and Safety	B-	B-/D	Health and safety of construction personnel is a very important aspect in the construction management by the contractor. Instilling due awareness among migrant workers on the dangers of communicable diseases and the importance in respecting the customs and traditions of village people is the most significant social aspect to be addressed by the construction contractor. Full commitment and adherence to the concept of “Safety First” in the conducting of all construction/ installation related activities by the construction contractor are necessary for enhanced safety of the construction work force. Operational safety is integral to overall operation of the gas field system to which compressor systems will be added as an additional sub-system. As such adherence to updated safety guidelines with the compressor systems duly incorporated needs to be ensured by BGFCL.

Legend:
A+/- : Significant positive/negative impact is expected
B+/- : Positive/negative impact is expected
C+/- : Extent of positive impact/extent of negative impact is unknown (needs further investigation on whether the impact can be clarified as the ESC Study progresses)
D : No significant impact is expected or no impact at all is expected

It is evident from the above scoping results that most adverse effects consequent to the implementation of compressor installations in the gas fields of Narsingdi and Location-C of Titas are of short-term and basically confined to the construction/installation stage of the project and could be managed with the adoption of good construction/installation practice by the construction contractor. Also there is no social issue involved since the compressors will be installed within the existing property boundary of BGFCL (operational industrial areas).

Moreover, in consideration of the simplicity of the project principally involving installation machinery (compressor system) within operational gas fields no significant change in the scoping grades assigned as impact evaluation in the above Table 6.1-23 is expected as the result of the EMP study by BGFCL.

The results of the above scoping also indicate that the TOR for EMP need to focus on due mitigation, management and monitoring measures on ambient air quality, noise/vibration, waste management and health and safety aspects during construction/installation stage of compressors. During the operation stage, health and safety in the form of safe operation of the entire gas field system with the (newly) operational compressor systems superimposed is very important.

Accordingly the TOR on environmental considerations formulated with due focus on the environmental and safety aspects that are given below in Table 6.1-24.

Table 6.1-24 TOR for Environmental Considerations (BGFCL Compressors)

Environmental Component		Survey Items	Methodology
1	Air Quality	• Clarify ambient air quality standards • Establish baseline ambient air quality condition in the project site and its vicinity for dust ($SPM_{2.5}$/SPM_{10}) before commencement of any construction/installation related activity • Identify current air pollution sources • Formulate EMP	• Collection of secondary data • Interview with relevant agencies • Field reconnaissance and expert opinion/judgement
2	Noise/Vibration Level	• Clarify ambient noise/vibration standards • Establish baseline noise/vibration level in the project site and its vicinity before commencement of any construction related activity • Formulate EMP	• Collection of secondary data • Interview with relevant agencies • Field reconnaissance and expert opinion/judgement
3	Waste Management	• Clarify waste management standards • Predict types and management of construction/installation related wastes • Formulate EMP	• Collection of secondary data • Interview with relevant agencies and expert opinion/judgement
4	Health and Safety	• Construction/installation contractor fully commits to and follows the “Safety First” concept • Update operational safety manual to conform with compressor operation superimposed on the existing operational gas field system • Formulate EMP	• Conduct regular joint site inspections by all relevant in-charge personnel of EHS (BGFCL, the supervising consultant and construction contractor) • Confirm due operational safety of compressor superimposed overall gas field operational system with due trials including mock drills as appropriate

Source: JICA Survey Team

(4) Environmental Impact Evaluation and Mitigation

Potential adverse environmental impacts consequent to the installation of the compressor systems would be mostly limited to the construction/installation stage of the project and will be mostly confined to the compressor installation areas (industrial areas) as evident from the scoping results of Table 6.1-23. Potential adverse effects of the construction/installation stage of the project are evaluated as manageable with the adoption of technically sound construction/installation methods (adoption of good construction/installation practice).

In this respect, the construction/installation contractor shall fully commit and adhere to the concept of safety first as the most import mitigation measure of construction safety.

The other significant mitigation measures of the construction/installation stage include:

- Transportation of material and equipment prone to dust generation in covered vehicles.
- Transportation of machinery/equipment in duly sized packaging so as not to cause overloading and to ensure safe transportation including not resulting in damage to the transportation roads. Moreover, scheduling of all transportation will be duly planned so as to minimize interference with regular road traffic.
- Water spraying of dust prone cleared lands including storage of dust prone material under vinyl sheet covering.
- Good housekeeping of construction site and worker camp site including maintenance of good sanitary conditions and a solid waste management system with separation of garbage according to the type of garbage to facilitate effective reuse/recycling as appropriate.
- Limiting activities having potential to cause high noise/vibration to day-time only, even though the tolerance level for such activities is high in this case since the project sites are existing industrial areas.

Finally, concerned to noise and vibration due to the operation of compressors driven by gas engines (during the operational stage of the compressor system) sound proofing is a practical long-term mitigation measure that could be implemented, if necessary. The environmental impact mitigation/management plan is summarized in Appendix 6.

(5) Environmental Monitoring Plan

Environmental monitoring is regarded as necessary for the elements of air quality and noise/vibration only for construction/installation stage of the project. The proposed environmental monitoring plan is summarized in Table 6.1-25. The construction contractor will be responsible for the conduct of monitoring works.

An overall monitoring plan in the form of a draft environmental monitoring form is given in Appendix 7 that is provided for use as appropriate by BGFCL for the formulation of EMP, which is necessary for obtaining ECC from DoE.

It is further noted that any potential emission of air pollutants due to operation of the electricity generators (if natural gas is used for generation of electricity for operation of the compressors independent of electricity from the national grid with small-capacity generators) would not be that significant to cause significant ambient air quality deterioration since natural gas is a cleaner fuel and does not result in any significant fugitive emission (NO_x, SO_x and others).

Table 6.1-25 Environmental Monitoring Plan
(Construction/installation stage-Conduction by Contractor)

Monitoring parameter	Unit	Bangladesh Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method)
(Ambient air quality) SPM_{10}	μgm/m^3	150 (Statutory Rules 2005)	50 (World Bank Guideline) 150 Interim Value	• One Sampling Point near the project site another 1 km. away from the project site. • Per month one 24-hr. day sampling • High Volume Dust Sampler
(Ambient air quality) $SPM_{2.5}$	μgm/m^3	65 (Statutory Rules 2005)	25 (World Bank Guideline) 75 Interim Value	• One Sampling Point near the project site another 1 km. away from the project site. • Per month one 24-hr. day sampling • High Volume Dust Sampler
Noise level	dB	70 (Night-time) 75 (Day-time) (Industrial Area) (Env. Rule 1997)	70 (Night-time) 70 (Day-time) (Industrial Area) (World Bank)	• 100m from the construction site • Per Month one 24-hr. day sampling • Sound level meter

Note: For air quality sampling during the construction stage at a radius of 1km distance from the project site is regarded as the limit of area of influence of air pollution

(6) Environmental Checklist

With due consideration to those aspects described above, an environmental checklist was formulated comprehensively for both relevant compressor projects in the gas fields of Narsingdi and Titas-Location C using the oil and gas field sector checklist of JICA. The completed environmental checklist is given in Appendix 8. It is further noted that consultation with external stakeholders is not necessary since the installation of compressors will be confined within the existing property boundary of the gas fields (industrial areas) belonging to BGFCL as also noted in the checklist.

6.1.13 Associated Risks under the Project

In order to smoothly implement the proposed construction projects, several risks should be fully analysed in terms of gas production life, environmental conditions, technical issues, opposition by local residents, exchange rate, contractors' skill, etc. It is desirable that appropriate measures for all the risks are taken before commencement of the construction. The following issues are considered as risks to the projects:

No.	Associated Risk	Responsibility	Measures
1.	**Preparatory Stage**		
1.1	Schedule delay of basic engineering work	BGFCL	Latest reservoir data of Narsingdi and Titas Gas Field (Location C) shall be acquired and provided for the Consultant at an early stage in the basic engineering phase.
1.2	Overall schedule delay due to project approval delay by GOB	BGFCL	1) Early approval of DPP 2) Early contract of SLA
2.	**Implementation Stage**		
2.1	Delay of works and completion	BGFCL/ Consultant/Contractor	1) Progress to be closely monitored in order to timely cope with problems (e.g. lack of understanding on contract, Misunderstanding of procurement schedule, inefficient work procedure, inadequate risk assessment and project management, etc.). 2) Confirmation of delivery period for the longest lead item (gas compressor) 3) Contract indicating: i) Construction deadline ii) Delay penalty by reasons attributed to the Contractor 4) Scheduling in consideration of supposable causes of delay (e.g. Wet season).
2.2	Lack of contractor's ability	BGFCL/ Consultant	1) Selection of qualified Consultant who prepares tender documents and evaluates them. 2) Careful check and review of tender documents submitted by the Contractor 3) Execution of company survey for the Contractor's ability as required 4) Contract indicating "contract-out conditions" by reasons

No.	Associated Risk	Responsibility	Measures
			attributable to the Contractor (e.g. More than five (5) months schedule delay for major milestone, etc.) 5) Submission of client certificate or contract document for the contractor's project experiences
2.3	Imperfect quality	BGFCL/ Consultant/Contractor	1) Submission of qualification certificate for welding and non-destructive testing activity 2) Sufficient design review of the Contractor's design documents 3) Check of quality control records prepared by the Contractor 4) Monitoring of all contractor's activities for taking quick countermeasures 5) Establishment of proper acceptance criteria for all contractor's activities 6) Penalizing the Contractor in case of non-fulfilment of equipment performance
2.4	Cost overrun	BGFCL/ Consultant	1) Monitoring of all contractor's activities for taking quick countermeasures 2) Preparation of appropriate tender documents for prevention of unexpected change orders 3) Progress to be closely monitored in order to timely cope with unexpected problems. 4) Securing of contingency
2.5	Unexpected trouble with the compressor (at the time of first running and commissioning)	BGFCL/ Consultant/Contractor	Assignment of the Manufacturer's supervisor arranged by the Contractor
2.6	Non-fulfilment of compressor performance (at the time of	BGFCL/ Consultant/Contractor	Implementation of Factory Acceptance Test at

No.	Associated Risk	Responsibility	Measures
	commissioning)		Manufacturer's facility
2.7	Accident during field construction work	BGFCL/ Consultant/Contractor	1) Establishment and execution of EHS program 2) Review of construction procedure for all field construction works 3) Assignment of EHS manager and staffs in BGFCL and the Contractor 4) Execution of risk assessment for all field construction work procedures and necessary countermeasures against the possible risks
2.8	Environmental pollution	BGFCL/ Consultant/Contractor	1) Establishment and execution of EHS program 2) Review of environmental protection measures for all field construction works 3) Checking and Monitoring of all waste disposal proceedures 4) Assignment of EHS manager and staffs in BGFCL and the Contractor
3.	**Operation & Maintenance Stage**		
3.1	Incorrect operation of compressor	BGFCL	Acquisition of operational knowledge and technique by operators
3.2	Unexpected trouble with the compressor (during operation)	BGFCL	1) Execution of maintenance agreement with the Manufacturer 2) Acquisition of maintenance knowledge by maintenance staffs under the supervision of the contractor

In addition to the above risks, further risks should be considered during the "Implementation Stage" in case of remarkable changes of wellhead pressure and/or gas production rate against forecast data.

After issuance of the purchase order for the proposed compressor units and related facilities, if wellhead pressure remarkably declines or production rate changes extremely in excess of current production forecast, the detailed design output such as sizing of the separator and piping, capacity and inlet/outlet pressure of the compressors will not be applicable to the changed operating condition.

In such cases, correction of the design work must be required urgently in order to change planned manufacturing works. According to progress of engineering or manufacturing works, additional payment may be claimed as a change order.

6.2 Construction of Gas Transmission Pipeline Dhanua - Elenga and West Bank of Jamuna Bridge – Nalka

6.2.1 Scope of the Project

(1) Location of the Project

- The pipeline between Dhanua and Elenga goes through the following districts and upazilas.

District	Upazila (sub-district)
Gazipur	Sreepur
Mymensingh	Bhaluka
Tangail	Sakhipur
	Kalihati

- The pipeline between the West bank of Jamuna bridge and Nalka goes through the following district and upazilas.

District	Upazila (sub-district)
Sirajganj	Royganj
	Ullah Para
	Kamarkhanda
	Sirajganj Sadar

(2) Scope of the Project

The following table summarizes the Contractor's scope of works which are applied to two (2) proposed pipeline projects, Dhanua-Elenga and West Bank of Jamna Bridge - Nalka. Basically, the Contractor must provide all equipment and materials necessary for the proposed facility including but not limited to, the construction materials listed in the table.

No.	Scope of Works	Remarks
Part 1	**Dhanua- Elenga pipeline**	
1.	Pipe laying 1) Pipe 2) Induction bend 3) Valve station ✓ Valve ✓ Tees 4) In- take/ Off-take Nozzle 5) Pig Launcher/ Receiver (existing) 6) SCADA 7) Cathodic Protection 8) Shrink Tube 9) Insulation Joint 10) Road crossing 11)Railway crossing (Rajabari area) Thrust Boring Method	 30" x 0.562",0.625"(HDD) Spec.: API 5L X60, L-SAW Coating: 3L-PLP Length :52km 30" 5DR 2 stations 30" Ball, Actuator 12", 8" 30" x 12" 7 pieces 1 (relocation) Only cable connection Impressed current anode Test Box Polyethylene Mono block type rating600# Major : 5 Locations (Thrust Boring Method) Minor: 15 Locations Casing pipe :34" or 36" 1 Location
2.	Horizontal Directional Drilling (HDD) Salda river 311.29m Tonki-1 river 327.07m Tonki-2 river 325.9m Bongsi river 365.64m Safai river 315.61m	Total 1,991.12m

No.	Scope of Works	Remarks
	Langalia river 345.61m	
3.	Metering Station Detailed engineering, Procurement, Installation, Commissioning and Testing of Metering Station units, consisting of the following equipment: Following is typical equipment list which will be finalized after detailed design. ✓ Knockout Drum ✓ Filter Separator ✓ Liquid Separator ✓ Water Bath Heater ✓ Pressure Regulator ✓ Flow meter (Orifice Type) ✓ Piping ✓ Electric supply system ✓ Instrument gas system ✓ Power Cables & control cable ✓ Operation Building ✓ All bulk materials required for proposed facility ✓ Relocation works of existing facility (if necessary)	2 stations
4	Preparation of commissioning procedure and operation manual (Metering Station)	
5	Assistance of GTCL for commissioning and start-up work	
6	Preparation of schedule and quality control records	
7	Submission of weekly, monthly progress reports	
8	Submission of EHS management program	To be submitted by commencement of field construction.
9.	Submission of as-built documents	To be submitted within 1 month after facility handover.
10	Defect Liability Period	12 months
Part 2	**West Bank of Jamna Bridge- Nalka pipeline**	
1.	Pipe laying 1) Pipe	 30” x 0.562”,0.625”(HDD)

No.	Scope of Works	Remarks
		Spec.: API 5L X60, L-SAW Coating: 3L-PLP Length :14km
	2) Induction bend	30” 5DR
	3) Valve station	0
	4) In- take/ Off-take Nozzle	1 piece
	5) Pig Launcher/ Receiver	1 set
	6) SCADA	Only cable connection
	7) Cathodic Protection	Impressed current anode Test Box
	8) Shrink Tube	Polyethylene
	9) Insulation Joint	Mono block type rating600#
	10) Road crossing	Major: 3 Locations (Thrust Boring Method) Minor: 7 Locations Casing pipe :34” or 36”
	11) Railway crossing	1 Location
2.	Horizontal Directional Drilling (HDD)	Total 0m
3.	Metering Station Detailed engineering, Procurement, Installation, Commissioning and Testing of Metering Station units consisting of the following equipment: Following are typical equipment, they will be finalized after detailed design. ✓ Knockout Drum ✓ Filter Separator ✓ Liquid Separator ✓ Water Bath Heater ✓ Pressure Regulator ✓ Flow meter (Orifice Type) ✓ Piping ✓ Electric supply system ✓ Instrument gas system ✓ Power Cables & control cable ✓ Operation Building ✓ All bulk materials required for proposed facility	1 station

No.	Scope of Works	Remarks
	Relocation works of existing facility (if necessary)	
4	Preparation of commissioning procedure and operation manual (Metering Station)	
5	Assistance of GTCL for commissioning and start-up work	
6	Preparation of schedule and quality control records	
7	Submission of weekly, monthly progress reports	
8.	Submission of EHS management program	To be submitted by commencement of field construction.
9.	Submission of as-built documents	To be submitted within 1 month after facility handover.
10.	Defect Liability Period	12 months

Further details of the project are described in the following sections.

6.2.2 Status of Related Projects

Recently, GTCL has reinforced the transmission pipeline network in the country. Several parts of the pipeline network are under construction at present and improvement of gas transmission capacity will be expected after the construction. Moreover, they are planning further reinforcement of the pipeline network by construction of some future pipelines. On-going projects and under-planning projects scheduled by GTCL are shown in the following tables.

Table 6.2-1 Pipeline Project (ongoing)

as of July 2013

No.	Project Name	Size	Length	Period	
		(in)	(km)	from	to
1	Bheramara-Khulna	20	165	Jul-07	Jun-14
2	Hatikumrul-Isshardi Bheramara	30	82	Jul-06	Jun-14
3	Bonpara-Rajshahi	12	53	Jul-06	Dec-13
4	Monohodhi-Dhanua, Elenga- East bank of Jamuna Bridge	30	51	Jan-06	Jun-14
5	Ashugonj & Elenga Compressor Station	-	-	Jan-06	Sep-15
6	Bakhrabad-Siddhirgonj	30	60	Jul-07	Jun-14
7	Bibiyana-Dhanua	36	137	Apr-11	Jun-13

8	Ashugonj to Bakhrabad	30	61	Jan-10	Jun-13
9	Moheshkhali-Anowara	30	91	Apr-11	Dec-12
10	Titas-AB	24	8	Jan-09	Dec-12
11	Srikail-AB	20	1.2	Oct-12	Mar-13

Source: GTCL Questionnaire Reply Annex-1 "Projects under implementation of Gas Transmission Company Limited (GTCL)"

Table 6.2-2 Pipeline Project (under planning)

as of July 2013

No	Project Name	Size	Length	Period		Remarks
		(in)	(km)	from	to	
1	Bakhrabad-Feni-Chittagong	30	201	Jul-15	Jun-18	
2	Jalalabad-Bibiyana	24	54	Jul-14	Jun-17	
3	Langalband-Maowa	30	40	Jul-15	Jun-17	
4	Maowa-Zanjira	30	20	Jul-15	Jun-17	
5	Bogra-Rangpur	20	100	Jul-16	Jun-19	
6	Dhanua-Elenga	30	52	Jul-14	Jun-16	Selected
7	West Bank of Jamuna Bridge-Nalka	30	14	Jul-14	Jun-16	Selected

Source: GTCL Questionnaire Reply Annex-1 "Proposed Gas Transmission Pipelines"

In order to reinforce the gas supply to the western industrial area that includes big consumers at Bheramara, Ishiward, Kushtia, Jhinaidah, Jessore, and Khulna, the reinforcement of transmission pipelines is indispensable. The pipeline that covers these areas will be completed by June 2014 as shown in the above table. On the other hand, an upstream pipeline, Bibiyana-Elenga will be completed within this year and also the compressor stations at Ashuganj and Elenga will start operation soon. The 30 inch loop pipeline from Ashuganji to Nalka is currently being operated except for Dhauna-Elenga and the West Bank of Jamna Bridge-Nalka. Therefore, this project is urgently required for the reinforcement of gas supply to the western Industrial area compared with other planned pipelines. This is verified by means of “Pipeline Network Analysis” (Refer to Appendix1).

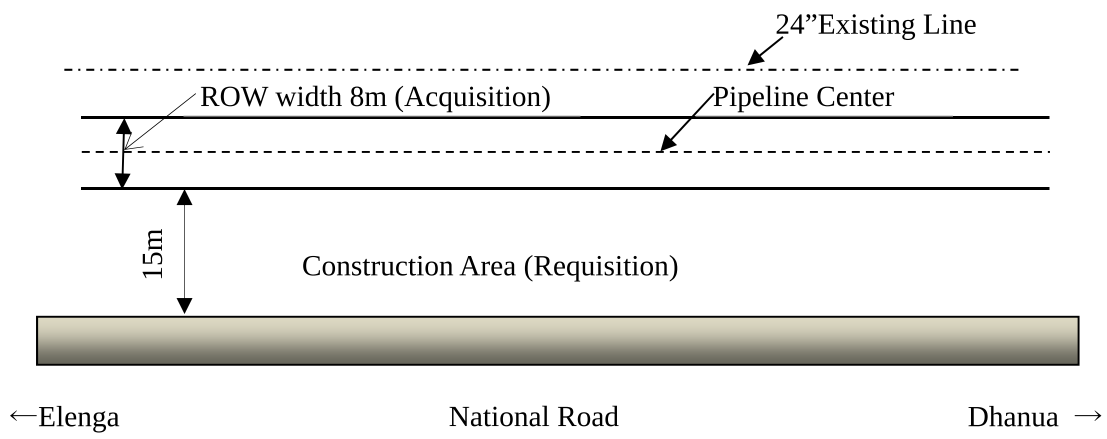
6.2.3 Preliminary Design of the Project

(1) The design of the pipeline and the metering stations will be performed in accordance with ASME 31.8 " Gas Transmission and Distribution Piping Systems" and related US standards.

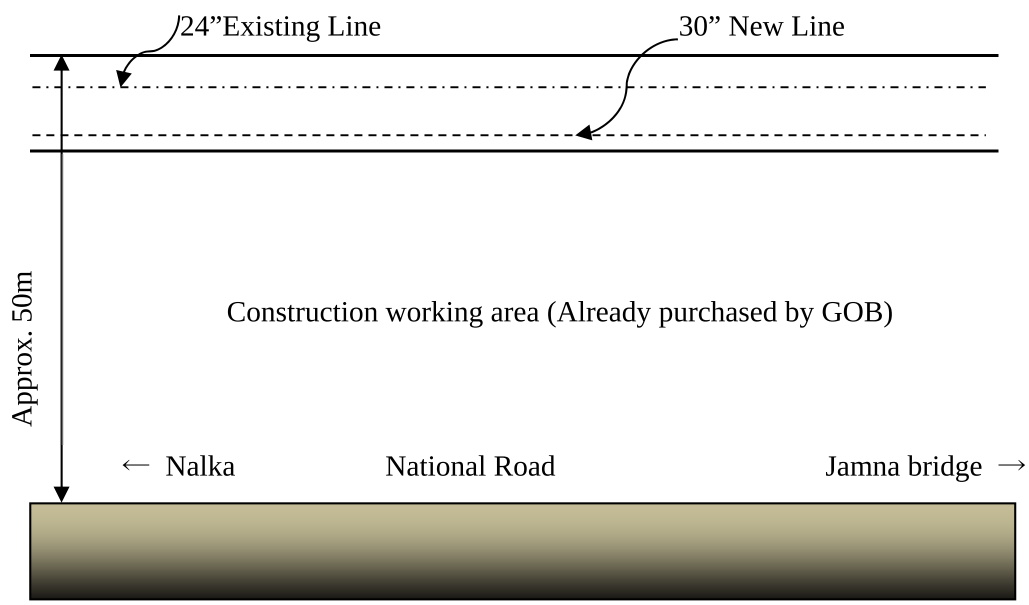
(2) Pipe manufacturing will be done in accordance with API standard 5L "Specification for Line Pipe". Pipe grade is X60 and the wall thickness is 14.3mm in general, 15.9mm in HDD and major crossing areas such as national road crossings and railway crossings.

(3) Pipe coating applied will be three layer polyethylene based on CAN/CSA-Z245.21-M92 "External Polyethylene Coating for Pipe".

(4) Typical Drawing of ROW, Crossings



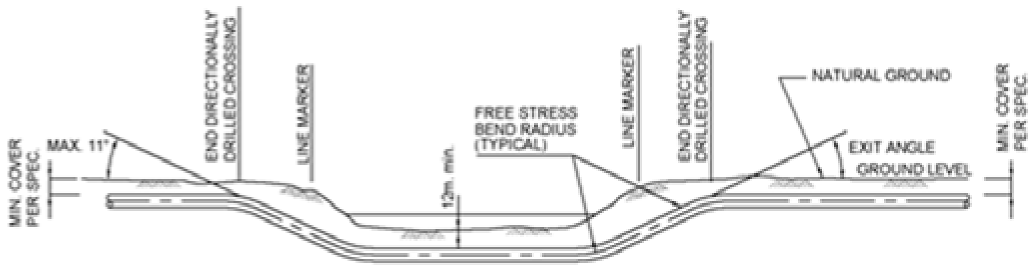
Dhanua- Elenga ROW condition



West Bank of Jamuna Bridge- Nalka ROW Condition

(5) HDD

Typical drawing of HDD for big river crossing is shown as below.

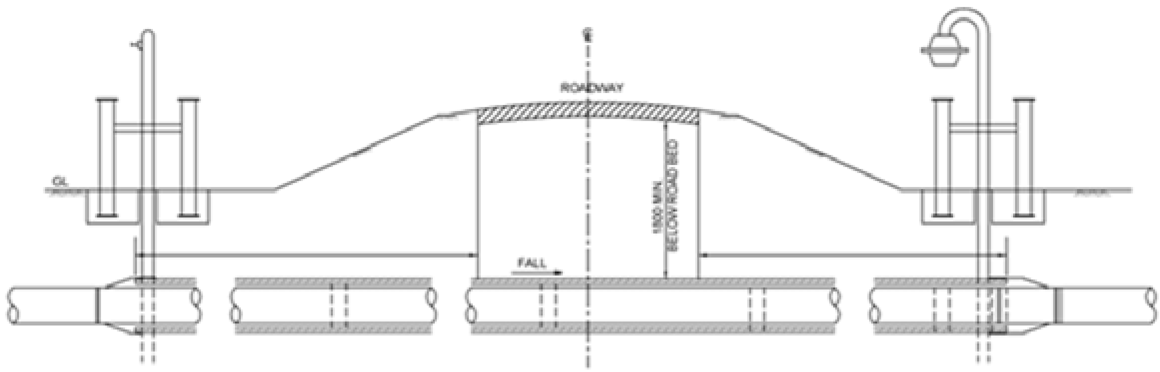


Source: GTCL

Figure 6.2-1 HDD of River Crossing

(6) Thrust Boring (TB) for National Road & Railway crossings

Typical drawing of TB is as shown below.



Source: GTCL

Figure 6.2-2 Thrust Boring of Road Crossing

(7) Metering Stations

Metering stations will be installed at Dhanua, Elenga and near Nalka, in total, three.

Facility configuration of the GTCL standard metering station is as follows;

1) Knockout Drum x 1
2) Filter Separator x 2
3) Liquid Separator x 1

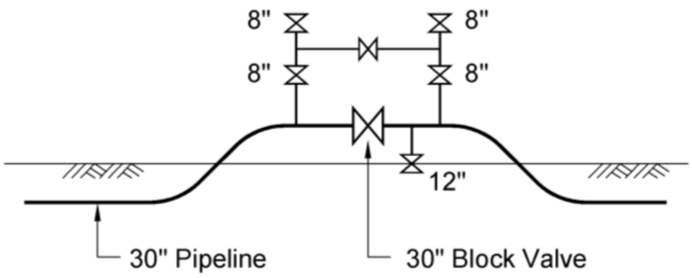
4) Water Bath Heater x min. 2 (Whether it is necessary or not depends on process calculation results)
5) Pressure Regulator x 2 or 3
6) Flow meter (Orifice type) x min. 2

(8) Block Valve Station

Facility configuration of the GTCL standard valve station is as follows;

1) 30” mainline ball valve x 1
2) 12” offtake valve x 1
3) 8” bypass & vent valve x 5

Distance between valve stations is 17 km in GTCL standard.



Source: JICA Survey Team

Figure 6.2-3 Typical Drawing of Block Valve Station

6.2.4 Construction Plan

(1) Access Way

Since there is a well paved national road from Chittagong to Site and also a well paved road runs beside the Right of Way (ROW), transportation of pipes and heavy equipment for construction will be easily carried out.

(2) Weather Condition

In the rainy season, from May to October, almost 70% of the land may be flooded in Bangladesh. For this reason, pipe laying works have been performed in the dry season.

This project is also to be executed in dry season in order to maintain good pipeline quality and safety.

(3) Local Contractor

Two local pipeline contractors were investigated in Dhaka. They have pipeline heavy equipment such as pipe layers, bending machine etc. They also have good track records with transmission pipelines. Considering the above, local the contractors' ability is high and it is possible for them to undertake this project. However, in regard to HDD and Metering stations, they have to rely on a Foreign company.

(4) Permission

1) ROW Acquisition

The land acquisition & requisition proposal will be submitted by GTCL to the respective Deputy Commissioners (DC) after approval of the DPP by ECNEC. After the submission of the proposal, DC office will conduct a feasibility survey and estimate the amount for compensation. Upon depositing the funds for compensation to DC by GTCL, DC will hand over the acquisitioned land and simultaneously start payment to the PAPs. After the approval of DPP by ECNEC and the submission of the proposal for land acquisition and requisition, it will take a minimum of 18 months to complete the above process.

2) Permission for Crossings

In case of crossings such as road crossings, railway crossings and river crossings, prior consultation should be done with the Road Highway Department, Railway Authority or River Authority to obtain their permission. GTCL will obtain the permission with the assistance of the Consultant and the Contractor before starting crossing works, which will be started in September 2016.

(5) Topographic survey and Geological survey

1) Topographic survey

As a preparation step, GTCL normally carries out a route survey for a proposed pipeline by themselves together with a survey company in order to avoid several obstacles such as overpopulated areas, rivers, main roads, faults and so on, as much as possible. Accordingly, the appropriate pipeline route is selected as a result of a detailed survey to be carried out by GTCL personnel and a survey company.

Furthermore, the route survey for the selected pipelines had been previously carried out as a part of ADB funded project, and its result is still available from GTCL.

Therefore, it was confirmed with GTCL that a topographic survey by a Survey Team is not required in this preparatory survey work.

2) Geological survey

For a pipeline construction project, a geological survey is normally not required in the feasibility study phase, since there will be no significant impact on civil design and cost due to the geological conditions.

Therefore, it was confirmed with GTCL that a geological survey by a Survey Team is not required in this preparatory survey work.

(6) Safety Plan

Some of the most common types of pipeline construction accidents are construction site falls, crane accidents, electrical accidents, trench collapse, fires and explosions, and welding accidents.

To prevent such accidents, a safety plan should be prepared by the contractor for GTCL's approval prior to the installation works. This plan should include the contractor's safety scheme, safety measures, communication network in case of accident, etc.

Then, during the construction stage, periodic and also random safety patrols will be carried out by GTCL and/or a contractor in order to ensure that all works are carried out in a safe manner according to the said safety plan with the PDCA (Plan-Do-Check-Act) method.

1) Responsibilities of implementation agency for safe construction are as follows.

a) Dissemination of Information

- Details of Project
- Condition of project site, etc.

b) Confirmation and approval (Evaluates and approves)

- Construction plan by contractor
- Construction schedule by contractor

2) A list of disasters and countermeasures that are predicted during construction period.

a) Use safety equipment at all times and wear appropriate protection, such as:

- Safety helmet properly fastened
- Safety Shoes
- Gloves
- Ear protectors
- Dust glasses
- Safety belt and rope

Keep safety equipment properly maintained and in good condition after use.

b) Pay attention to the following:

- Do not run or jump

・Watch your step
・Watch against bumping your head.
・Turn your head when walking backwards.
・Avoid lifting too heavy materials.

3) Construction Accident and Control Measures

Construction Accident	Control Measures
Crane Accidents	・Keep the cargo weight limit. ・Select the suitable type of crane based on the Crane Specification ・Keep workers out of the crane working area. ・Set outriggers to avoid tipping the crane over. ・Arrange decking so that the crane does not sink. ・Set the crane level on the ground. ・Attach an assist rope for long material. ・Don't get below the cargo ・Appoint a signalman and signal the instructions for the operator.
Electrical Accidents	・Have all electric equipment checked regularly by a qualified electrician. ・All equipment must be in good condition and shall be grounded properly. ・Carry out cable insulating properly. ・Avoid submerging electric cable under water, except for insulated cable when necessary. ・Do not use any electric equipment in poor condition or in wet condition. ・Electric hand tools shall be protected by earth leakage or similar safety cut out switches which activate immediately in case of sudden increase in current.
Welding Accidents	・Before work starts, check equipment as follows: ·Acetylene welder – ensure absence of leakage along the hose to be used. ·Electric welder – ensure all insulating systems are in good condition ・Always wear appropriate safety equipment: ·For welding: wear helmet, eye protector, gloves, safety shoes, etc. ・Use grounding for welding machine ・Provide adequate air circulation such as blower during welding . ・Never perform welding near inflammable objects.
Falls	・Edges of excavations should be protected with substantial barriers where people are liable to fall into them. ・Barricade hazardous areas

Construction Accident	Control Measures
	・All works carried out above the ground level or wherever the risk of falling exists, shall be aided with platforms, catwalks, scaffolds, ladders and any other means to prevent the risks of falling. ・Use of safety belt shall be compulsory. Their mooring lines shall be short enough not to allow a free fall greater than 1.5 m. ・Check thoroughly working platform and scaffolding before using. ・Scaffolds, working platforms, etc. shall have a minimum width of 60 cm and they shall be equipped with railings. ・Cover holes in floors. ・Use safety belt in the absence of handrails or scaffoldings.
Trench Collapses	・The need for adequate support will depend on the type of excavation, the nature of the ground and the ground water conditions. ・Keep machinery, material and soil heaps at sufficient distance to avoid collapse of the sides of the excavation ・After rain, check ground condition and report immediately any presence of cracks. ・Keep water out of trench
Fires	・Open fires are prohibited ・Know where firefighting equipment is located and be trained on how to use it. ・Never perform welding near inflammable objects. ・All site personnel are required to confirm that there are no live fires left behind before leaving their working place.

Safety activities of GTCL, the executing agency of the gas pipeline project are controlled by the Health & Safety Engineering Department.

(7) Lessons from previous projects

GTCL had an experience with a supplier who failed to supply piping materials due to a rise in the market price and had to be terminated. Thereafter, GTCL added the price adjustment clause in the contract document to avoid such situation. This case should be considered when tender documents are prepared by the Consultant.

6.2.5 Package for the Procurement of the Project

As a result of a series of discussions among GTCL, JICA and the Survey Team, it was agreed to divide the project procurement into the following packages instead of a full turnkey contract, in order to prevent project cost increase.

Contract Package	Selection Method
(1) Consulting Service	Short Listing, QCBS (80%:20%) JICA Standard Request for Proposal (SRFP) [Consultants]
(2) Material & Equipment	International Competitive Bid (ICB) 2 envelope 1stage (JICA Standard Bidding Document (SBD) [Goods])
(3) Pipe laying	Local Competitive Bid (LCB)
(4) Horizontal Directional Drilling (HDD)	ICB with PQ, 2 envelope 1 stage JICA SBD [Work]
(5) Metering Station (Detail Design)	ICB with PQ, 2 envelope 1 stage JICA SBD [Plant]

(1) Consulting Service Contract

The consultant will be selected according to the following guidelines and standard documents for bidding prepared by JICA.

- Guidelines for the Employment of Consultants under Japanese ODA loans
- Standard Request For Proposals Under Japanese ODA Loans
  for Selection of Consultants (October 2012)

The selection procedure of the Consultant is as follows;

1) Preparation of Terms of Reference (refer to Appendix 3)
2) Preparation of Short List of Consultants
   - The consultants have satisfactory overseas experience of the consulting services concerned (e.g., detailed design, supervision)
   - Consultants must have experience in a developing country
   - The number of the short-listed consultants is 3 to 5
3) Preparation of Letter of Invitation
4) Sending of the Letter of Invitation to Consultants
5) Evaluation of Proposals
   - Evaluation of Consultants' proposals will be executed based on the evaluation criteria.
   - Final result should be approved by the Board and JICA's concurrence.
   - Contract Negotiation

- Informing Unsuccessful Consultants

Since gas pipelines are quite familiar to consultants in Bangladesh, the assignment of a highly specialized consultant is not needed to manage the project. Therefore, the Quality-Cost-Based Selection (“QCBS”) method is recommended for the consultant selection with the ratio of 80% for the quality and 20% for the cost.

(2) Material & Equipment Contract

The Material & Equipment Vendor or Trading company will be selected in accordance with the following standard documents for bidding prepared by JICA.

- Standard Bidding Documents under Japanese ODA Loans- Procurement of Goods- May 2013
- ICB with PQ and Single-Stage 2 envelope method will be applied.

(3) Pipe laying Contract

Several contractors in Bangladesh are well experienced in pipeline projects and deeply versed in the pipe laying method in this country. Furthermore, they have the heavy equipment necessary for pipeline construction, such as pipe layers, bending machines, internal clamps, etc.

For above reason, the pipe laying contractor will be selected by Local Competitive Bid procedure in accordance with the standard documents of the Central Procurement Technical Unit (CPTU) for procurement of goods, works and services.

(4) Horizontal Directional Drilling (HDD) Contract

The contractor will be selected by ICB with PQ in accordance with the following standard documents for bidding prepared by JICA.

- Standard Bidding Documents Under Japanese ODA Loans – Procurement of Works- October 2012
- ICB with PQ and Single-Stage 2 envelope method will be applied.

(5) Metering Station Contract (Design and Build contract)

The Metering Station Contractor will be selected by ICB with PQ in accordance with the following standard documents for bidding prepared by JICA.

- Standard Bidding Documents under Japanese ODA Loans –Procurement of Plant Design, Supply and Installation- February 2013
- ICB with PQ and Single stage, 2 envelope method will be applied.

(6) Possibility for the Utilization of Local Consultants and Contractors

Concerning the pipeline construction, some local contractors have a good ability and the heavy equipment for pipe laying. For this reason, local competitive bidding is recommended for the pipe laying contract.

Regarding Consulting Service, there is some possibility to join the project together with international consultants, since they have experts such as civil engineers, mechanical engineers, electrical engineers, etc.

6.2.6 Consulting Services

The Consultant will keep GTCL and JICA fully informed on all matters relating to the Services and the Project at all times during the period of the Services. This can be done through oral communications and will be confirmed by the submission of letters, monthly, weekly and other reports in writing, all as appropriate for the purpose.

(1) Scope of Works of the Consultant

The services of the consultant are to undertake the necessary conceptual study, design, engineering, project management and execution including supervision of construction, and commissioning.

The Consulting Services for the project shall be carried out in accordance with the following major scope of works:

Task A: Services for Pre-Construction Stage

A.1 Project Management

A.2 Review of Existing Data and information

A.3 Basic Engineering & Detailed Engineering

A.4 Preparation of Bid Documents and Assistance with Bid

A.5 Environmental considerations

Task B: Services for Construction Stage

B.1 Project Management Plan (Construction Stage)

B.2 Review of Contractor’s Detailed Design (Metering Station only)

B.3 Assistance with Procurement (Material & Equipment; Metering Station)

B.4 Supervision of Construction

B.5 Environmental Monitoring

B.6 Monitor Commissioning Work

Task C: Service for Post-Construction Stage

C.1 Final Acceptance

C.2 As-built Documents

(2) Reports and Documents

The consultant shall prepare and submit to GTCL the following documents and reports.

1) Inception Report (including schedule)
2) Engineering Report (including basic design report)
3) Construction schedule and cost estimate
4) Draft of pre-qualification documents
5) Draft of Bid documents
6) Draft of evaluation criteria and method of pre-qualification
7) Draft of evaluation report of pre-qualification
8) Draft of evaluation criteria and method of international competitive bidding
9) Draft of evaluation report of international competitive bidding
10) Monthly progress report
11) Quarterly progress report
12) Project completion report

(3) Expertise Requirements

The engineering services shall be provided by foreign and local consultants, which shall include but not be limited to the following:

International Consultant

1) Project Manager (Team Leader)
2) Pipeline Engineer
3) Mechanical Engineer (Valve, Metering station Equipment)
4) Electrical Engineer (Cathodic Protection, Metering Station)
5) Instrument Engineer (Metering Station)

6) Civil & Building Engineer (Metering Station)
7) Process Engineer (Metering station)
8) Contract Manager
9) Environmental Engineer
10) Construction Manager (All construction and QA/QC)

Local Consultant

1) Deputy Project Manager (Local Team Leader)
2) Document Specialist (Tender Documents and Letters etc.)
3) Environmental Engineer
4) Welding Engineer
5) EHS Specialist
6) QA/QC Engineer
7) Pipeline Engineer
8) Mechanical Engineer (Metering station Equipment)
9) Piping Engineer (Metering station piping)
10) Civil Engineer (Pipeline & Metering station)
11) Building Engineer (Metering station)
12) Electrical Engineer (Metering station)
13) Instrument Engineer (Metering station)
14) NDT Inspector (X-ray film check)
15) Inspectors (check for defect in pipes, coating etc.)

(4) Duration of Service

The engineering service shall cover the duration of 52 months, starting from the commencement of consultant services to the completion of the project.

1)	Basic & Detailed Design	:	6	months
2)	Tender Document Preparation	:	2.5	months
3)	PQ , Evaluation and Tender Stage	:	4	months
4)	Evaluation, Negotiation and Contract Stage	:	3.5	months
5)	Detailed Design by Contractor	:	6	months
6)	Procurement of Pipe & other material	:	12	months
7)	Construction/Installation Stage	:	18	months
8)	Defect Liability Period	:	12	months
9)	Foreign Consultant	:	125	Man-Months

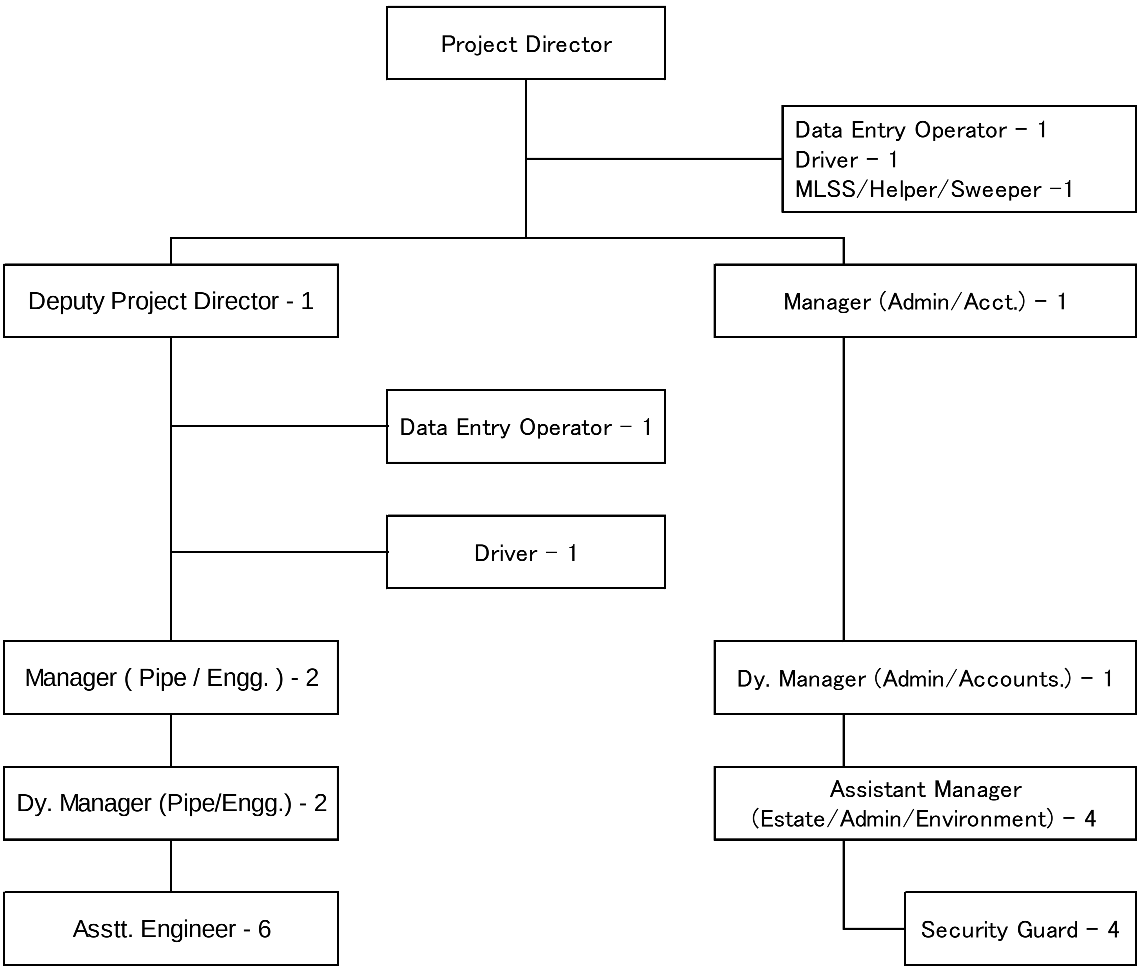
10) Local Consultant : 210 Man-Months

The detailed terms of reference (TOR) for the Engineering Consultancy Services is given in Appendix 3 of this Report.

6.2.7 Organization for the Project Implementation and O&M

GTCL have a great deal of experience with pipeline projects, so they are familiar with the pipeline project under the ADB and World Bank loan. Organization charts for the project implementation and O&M are proposed as follows.

(1) Implementation



Source: JICA Survey Team based on the information from GTCL

Figure 6.2-4 Organization Chart for Project Implementation

- Manpower requirements for execution of the project will be arranged from the existing manpower of GTCL. No extra manpower will be recruited.
- It is recommended that the Project Director and Deputy Project Director are assigned from the DPP preparation stage and other members will be assigned according to the progress and requirements of the project. All members will work full-time.
- Key members need to be assigned from the detailed design stage.
- A weekly coordination meeting among BGFCL, the Consultant and Contractor, monthly meetings to report to JICA, ad hoc meetings to solve some important problems etc. should be held timely among project members.
- On the job training (OJT) will be carried out for freshmen under an expert’s guidance for the engineering and construction of the pipeline and metering stations.

Work responsibility schedule for the Project Implementation of Gas Pipeline Project

Position	No	Responsibility	Assignment Before
Project Director	1	Provide effective line management on the implementation of the project.	DPP preparation
Deputy Project Director	1	Will work under respective Manager/Project Engineer and to assist his reporting officer for doing the responsibilities assigned as mentioned above.To act as Environment, Health and Safety（EHS）Manager in this Project.	DPP preparation
Manager (Pipeline Engineering)	2	To organize pipeline engineering activities	Consultant Selection
Manager (Admi. Accountant)	1	To organize financial/ accounting activities	Procurement of materials
Deputy Manager (Pipeline Engineering)	2	To assist Manager	Detail Design (by Consultant)
Deputy Manager (Admi.Accountant)	1	To assist Manager (Admi. Accountant)	Procurement of materials
Assistant Engineer	6	To supervise contractor's activities	Construction
Deputy Manager (Admi.Accountant)	2	To assist Manager (Admi. Accountant)	Procurement of materials
Assistant Manager (Estate/Admin/Finance)	4	To work by means of instruction of Deputy Manager	Construction
Computer Operator	2		As required
Driver	2		As required
Office Boy	1		As required
Security Guard	4		As required
TOTAL	27		

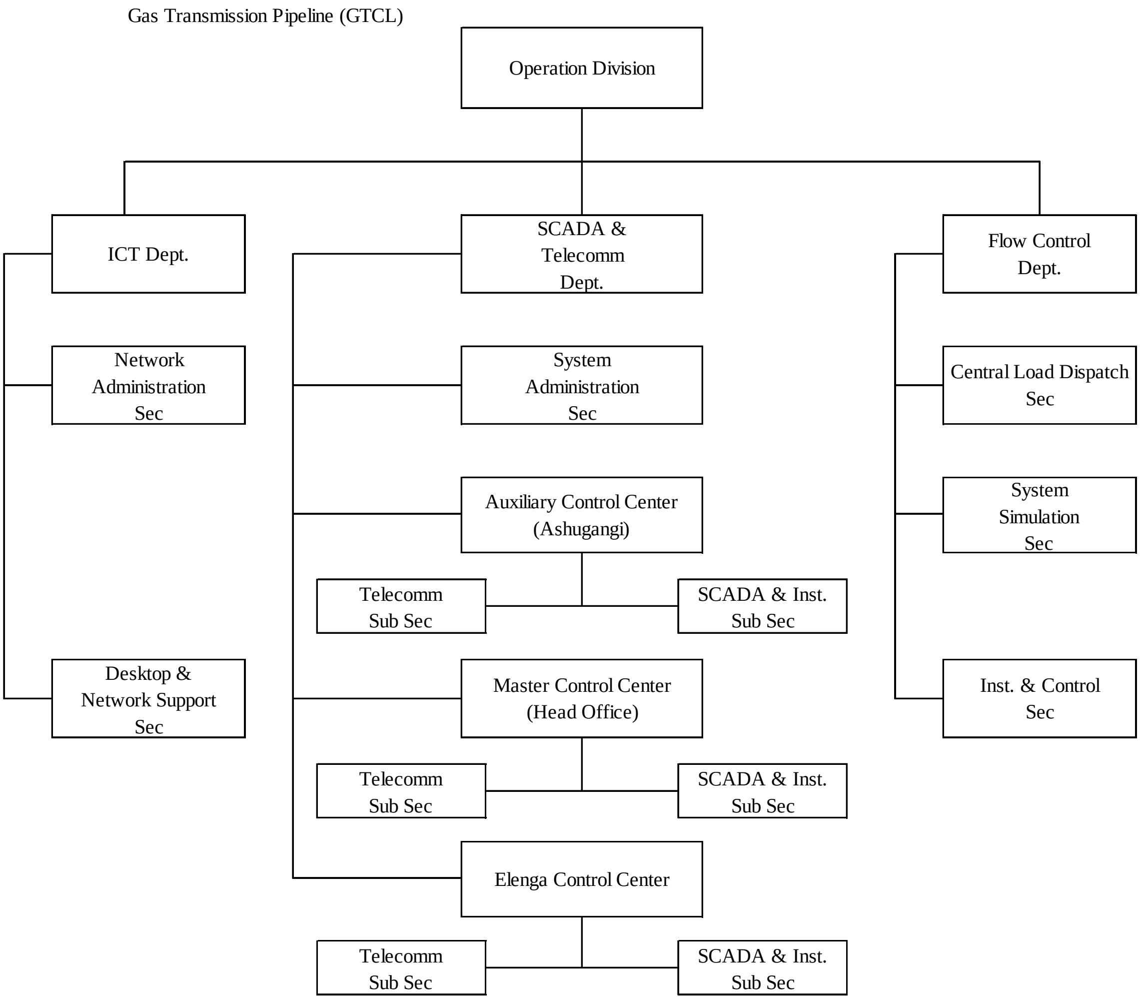
・Requirement of manpower for execution of the project will be met from Company set-up.

・No extra manpower will be recruited.

(2) Operation and Maintenance

1) Operation Division

The Operation Division is a separate division responsible for gas wheeling, load dispatch, load monitoring and overall load management including SCADA control.

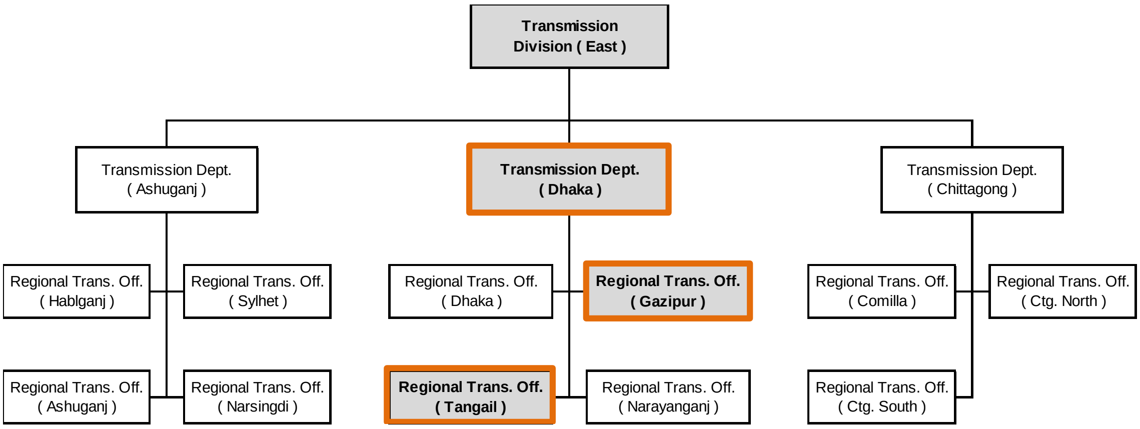


Source: JICA Survey Team based on the information from GTCL

Figure 6.2-5 Organization Chart of GTCL's Operation Division

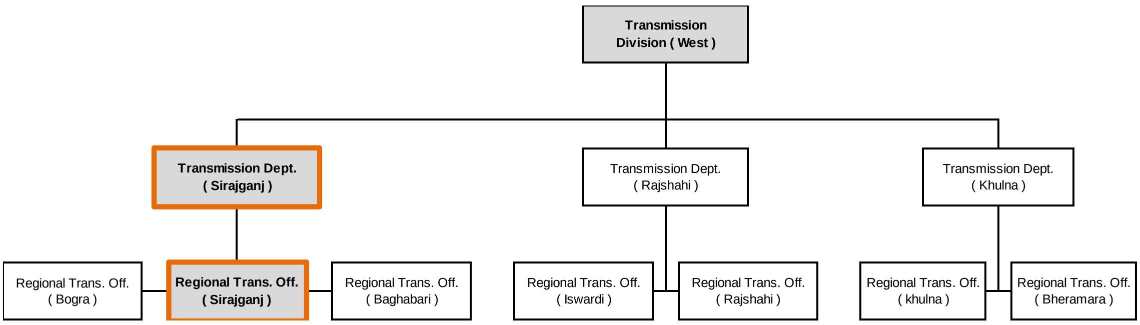
2) Transmission Division

The transmission division is responsible for the whole gas transmission network, and is divided into East and West Divisions. The Dhanua – Elenga pipeline will be operated under the East Division, and the West Bank of Jamuna Bridge – Nalka pipeline will be under the West Division as shown in Figure 6.2-6 and Figure 6.2-7.



Source: JICA Survey Team based on the information from GTCL

Figure 6.2-6 Organization Chart of Transmission East Division

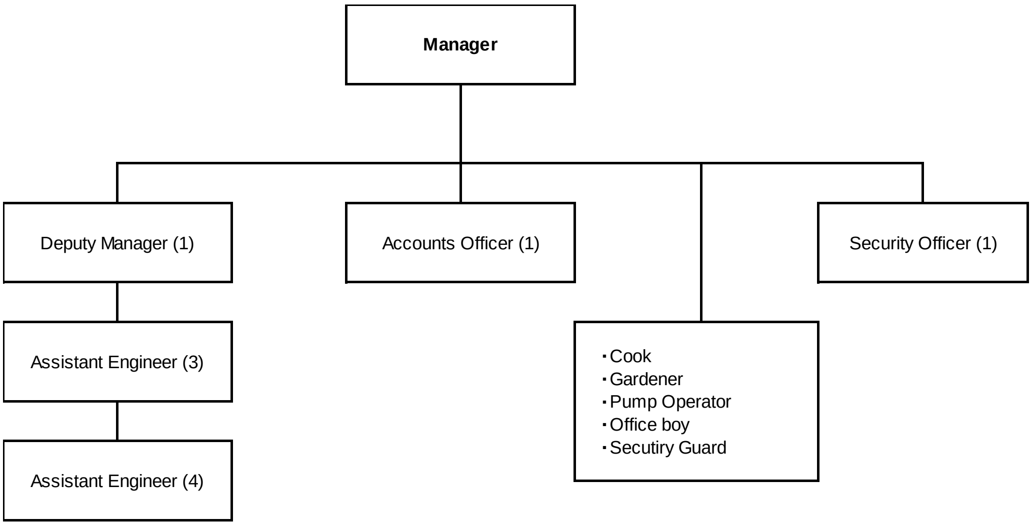


Source: GTCL

Figure 6.2-7 Organization Chart of Transmission West Division

3) Regional Transmission Office

Regional transmission offices are responsible for gas transmission activities, safety and security of the pipelines, ROW and all above ground installations. Gas metering and regulation activities are the prime responsibility of the regional transmission offices.



Source: JICA Survey Team based on the information from GTCL

Figure 6.2-8 Organization Chart of Regional Transmission Office

- Operation and maintenance for the pipelines to be constructed by the project will be covered by the existing operation and maintenance team of GTCL without recruiting additional staffs.
- Key members need to be educated from the detail design stage.

Work responsibility schedule for O&M of Gas Transmission Pipeline Project

Position	Number	Responsibility
Manager	1	To manage and monitoring smooth load balancing in accordance with the HQ instruction
Deputy Manager	1	To manage and review load balancing
Assistant Engineer	3	To make a daily report and send to HQ
Shift Operator	4	To operate and monitoring load balance
Accounts Officer	1	To control accounting the regional office
Security Officer	1	To check security control in the regional office
Total	11	

・All staffs are GTCL members.

・No additional employment will be necessary, since on-going project will be completed at the start of this project.

6.2.8 Project Implementation Schedule

The Project Implementation Schedule is proposed as shown in the Figure 6.2-9, and the schedule of each phase of the Project is explained below.

(1) Preparatory Phase

GTCL should prepare the DPP and obtain approval from the government prior to the loan agreement.

(2) Implementation Phase-1 (Procurement)

1) Selection of Consultant

After the loan agreement is concluded, GTCL will select a consultant. Nine months will be needed for the selection of a consultant in consideration of the necessary processes such as preparation of the terms of reference (“TOR”), tender, evaluation and contract.

2) Selection of Supplier & Contractors

GTCL and the consultant will select a supplier and contractors for the following packages which are described in Section 6.2.5.

a) Procurement of Material and Equipment (ICB)
b) Pipe laying work (LCB)
c) Horizontal Directional Drilling (HDD) work (ICB)
d) Design and Build of Metering Stations (ICB)

Fifteen months will be needed for each selection in consideration of the necessary processes such as basic design, detail design (necessary only for HDD work), preparation of tender documents, prequalification (“PQ”), tender, evaluation, negotiation and contract.

(3) Implementation Phase-2 (Detail Design & Installation)

The implementation schedule of each package will be as follows:

1) Procurement of Material and Equipment

Procurement of material and equipment will be carried out by the selected supplier in consideration of the implementation schedules of other succeeding packages. Total procurement period will be 18 months.

2) Pipe Laying

Pipe laying will be carried out in two dry seasons by the selected local contractor. Total construction period will be 20 months.

3) HDD work

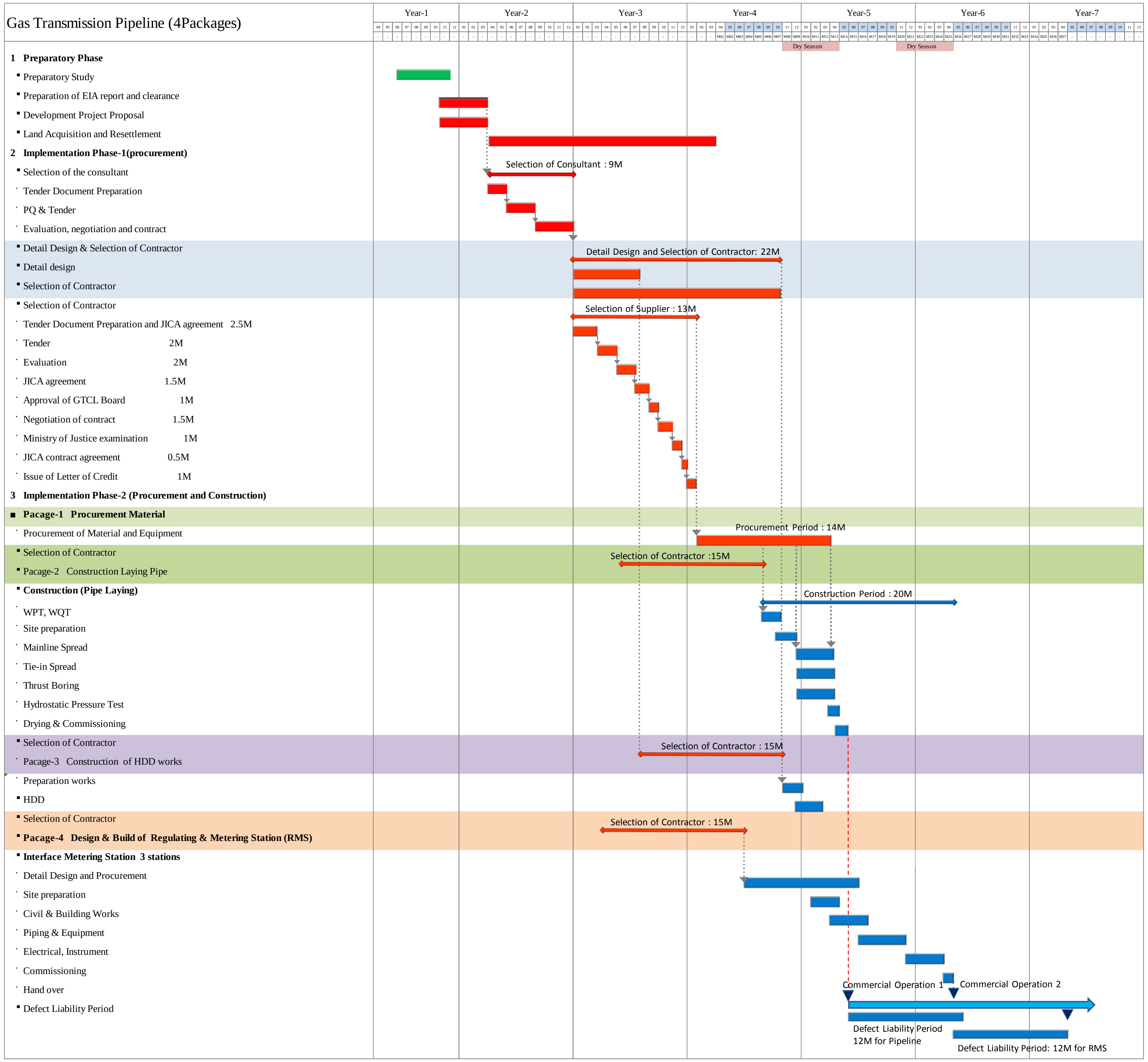
HDD work will be carried out in one dry season by the selected contractor. Total construction period will be 6 months.

4) Metering Stations

Detail design, procurement and construction of three metering stations will be executed by the selected contractor. Total period of this package will be 22 months.

5) Defect Liability Period

Defect liability period of each construction package will be 12 months after the completion of each package.



Source: JICA Survey Team

Figure 6.2-9 Project Implementation Schedule of Gas Transmission Pipeline (Dhanua - Elenga and West Bank of Jamuna Bridge – Nalka)

6.2.9 Project Cost

The Project Cost is composed of the following items,

Table 6.2-3 Composition of Project Cost for Gas Transmission Pipelines

No.	Item	Remarks
A	Eligible for ODA loan	
1)	Construction cost of Gas Transmission Pipeline	
2)	Project management cost (cost for consulting service)	
3)	Dispute Board Fee	
B	Non-eligible for ODA loan	
1)	Land Acquisition cost and Land requisition Cost	
2)	GTCL’s administration cost	
3)	Bank charge cost	
4)	VAT and Custom duties	

And, the following rates are adopted in this estimate based on the survey and recent project data in Bangladesh.

Table 6.2-4 Precondition of Cost Estimate for Gas Transmission Pipelines

No.	Item	Rate
1.	Price escalation (Foreign Portion)	1.3%
	Price escalation (Local Portion)	3.4%
2.	Physical Contingency	5%
3.	Interest during construction	0.01%
4.	TAX	25% (VAT: 15% + AIT: 10%)
5.	Custom Duty	42.3% on Cost Freight Value
6.	Administration cost	4% of the Project cost
7.	Bank charge cost	1% of the Project cost

The exchange rates used in this estimate are as follows:

1)	1 USD=99.7 JPY
2)	1 USD=77.8 BDT
3)	1 BDT=1.28 JPY

According to the above composition and preconditions, the total Project cost is estimated based on the Project implementation schedule “Figure 6.2-9” in Section 6.2.8 as well as the results of studies described in other chapters. Table 6.2-5 is the summary sheet of the total Project cost estimate.

Table 6.2-5 Project Cost of Gas Transmission Pipeline (GTCL)

	Item	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local
			[1,000 JPY]			[1,000 BDT]			[1,000 USD]	
	Eligible Portion									
a	Gas Transmission Pipeline (a1+a2+a3+a4+a5)	5,159,324	3,035,076	2,124,247	4,030,722	2,371,153	1,659,568	51,748	30,442	21,306
a1	Pipe line Laying	1,914,240		1,914,240	1,495,500		1,495,500	19,200		19,200
a2	Pipe procurement	2,541,562	2,468,834	72,727	1,985,595	1,928,777	56,818	25,492	24,763	729
a3	HDD	299,100	299,100		233,672	233,672		3,000	3,000	
a4	Metering Station	312,000	174,720	137,280	243,750	136,500	107,250	3,129	1,752	1,377
a5	Dispute Board	92,422	92,422		72,205	72,205		927	927	
b	Contingency (b1+b2)	715,421	309,460	405,961	558,923	241,766	317,157	7,176	3,104	4,072
b1	Price Contingency on A F 1.3% L 3.4%	435,671	150,197	285,474	340,368	117,341	223,027	4,370	1,506	2,863
b2	Physical Contingency on A 5.0%	279,750	159,264	120,486	218,554	124,425	94,130	2,806	1,597	1,208
c	Consulting Service	544,359	352,013	192,346	425,280	275,010	150,270	5,460	3,531	1,929
d	Contingency (d1+d2)	70,738	33,537	37,201	55,264	26,201	29,063	710	336	373
d1	Price Contingency on A F 1.3% L 3.4%	41,447	15,177	26,270	32,381	11,857	20,524	416	152	263
d2	Physical Contingency on A 5.0%	29,290	18,360	10,931	22,883	14,343	8,540	294	184	110
A	**Total of Eligible Portion (a+b+c+d)**	6,489,841	3,730,086	2,759,754	5,070,188	2,914,130	2,156,058	65,094	37,413	27,681
	Non Eligible Portion									
e	Administration Cost (including Bank Charge 1%) 5%	445,414		445,414	347,979		347,979	4,468		4,468
f	House compensation	22,848		22,848	17,850		17,850	229		229
g	Contingency (g1+g2)	2,569		2,569	2,007		2,007	26		26
g1	Price Contingency on A F 1.3% L 3.4%	1,358		1,358	1,061		1,061	14		14
g2	Physical Contingency on A 5.0%	1,210		1,210	946		946	12		12
h	Land Acquisition & Requisition	2,149,010		2,149,010	1,678,914		1,678,914	21,555		21,555
i	Contingency (i1+i2)	244,003		244,003	190,628		190,628	2,447		2,447
i1	Price Contingency on A F 1.3% L 3.4%	130,050		130,050	101,602		101,602	1,304		1,304
i2	Physical Contingency on A 5.0%	113,953		113,953	89,026		89,026	1,143		1,143
j	Custom Duties、 VAT and AIT (j1+j2)	3,461,452		3,461,452	2,704,259		2,704,259	34,719		34,719
j1	VAT : 15% & AIT: 10%	2,229,548		2,229,548	1,741,835		1,741,835	22,363		22,363
j2	Custom Duties on Foreign Portion of A 42.3%	1,231,903		1,231,903	962,424		962,424	12,356		12,356
k	Interest During Construction 0.01%	2,122	2,122		1,658	1,658		21	21	
B	**Total of Non Eligible Portion (e+f+g+h+i+j+k)**	6,327,417	2,122	6,325,295	4,943,295	1,658	4,941,637	63,465	21	63,443
	Grand Total (A+B)	12,817,258	3,732,209	9,085,049	10,013,483	2,915,788	7,097,695	128,558	37,434	91,124

Source: JICA Survey Team

6.2.10 Economic and Financial Analyses

(1) Outline of Economic and Financial Analyses of the Project

The evaluation and computation of the financial internal rate of return (FIRR) and economic internal rate of return (EIRR) including sensitivity analysis were carried out for the Project on an incremental basis of the comparison between “with project” and “without project” scenarios. The cash flow is projected and the financial and economic viability of the Project are examined.

(2) Key Assumptions Used for Financial Analysis

1) Inflation

- Price escalation for the foreign currency components: 1.3 % per annum
- Price escalation for the domestic currency components: 3.4 % per annum

2) Increase of gas price

It is assumed that the gas price will have increased for the project implementation at 9% every year, as the average increase rate in gas price to all sectors for last 32 years[12] has been 9%.

3) With-project and Without-project Scenarios

The financial analysis considered only the increase in revenues and costs directly associated with each project component. Therefore, the revenues and costs of existing systems are not considered.

4) Financing

It is assumed that the majority of the total initial investment cost including IDC will be financed with a yen-denominated soft loan from JICA, which is sublet to executing agencies from GOB on the basis of the Subsidiary Loan Agreement. These loan conditions are given below:

a) Yen-denominated soft loan

- Interest rate: 0.01 % per annum
- Repayment period: 40 years including 10 year grace period (The grace period starts in the year of the first disbursement of the loan.)

b) Subsidiary Loan to each executing agency from MOF

Conditions of SLA such as interest rate, repayment period including grace period and debt equity ratio for each executing agency are described in the Section of the financial analysis for the Project.

[12] It is considered that the period when gas price increases is 35 years, because project period is 35 years. However, the data of gas sales volume for last 35 years was not collected so that such data for last 32 years was utilized

(3) Key Assumptions Used for Economic Analysis

1) Economic costs

In the economic analysis, we use true economic prices instead of often-distorted financial or market prices. For this purpose, we disregard all transfer payments within the country, such as taxes and duties. Then, we convert distorted market prices into economic prices by multiplying them by conversion factors. As far as the Project is concerned, while no "border distortion" is assumed, domestic currency components of the initial capital investment are expected to be subject to domestic distortion. In particular, wage rates of unskilled labour tend to exceed "opportunity-cost" wages. For simplicity, we use the standard conversion factor of 0.97[13] in our calculations, to be applied to market prices of all domestic currency components.

2) Economic Discount Rate

A 12% economic discount rate[14] is used as a cut-off rate for the Project to evaluate whether the Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

(4) Financial Analysis for Gas Transmission Pipelines

For the GTCL, the construction of pipelines is used to reinforce gas transmission capacity and to reduce the disparity of natural gas supply to the western part of the country.

1) Initial Investment Costs

As described earlier in this report, the total cost of the eligible portion for the transmission pipelines including consulting service is estimated at approximately US$ 65 million. With administration cost, house compensation, land acquisition & requisition, VAT & AIT and custom duties, the total initial investment cost (excluding IDC) is estimated at approximately US$ 129 million. Table 6.2-5 in Section 6.2.9 shows the estimate of the initial investment costs.

2) O&M Costs

The estimated amount necessary for O&M works for the Project, excluding price escalation, will be around BDT 25 million per year. Approximate operating expenditures include personnel positioning and staff assignment, vehicles and consumable parts. The breakdown of O&M costs is as follows:

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[13] The standard conversion factor of 0.97 is used, referring to ADB report, "Third Natural Gas Development Project"

[14] The 12% of economic discount rate is used, referring to ADB report, "Natural Gas Access Improvement Project"

Table 6.2-6 Breakdown of O&M Costs for Gas Transmission Pipelines

(Unit: 1,000 BDT/year)

Work Item	Annual Cost
Personnel positioning and staff assignment	12,100
Vehicles	9,000
Consumable parts	3,500
Total	24,600

Source: JICA Survey Team

3) Conditions of SLA

- Interest rate: 4% per annum
- Repayment period 15 years including 5 years grace period
- Currency: Bangladesh Taka
- Debt equity ratio: 60 : 40[15]

4) Others

Other key assumptions used in our analysis are as follows:

- Depreciation: 30-year straight line
- Corporate income tax: 37.5%

Property taxes or working capital requirements are not considered in projecting the cash outflow stream. Potential revenues other than sales revenue, such as interest earnings, are not taken into account either, since they will be comparatively small.

5) Increase in the Volume of Gas Supply

The construction of transmission pipelines contributes to reinforcing gas transmission capacity to the western part of the country. The increase in gas volume that is supplied as a result of the investments would be 150 MMSCFD.

6) Revenue

The GTCL derives its revenue from its transmission margin (wheeling charge) on gas volumes transported. For analysis purposes a rate of USD 0.145/MCF (Taka 0.32/m^3) for GTCL's margin is used.

7) Weighted Average Cost of Capital

Refer to Section 6.1.10 (4) 7) for the explanation of WACC.

[15] This is the information referring to MoF's "Lending and Relending Terms of Local/Foreign Currency Loans" for Petrobangla.

The following are the assumptions that are laid down for the project:

- Cost of Equity = 17% p.a. (before tax)
- Equity／(Equity + Debt) = 20%
- Debt Cost = 4% p.a.
- Debt／(Equity + Debt) = 80%
- Corporate Tax Rate = 37.5%

Those assumed figures are inserted into the formulae to draw the output rates for WACC as follows;

WACC = 8.58%

As a result of the above exercise, the weighted average of capital costs is 8.58% on the basis of before tax. We conclude this section by confirming that the project is to be deemed viable when the project FIRR will be found at above the WACC of 8.58%.

(5) FIRR on the Total Investment Cost (Project FIRR)

To confirm the underlying financial viability or the true soundness of the Project, the financial internal rate of return (FIRR) of the Project was calculated. The revenue and costs for gas transmission pipelines are summarized in the below table.

Table 6.2-7 Costs and Revenue of Gas Transmission Pipelines for Financial Analysis

Costs:	Construction cost of gas transmission pipelines, project management cost, dispute board fee, land acquisition cost and land requisition cost, GTCL's administration cost, taxes, IDC and operation& maintenance
Revenue:	Gas revenue (transmission margins) from incremental volume of gas supply to western part of the country

Source: JICA Survey Team

The result of the calculation of the FIRR is as follows.

FIRR: 11.67%

The FIRR is at 11.67%, which exceeds 8.58%, WACC. Therefore the Project is regarded as financially viable.

Table 6.2-8 Project FIRR for Transmission Pipelines

(Thousand USD)

Project Year	Project Life	Cash Inflow					Cash Outflow							Net Cash Flow for		
		Owned Capital	Foreign Loan	Domestic Loan	Operating Revenue	Total Revenue	Capital Costs	O&M Costs	Interest Foreign Loan	Interest Domestic Loan	Repay Foreign Loan	Repay Domestic Loan	Total Cost	Cash Balance	Project IRR	Cumulative Cash Balance
2		2,283	5,856	3,424	0	11,563	11,563						11,563	0	-11,563	0
3		3,511	9,005	5,266	0	17,781	17,781						17,781	0	-17,781	0
4		5,807	14,894	8,710	0	29,411	29,411						29,411	0	-29,411	0
5		13,258	34,006	19,886	6,216	73,366	67,150		0	0	0	0	67,150	6,216	-60,934	6,216
6	1	490	1,258	736	11,514	13,998	2,484	374	0	0	0	0	2,858	11,140	8,656	17,356
7	2	29	75	44	12,224	12,373	149	387	3,383	1,979	5,639	3,298	14,834	-2,462	11,688	14,894
8	3				12,934	12,934		400	3,158	1,847	5,639	3,298	14,341	-1,408	12,533	13,487
9	4				13,643	13,643		414	2,932	1,715	5,639	3,298	13,997	-354	13,230	13,133
10	5				14,353	14,353		428	2,707	1,583	5,639	3,298	13,654	699	13,925	13,832
11	6				15,063	15,063		442	2,481	1,451	5,639	3,298	13,311	1,752	14,621	15,584
12	7				15,773	15,773		457	2,256	1,319	5,639	3,298	12,968	2,804	15,315	18,388
13	8				16,482	16,482		473	2,030	1,187	5,639	3,298	12,627	3,856	16,010	22,244
14	9				17,192	17,192		489	1,804	1,055	5,639	3,298	12,285	4,907	16,703	27,151
15	10				17,902	17,902		506	1,579	923	5,639	3,298	11,944	5,958	17,396	33,109
16	11				18,612	18,612		523	1,353	791	5,639	3,298	11,604	7,008	18,089	40,117
17	12				19,322	19,322		541	1,128	660	5,639	3,298	11,264	8,057	18,781	48,174
18	13				20,031	20,031		559	902	528	5,639	3,298	10,925	9,106	19,472	57,280
19	14				20,741	20,741		578	677	396	5,639	3,298	10,587	10,154	20,163	67,434
20	15				21,451	21,451		598	451	264	5,639	3,298	10,249	11,202	20,853	78,636
21	16				22,161	22,161		618	226	132	5,639	3,298	9,912	12,249	21,543	90,885
22	17				22,871	22,871		639	0	0	0	0	639	22,232	22,232	113,117
23	18				23,580	23,580		661	0	0	0	0	661	22,920	22,920	136,036
24	19				24,290	24,290		683	0	0	0	0	683	23,607	23,607	159,643
25	20				25,000	25,000		706	0	0	0	0	706	24,294	24,294	183,937
26	21				25,710	25,710		730	0	0	0	0	730	24,979	24,979	208,916
27	22				26,419	26,419		755	0	0	0	0	755	25,664	25,664	234,580
28	23				27,129	27,129		781	0	0	0	0	781	26,348	26,348	260,929
29	24				27,839	27,839		807	0	0	0	0	807	27,032	27,032	287,960
30	25				28,549	28,549		835	0	0	0	0	835	27,714	27,714	315,674
31	26				27,129	27,129		863	0	0	0	0	863	26,266	26,266	341,940
32	27				29,968	29,968		893	0	0	0	0	893	29,076	29,076	371,016
33	28				30,678	30,678		923	0	0	0	0	923	29,755	29,755	400,771
34	29				31,388	31,388		954	0	0	0	0	954	30,434	30,434	431,205
35	30				32,098	32,098		987	0	0	0	0	987	31,111	31,111	462,316
Total		25,377	65,094	38,066	658,263	786,800	128,537	19,004	27,067	15,828	84,584	49,464	324,484	**462,316**	510,722	
FIRR															**11.67%**	

Source: JICA Survey Team

(6) Sensitivity of FIRRs

Separate analyses were carried out to examine the sensitivity of projected financial returns to adverse changes in key variables. The risks involved in the Project in terms of financial viability are the future uncertainty of the initial investment cost and the exchange rate between the local currency and the US dollar. Hence, the variables considered for the sensitivity analyses are as follows;

a) 10% higher cost of eligible portion in initial investment cost
b) 20% higher cost of eligible portion in initial investment cost
c) 10% lower exchange rate than assumed, i.e., 85.58 BDT/USD and thus 0.13 USD/MCF of income from transmission margin
d) 20% lower exchange rate than assumed, i.e., 93.36 BDT/USD and thus 0.12 USD/MCF of income from transmission margin

The results of the above sensitivity test are summarized below:

Table 6.2-9 Results of Sensitivity Analysis on FIRR for Compressors

	Item	Project FIRR
1	10% higher cost of eligible portion in initial investment cost	10.94%
2	20% higher cost of eligible portion in initial investment cost	10.27%
3	10% lower exchange rate	10.59%
4	20% lower exchange rate	9.44%
5	Combination of the above 1 and 3	9.89%
6	Combination of the above 1 and 4	8.79%
7	Combination of the above 2 and 3	9.26%
8	Combination of the above 2 and 4	8.20%

Source: JICA Survey Team

The above sensitivity analysis indicates that all the FIRRs except for combination of both 20% higher costs of the eligible portion and 20% lower exchange rate show over the 8.58% of the WACC, cut off rate. Therefore, the financial feasibility of the Project is deemed to be sufficiently high.

(7) Conclusion on Financial Viability

The project FIRR of the base case is at 11.67%, which exceeds the 8.58%, of the WACC. Therefore, the Project is regarded as financially viable and a sound investment. As a result of the sensitivity analysis of the FIRRs, all the FIRRs exceeded the cut off rate so that the financial feasibility of the Project is deemed to be sufficiently high. To sum up, it is deemed that the Project is financially feasible.

(8) Economic Analysis for Gas Transmission Pipelines

Refer to Section 6.1.10 (8) for the explanation of the economic analysis.

(9) Economic benefit

The construction of the pipelines attributes to the increase in the volume of gas supply to the western part of this country. Such increase in the volume of gas supply is considered as a benefit to society. Thus, the increase in the revenue brought by the gas transmission due to construction of the pipelines is regarded as the main economic benefit.

(10) EIRR

The benefit and costs for gas transmission pipelines are summarized in the below table.

Table 6.2-10 Costs and Benefit of Gas Transmission Pipelines for Economic Analysis

Costs:	Construction cost of gas transmission pipelines, project management cost, dispute board fee, land acquisition cost and land requisition cost, GTCL's administration cost and operation& maintenance (excluding taxes and IDC)
Benefit:	The construction of pipelines contributes to the incremental volume of gas supply to western part of this country. Such incremental volume of gas supply is considered as a benefit toward the society. Thus, the incremental revenue brought by gas transmission due to construction of pipelines is regarded as a main economic benefit.

Source: JICA Survey Team

Table 6.2-11 exhibits the calculation of the EIRR of the Project based on the economic benefits and costs discussed earlier. The EIRR is calculated at 15.41%, which clearly supports the economic viability of the Project, because 15.41% of the EIRR is above the 12%, cut off rate of the evaluation criteria for economic analysis.

Table 6.2-11 EIRR of the Project for Transmission Pipelines

(Thousand USD)

Project Year	Project Life	Cash Inflow		Cash Outflow			Net Cash Flow for	
		Benefits	Total Benefit	Capital Costs	O&M Costs	Total Cost	Cash Balance	Cumulative Cash Balance
2		0	0	9,039		9,039	-9,039	-9,039
3		0	0	13,967		13,967	-13,967	-23,006
4		0	0	20,509		20,509	-20,509	-43,515
5		6,216	6,216	46,647		46,647	-40,431	-83,946
6	1	11,514	11,514	1,844	374	2,218	9,296	-74,650
7	2	12,224	12,224	120	387	507	11,717	-62,933
8	3	12,934	12,934	0	400	400	12,533	-50,400
9	4	13,643	13,643	0	414	414	13,230	-37,170
10	5	14,353	14,353	0	428	428	13,925	-23,245
11	6	15,063	15,063		442	442	14,621	-8,625
12	7	15,773	15,773		457	457	15,315	6,691
13	8	16,482	16,482		473	473	16,010	22,700
14	9	17,192	17,192		489	489	16,703	39,404
15	10	17,902	17,902		506	506	17,396	56,800
16	11	18,612	18,612		523	523	18,089	74,889
17	12	19,322	19,322		541	541	18,781	93,670
18	13	20,031	20,031		559	559	19,472	113,142
19	14	20,741	20,741		578	578	20,163	133,306
20	15	21,451	21,451		598	598	20,853	154,159
21	16	22,161	22,161		618	618	21,543	175,702
22	17	22,871	22,871		639	639	22,232	197,933
23	18	23,580	23,580		661	661	22,920	220,853
24	19	24,290	24,290		683	683	23,607	244,460
25	20	25,000	25,000		706	706	24,294	268,753
26	21	25,710	25,710		730	730	24,979	293,733
27	22	26,419	26,419		755	755	25,664	319,397
28	23	27,129	27,129		781	781	26,348	345,745
29	24	27,839	27,839		807	807	27,032	372,777
30	25	28,549	28,549		835	835	27,714	400,491
31	26	29,259	29,259		863	863	28,395	428,886
32	27	29,968	29,968		893	893	29,076	457,962
33	28	30,678	30,678		923	923	29,755	487,717
34	29	31,388	31,388		954	954	30,434	518,151
35	30	32,098	32,098		987	987	31,111	549,262
Total		660,392	660,392	92,126	19,004	111,130	**549,262**	
EIRR							**15.41%**	

Source: JICA Survey Team

(11) Sensitivity Analysis for the EIRRs

A sensitivity test was performed on the EIRR for the initial investment cost only, which is the largest foreign cost component. The results of the test are as follows:

Table 6.2-12 Results of EIRR Sensitivity Analysis for Transmission Pipelines

	Scenario	EIRR of the Project
1	10% higher initial investment cost	14.25%
2	20% higher initial investment cost	13.24%

Source: JICA Survey Team

Generally, higher EIRRs are expected for energy projects, whereas a substantial cost overrun of the initial investment cost could undermine the Project's viability. As a result of this sensitivity analysis, the EIRRs are over 12% in the cases of a 10% and 20% higher initial investment. Thus, it can be said that the Project is economically viable.

(12) Conclusion on Economic Feasibility

It can be concluded that the Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

6.2.11 Operation and Effect Indicators

JICA should conduct ex-post evaluation two years after the Project completion at JICA's expense, so as to assess the Project's effectiveness, impact, and sustainability.

(1) Operation Indicator

Basically transmission pipelines should transmit gas without any outage hours for continuous supply. Any outage hours due to external reasons should not be counted in these outage hours.

This data will be obtained by means of operation records and daily reports.

Operation Indicators	Original (Yr 2013)	Target (Yr 2020)
Outage Hours by Pipeline Defect [hour]	N/A	0
Outage Hours by Human Errors [hour]	N/A	0

(2) Effect Indicator

GTCL have a measuring system which can measure the gas flow rate of each pipeline. Therefore, the gas flow rate of the following pipelines will be measured and compared.

1) Existing 24” pipeline prior to the operation of the new 30” pipeline
2) Sum of existing 24” pipeline and new 30” pipeline

The flow rate of 2) should be more than the flow rate of 1).

The measuring point should be discussed and finalized with GTCL.

Effective Indicator	Original (Yr 2013)	Target (Yr 2020)
Daily Gas Transmission Volume [MMSCFD]	400*	550

* The Original is gas flow at Elenga valve station at the time of completion year. The above base value is tentatively set at 400mmscfd based on the information from GTCL, and it should be re-set based on the actual measurement prior to the operation of the new pipeline.

6.2.12 Environmental and Social Considerations

(1) Overall Environmental and Social Aspects

Conduct of EIA is mandatory for all gas transmission pipeline projects irrespective of the scale of the project (according to ECR 1997). As such, EIA studies should be conducted and submitted by the project proponent, GTCL, for review and approval by DoE for both projects (Dhanua-Elenga and West Bank of Jamuna Bridge-Nalka gas transmission pipelines). However, in this instance conducting an IEE was exempted by DoE as is widely adopted for public sector projects and also considering the fact that EIA studies were previously completed for both projects in 2005 under ADB as components of larger transmission pipeline project schemes (Refer to Section 4.2).

Moreover, some small-scale resettlement of population is inevitable for the Dhanua-Elenga project even with rerouting of the ROW to minimize resettlement requirements and hence both EIA and ARAP studies are necessary for this project to meet JICA and other international donor agency requirements (even though ARAP is not mandatory for obtaining ECC from DoE). There is no private sector land acquisition or resettlement involved in the 14 km of planned ROW of the West Bank of Jamuna Bridge-Nalka since the land belongs to Jamuna Bridge Authority (State Entity) and there are no inhabitants living in the planned ROW.

Still, for the CGS (City Gate Station) at Nalka, acquisition of an area of about 1 ha (100m*100m) of privately owned vacant land (uninhabited) is necessary. However, conducting an ARAP is not necessary for this project component since no involuntary resettlement is involved.

As such, EIA studies for both projects and ARAP only for Dhanua-Elenga project were completed on a draft basis under subcontract to a local consultant with assistance from the JICA Survey Team in February 2014.

These EIA reports will be modified as appropriate by GTCL and submitted to DoE for review and approval so that ECC from DoE can be obtained at the latest by the end of March 2014. Submission to DoE by GTCL would include in addition to the modified EIA Report, NOCs (No

Objection Certificates) obtained from relevant local government authorities of the pipeline route for Dhanua-Elenga project and from Jamuna Bridge Authority (for ROW) and from relevant local government authorities (for CGS) for the West Bank of Jamuna Bridge-Nalka project. Accordingly, GTCL is recommended to obtain these NOCs also as soon as possible so that all necessary documents can be submitted to DoE for review and approval of EIA reports and hence the issuance of ECC by the end of March 2014.

In this respect the Survey & Environmental Department under the Planning Division of GTCL is responsible for all of the above-mentioned aspects.

1) Existing Natural and Social Environmental Condition

a) ROW of Dhanua-Elenga Pipeline

The proposed ROW of the Dhanua-Elenga pipeline (52 km in length and diameter 30 inch) passes mostly through rice fields interspersed with farming households and hence passes through areas of land-use having high anthropogenic influence. Moreover, there are no ecologically or culturally significant areas like primeval forests, protected areas or archeologically treasured areas located in or around the vicinity of the proposed ROW of the pipeline route. In fact, this ROW of the new pipeline route will be located mostly parallel with and nearby the already existing transmission pipeline (24 inch in diameter linking Dhanua with Elenga).

Accordingly, it is assessed that long-term potential adverse effects on important natural and cultural environmental resources consequent to construction and operation of this additional loop line (Dhanua-Elenga) are not that significant as is also illustrated under Item (6) of Section 4.2.1 of Chapter 4. In fact, this is also the case for the other ROW of the West Bank of Jamuna Bridge-Nalka pipeline (14 km in length and diameter 30 inch) as is illustrated under similar Item (6) of Section 4.2.2 of Chapter 4.

It is further noted that the ROW of this pipeline has 6 significant river crossings where the HDD method would be used to lay the pipes deep under the river bed without any open cut works across the rivers. Those 6 HDD river crossings are Salda River (312 m wide), Tanki-1 River (327 m wide), Tanki-2 River (326 m wide), Bangshai River (366 m wide), Safai River (316 m wide) and Langalia River (346 m wide).

Concerning significant social aspects, small-scale resettlement (consisting in total of 28 households representing a population of 140 persons) is required for the Dhanua-Elenga pipeline project mostly along its initial portion of ROW located between Dhanua and Sulgrampur. This resettlement was found to be inevitable even with rerouting of the ROW of the pipeline to the extent possible in order to minimize involuntary resettlement requirements as is also noted under Item (6) of Section 4.2.2 of Chapter 4. The ROW of the pipeline mostly passes through vacant and agricultural lands of rice fields for the final 20-km sector from Sulgrampur to Elenga and hence no significant involuntary resettlement would be involved. Still, there will be some resettlement near Elenga.

The required width of ROW to facilitate effective construction works is 23 m with 8m width as the permanent ROW to be acquired by GTCL. The remaining 15m width of the ROW will be acquired only temporarily (referred to as requisition), lasting until the all construction and restoration works following the laying and backfilling of the (underground) pipeline is completed. Still, for the purpose of resettlement, estimation of the entire land width of 23 m acquired for construction works is taken into account. Accordingly, the total area of land acquisition and requisition is determined at about 120ha (52 km*23m) and the total number of persons to be resettled is preliminarily determined as the 140 persons (as per the ARAP study) that live along this 120 ha of the land strip (ROW).

b) ROW of West Bank of Jamuna Bridge-Nalka Pipeline

The ROW of this pipeline (14 km in length and diameter 30 inch) would pass adjacent to the already existing pipeline that is located by the side of the road to Nalka, an area with high anthropogenic influence. Moreover, there are no ecologically or culturally significant areas like primeval forests, protected areas or archeologically treasured areas located in or around the vicinity of the proposed ROW of the pipeline route.

The ROW is basically vacant land with no inhabitants and belongs to the Jamuna Bridge Authority (a state entity). As such, there is no private sector land acquisition or resettlement involved for the pipeline route. Still, for the CGS (City Gate Station) at Nalka, acquisition of an area of about 1 ha (100m*100m) of privately owned vacant land (uninhabited) is necessary. Moreover, there is no surface water body like rivers located along the entire ROW of 14 km in length.

The required ROW width of 23m to facilitate construction works is fully available within the land belonging to the Jamuna Bridge Authority.

With due consideration to the above aspects following the guidelines of JICA for Category B projects, starting from alternative considerations followed with environmental scoping, EIA/ARAP and relevant management, mitigation and monitoring measures are dealt with in the following sections.

2) Alternative Considerations including Zero Option

a) Alternatives

Both pipelines (Dhanua-Elenga and West Bank of Jamuna Bridge-Nalka) are loop lines intended at expanding the gas carrying capacity (expansion of system capacity) of the existing East-West gas transmission system. Moreover, under ADB funding another loop system other than these 2 missing links has already been constructed and is in operation as noted under the respective items (6) of Sections 4.2.1 and 4.2.2. As such, there is no significant physical alternatives even with respect to route alignment (which is preferred to be placed in close proximity and parallel to the existing pipeline system) since they are intended to expand the carrying capacity of the already existing gas transmission system.

Still, some rerouting was done for the Dhanua-Elenga pipeline so as to minimize the resettlement requirements that could be regarded as a form of alternative consideration for minimizing adverse social impacts as described under Item (6) of Section 4.2.2 (that resulted in limiting the number of people for resettlement to 140). Accordingly in a broad sense there are 2 alternative routes for Dhanua-Elenga pipeline.

Alternative 1: Original ADB route of 2005

Alternative 2: Route with some rerouting and straitening wherever possible so as to minimize resettlement as well as any additional increase in the length of the pipeline (alternative by this project).

A summary of a comparative evaluation of both of these alternatives is given below in Table 6.2-13 that also justifies the selection of Alternative 2 as the best option with least adverse social effects consequent to the very significant reduction in households targeted for involuntary resettlement with no increase in overall length of pipeline (in fact slight decrease to 51.7 km in comparison to 52 km for Alternative 1).

Table 6.2-13 Route Alternative Comparison for Dhanua-Elenga Gas Transmission Pipeline

Relevant Comparative Aspects		Alternative 1 (ADB Route of 2005)	Alternative 2 (Rerouting to minimize resettlement and also straitening to minimize increase in overall length of pipeline)
Basic information	Starting point	Dhanua	Dhanua
	Ending point	Elenga	Elenga
	Distance/Length of pipeline route	52 km	51.7 km (length slightly less than 52 km of Alternative 1)
	Route Alignment	Close to the existing operational pipeline route	Basically close to the existing operational pipeline route with some deviation to minimize resettlement requirements and also straitening whenever possible to minimize increase in overall route length
Land use	Overall land use	Residential and agricultural lands with high anthropogenic influence	Same as Alternative 1
	Protected/ecologically /culturally important areas	None either along or nearby the pipeline route	Same as Alternative 1
Environmental and Social Aspects	Social Environment	No. of resettled households 194 (1000 persons)	No. of resettled households 28 (140 persons)
	Natural Environment	High anthropogenic influence	Same as Alternative 1
Recommended alternative and its reason		Not recommended	Recommended since all other conditions remain basically the same as Alternative 1 with very significant reduction in resettled households and hence much less adverse social impact for this Alternative 2.

Source: JICA Survey Team

No such route alternative consideration is necessary for the West Bank of Jamuna Bridge-Nalka pipeline route since the required 23 m width ROW for pipeline installation/construction works is available by the side of the existing pipeline route that is uninhabited and belongs to Jamuna

Bridge Authority, a state entity. As such, no private sector land acquisition or resettlement is involved in the entire pipeline route. Still privately owned land with an area of 1 ha (100m*100m) will be acquired for the CGS (City Gate Station) at Nalka though no resettlement is involved since it is only vacant land.

In effect, both these pipeline projects are basically reinforcement for existing operational gas pipeline systems that have already been partially completed under ADB funding and with this project the system will be fully completed and hence will facilitate effective operation of the entire East-West gas transmission system.

b) Zero option

The zero option will always be a viable and at times inevitable option for the construction of these two remaining links of the East-West gas transmission system as has been the case under present status. Financial limitation was reported as the cause for not completing these 2 portions (Dhanua-Elenga and West Bank of Jamuna Bridge-Nalka) of the pipelines under ADB funding during 2005-2009.

Under the condition of continued zero option, inefficient use of the portions of the pipeline system already completed under ADB funding would continue in the future since these two missing links constrict the carrying capacity of the gas transmission system (In operation following completion of construction under ADB funding in 2009). So deliberate focus on zero option (no action option) is unwarranted, but will always be an inevitable option as is the current status until funding and the related construction works to complete these two remaining links of the gas transmission system are accomplished.

3) Environmental Scoping and TOR for EIA/ARAP

Scoping for significant environmental and social aspects for the projects in this survey was conducted based on the typical environmental and social components relevant to the industrial sector , all projects basically belong to the industrial sector, (classified into 3 environmental groups, namely, Environmental quality and pollution control, Natural environment and Social environment) as already illustrated under Item (3) of the previous Section 6.1.12.

The scoping was conducted separately for each of the 2 project components since their statuses are not similar, in particular concerned to the social aspect of land acquisition and resettlement requirements that do exist for Dahnua-Elenga pipeline while it is basically non-existent for the West Bank of Jamuna Bridge-Nalka pipeline as described above.

The results of scoping with evaluation separated between positive (beneficial) and negative (adverse) effects with 4 ranking grades of A, B, C and D along with due reasoning for such ranking are given in Table 6.2-14 (Dhanua-Elenga) and Table 6.2-15 (Bank of Jamuna Bridge-Nalka).

Table 6.2-14 Environmental Scoping for Dhanua-Elenga Pipeline Project

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
Environment quality and pollution control	Air quality	B-	D	During construction, air pollutants are expected from land clearance, movement of heavy equipment and trucks, which would generate mostly dust and to some extent exhaust gaseous emission (CO, NO_x, SO_x, and others). During O&M, no significant air pollutant emission is expected since the pipeline is laid underground and conveys compressed natural gas.
	Water quality	B-	D	Potential river water quality deterioration while HDD construction/installation works across the six rivers i.e. Bangshai, Salda, Safai, Tanki-1, Tanki-2 & Langolia and finally the pipeline crossings at three points of Langolia canal could occur. However, no long-term adverse effects on water quality are anticipated during the project operational stage since the pipeline is laid underground and will not affect any water body.
	Noise/vibration	B-	D	Noise and vibration during construction/installation of the pipeline is a critical aspect and could not be entirely eliminated. Still, work prone to potentially high noise/vibration shall be scheduled for day-time only. As also noted above, since the pipeline is laid underground there is no potential noise/vibration issue involved during the operation stage of the project.
	Waste	B-	B-/D	Waste generation during construction activities include excess borrow pit soil due to pipeline trench back-filling following pipe laying, sanitary and solid waste generation due to working personnel and other construction related works. Waste generated during operation of the pipeline is pigging waste that has already been generated consequent to the existing gas transmission pipelines of more than 1000 km in length. As such, this pipeline with a length of only 52 km will result only in a marginal increase in pigging waste generation. Still, pigging waste management is a long-term requirement. These wastes due to construction and operation have to be managed properly with a good and effective waste management system.
	Soil	B-	D	Trenching and subsequent back-filling following pipeline work has the potential to affect the agricultural fertility of the excavated land area However, long-term adverse effects on soil fertility due to underground (laid) pipeline is regarded as not that significant.

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
	Climate change Factors	D	D	Natural gas results in less CO_2 emissions in comparison to other liquid petroleum sources. Still, overall, any such beneficial effects on overall climate change factors are regarded as not that significant when this project effect is individually taken into account.
Natural Environment	Topography	D	D	The project is not that large-scale to significantly affect topography, which is also evident from the already laid and operational gas transmission pipelines of more than 1000 km in length.
	Geology	D	D	Similar to the topography case above, potential adverse effects on geology are regarded as not that significant.
	Hydrology	D	D	Similar to the topography case above, potential adverse effects on hydrology are regarded as not that significant.
	Ecosystem	D	D	The project is not expected to affect the ecosystem since there is no important ecosystem that would be affected by the installation of the pipeline that will be laid underground basically in parallel/nearby the already existing underground pipeline.
	Biodiversity	D	D	Any potential adverse effect on biodiversity due to linear trenching and backfilling following pipe laying is regarded as only marginal and not that significant considering the highly anthropogenic influenced nature of the project affected area. In the operation stage since land is restored to original state as the pipeline is laid underground there would be no adverse effect on biodiversity.
	Protected areas	D	D	There are no protected areas located in or around the vicinity of the planned ROW of pipeline route and hence there is no adverse effect.
	Areas of environmental /ecological significance	D	D	There are no environmentally or ecologically significant, critical or vulnerable areas located in or around the vicinity of the planned ROW of the pipeline route, a condition similar to the case of the protected area of above.
Social Environment	Local Economy	B+	B+	Implementation of the project involving very significant demand for even unskilled labour for trenching and backfilling work has the potential for local employment opportunity during the construction stage of the project thereby contributing to the local economy. This is also possible to some extent during the operation stage as well for maintenance of facilities such as valve stations and also for patrolling work to ensure the integrity and protection of the ROW (of the newly laid underground pipeline).
	Resettlement	B-	D	Even with all efforts to minimize resettlement requirements with rerouting of the ROW to avoid residential areas to the greatest extent possible some small-scale resettlement is

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
				regarded as inevitable. In this respect, due compensation, living assistance, job training and other support systems conforming to the internationally accepted policies of WB (OP 4.12) shall be used as the mechanism both for execution and subsequent monitoring of resettlement activities. Since resettlement and its monitoring is a relatively short-term activity and hence no long-term adverse effect to correspond to the operation of the pipeline system is anticipated.
	Indigenous people	D	D	There are no indigenous people living in or around the vicinity of the ROW of the planned pipeline route. So no adverse effect is anticipated.
	Cultural Heritage	D	D	There are no cultural heritage sites located in or around the vicinity of the ROW of the planned pipeline route. So no adverse effect is anticipated.
	Health and Safety	B-	D	Health and safety of construction personnel is a very important aspect in the construction management by the contractor. Instilling due awareness among migrant workers on the dangers of communicable diseases and the importance in respecting the customs and traditions of village people is the most significant social aspect to be addressed by the construction contractor. Full commitment and adherence to the concept of “Safety First” in the conduct of all construction related activities by the construction contractor is necessary for the enhanced safety of the construction work force. No significant safety issue is anticipated consequent to the operation of the underground gas transmission pipeline with due adherence to safety guidelines of GTCL (having more than 20-year operational experience in gas transmission pipelines).

Legend:

A+/- : Significant positive/negative impact is expected

B+/- : Positive/negative impact is expected

C+/- : Extent of positive impact/extent of negative impact is unknown (needs further investigation on whether the impact can be clarified as the ESC Study progresses)

D : No significant impact is expected or no impact at all is expected

Table 6.2-15 Environmental Scoping for West Bank of Jamuna Bridge-Nalka Pipeline Project

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
Environment quality and pollution control	Air quality	B-	D	During construction, air pollutants are expected from land clearance, movement of heavy equipment and trucks, which would generate mostly dust and to some extent exhaust gaseous emission (CO, NO_x, SO_x, and others). During O&M, no significant air pollutant emission is expected since the pipeline is laid underground and conveys compressed natural gas.
	Water quality	D	D	There are no crossings of surface water bodies such as rivers or ponds along the entire 14 km ROW of the planned pipeline route. So no adverse effect on water quality consequent to the project is anticipated.
	Noise/vibration	B-	D	Noise and vibration during construction/installation of the pipeline is a critical aspect and could not be entirely eliminated. Still, work prone to potentially high noise/vibration shall be scheduled for day-time only. As also noted above, since the pipeline is laid underground there is no potential noise/vibration issue involved during the operation stage of the project.
	Waste	B-	B-/D	Waste generation during construction activities include excess borrow pit soil due to pipeline trench back-filling following pipe laying, sanitary and solid waste generation due to working personnel and other construction related works. Waste generated during the operation of the pipeline is pigging waste that has already been generated consequent to the existing gas transmission pipelines of more than 1000 km in length. As such this pipeline with a length of only 14 km will result only in a marginal increase in pigging waste generation. Still, pigging waste management is a long-term requirement. These wastes due to construction and operation have to be managed properly with a good and effective waste management system.
	Soil	B-	D	Trenching and subsequent back-filling following pipeline work has a potential to affect the agricultural fertility of the excavated and refilled land area. However, long-term adverse effects on soil fertility due to underground (laid) pipeline are regarded as not that significant.
	Climate change Factors	D	D	Natural gas results in less CO_2 emission in comparison to other liquid petroleum sources. Still, overall, any such beneficial effects on overall climate change factors are regarded as not that significant when this project effect is

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
				individually taken into account.
Natural Environment	Topography	D	D	The project is not that large-scale to significantly affect topography, which is also evident from the already laid and operational gas transmission pipelines of more than 1000 km in length.
	Geology	D	D	Similar to the topography case above, potential adverse effects on geology are regarded as not that significant.
	Hydrology	D	D	Similar to the topography case above, potential adverse effects on hydrology are regarded as not that significant.
	Ecosystem	D	D	The project is not expected to affect the ecosystem since there is no important ecosystem that would be affected by the installation of the pipeline that will be laid underground in parallel/nearby the already existing underground pipeline.
	Biodiversity	D	D	Any potential adverse effect on biodiversity due to linear trenching and backfilling following pipe laying is regarded as only marginal and not that significant considering the highly anthropogenic influenced nature of the project affected area located by the side of a highway. In the operation stage since land is restored to its original state as the pipeline is laid underground there would be no adverse effect on biodiversity.
	Protected areas	D	D	There are no protected areas located in or around the vicinity of the planned ROW of the pipeline route and hence there is no adverse effect.
	Areas of environmental /ecological significance	D	D	There are no environmentally or ecologically significant, critical or vulnerable areas located in or around the vicinity of the planned ROW of the pipeline route, a condition similar to the case of protected area above.
Social Environment	Local Economy	B+	B+	Implementation of the project involving very significant demand for even unskilled labour for trenching and backfilling work has a potential for local employment opportunity during the construction stage of the project thereby contributing to the local economy. This is also possible to some extent during the operation stage as well for maintenance of facilities such as valve stations and also for patrolling work to ensure the integrity and protection of the ROW (of the newly laid underground pipeline).
	Resettlement	D	D	The entire ROW of the planned pipeline route is located by the side of the existing underground pipeline that belongs to Jamuna Bridge Authority, a state entity of Bangladesh. Moreover, there are no inhabitants living along the entire ROW of the planned pipeline route. As such no private

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
				sector owned land acquisition or resettlement requirement is encountered along the pipeline route. But 100mX100m i.e. 1 ha of land will need to be acquired with proper payment of compensation for City Gate Station (CGS) at Nalka where no resettlement would be required since that will be only on vacant land.
	Indigenous people	D	D	There are no indigenous people living in or around the vicinity of the ROW of the planned pipeline route. So no adverse effect is anticipated.
	Cultural Heritage	D	D	There are no cultural heritage sites located in or around the vicinity of the ROW of the planned pipeline route. So no adverse effect is anticipated.
	Health and Safety	B-	D	Health and safety of construction personnel is a very important aspect in the construction management by the contractor. Instilling due awareness among migrant workers on the dangers of communicable diseases and the importance in respecting the customs and traditions of village people is the most significant social aspect to be addressed by the construction contractor. Full commitment and adherence to the concept of "Safety First" in the conduct of all construction related activities by the construction contractor is necessary for enhanced safety of the construction work force. No significant safety issue is anticipated consequent to the operation of the underground gas transmission pipeline with due adherence to safety guidelines of GTCL (having more than 20-year operational experience in gas transmission pipelines).

Legend:

A+/- : Significant positive/negative impact is expected
B+/- : Positive/negative impact is expected
C+/- : Extent of positive impact/extent of negative impact is unknown (needs further investigation on whether the impact can be clarified as the ESC Study progresses)
D : No significant impact is expected or no impact at all is expected

It is evident from the above scoping results that most adverse effects consequent to the implementation of both of these pipeline projects are of short-term and basically confined to the construction stage of the project and could be managed with the adoption of good construction practice by the construction contractor and the formulation and implementation of an adequate resettlement plan (ARAP for Dhanua-Elenga project) and its subsequent implementation and monitoring conforming to WB (OP 4.12) and JICA guidelines.

TOR on environmental and social considerations as overall work plan for both Dhanua-Elenga and West Bank of Jamuna Bridge-Nalka projects were formulated based on the above scoping results that was further used as the basis to formulate TOR for the conduct of EIA and ARAP studies under subcontract.

TOR as overall work plan are given below in Table 6.2-16 (Dhanua-Elenga Project) and Table 6.2-17 (West Bank of Jamuna Bridge-Nalka Project)

Table 6.2-16 TOR for Environmental and Social Considerations (Dhanua-Elenga)

Environmental and Social Component		Survey Items	Methodology
1	Air Quality	• Clarify ambient air quality standards • Establish baseline ambient air quality condition in the project site and its vicinity for dust ($SPM_{2.5}$/SPM_{10}) before commencement of any construction related activity • Identify current air pollution sources • Assess the impact	• Collection of secondary data • Interview with relevant agencies • Field reconnaissance and expert opinion/judgment
2	Noise/Vibration Level	• Clarify ambient noise/vibration standards • Establish baseline noise/vibration level in the project site and its vicinity before commencement of any construction related activity • Assess the impact	• Collection of secondary data • Interview with relevant agencies • Field reconnaissance and expert opinion/judgment
3	Water Quality	• Clarify surface water quality standards • Establish baseline water quality condition in the 5 major target rivers with HDD crossings (Bangshai, Salda, Safai, Tanki-1 and Tanki-2) with measurement of the following parameters: temperature, pH, DO (dissolved oxygen), EC/TDS (electric conductivity/total dissolved solids), COD, BOD, TSS and oil & grease and the other one smaller river/canal of Langolia with field parameters (temp., pH, DO, EC/TDS) • Assess the impact	• Collection of secondary data • Field reconnaissance survey • Field survey of surface water sampling and analysis and evaluation • Interview with relevant agencies
4	Waste Management	• Clarify waste management standards including wastewater discharge to surface waters standards • Predict types and management of construction related wastes • Assess adequacy of current pigging waste management of the operational system • Assess the impact	• Collection of secondary data • Interview with relevant agencies and expert opinion/judgment
5	Social Aspects including Resettlement	• Clarify socio-economic conditions of communities affected by land acquisition and resettlement (including inventory of lost property) for the project • Public perception of the project in	• Questionnaire based interview survey targeting all resettled population and at-least 20% of others affected by land acquisition and other losses along with

Environmental and Social Component		Survey Items	Methodology
		the communities surrounding the project site • Assess the impact	conduct of ARAP Study • Sampling interview survey including interview with relevant local government agencies and others
6	Stakeholder Consultation	• Clarify views and opinions of related people about the project • Clarify environmental and social issues that are important to the people living in the vicinity of the project site • Assess stakeholder interest and needs	• Public perception survey as sampling interview survey • Stakeholder meeting/small group discussion/consultation in the form of FGDs (focus group discussions)

Source: JICA Survey Team

Table 6.2-17 TOR for Environmental and Social Considerations (WBJB-Nalka)

Environmental and Social Component		Survey Items	Methodology
1	Air Quality	• Clarify ambient air quality standards • Establish baseline ambient air quality condition in the project site and its vicinity for dust ($SPM_{2.5}$/SPM_{10}) before commencement of any construction related activity • Identify current air pollution sources • Assess the impact	• Collection of secondary data • Interview with relevant agencies • Field reconnaissance and expert opinion/judgment
2	Noise/Vibration Level	• Clarify ambient noise/vibration standards • Establish baseline noise/vibration level in the project site and its vicinity before commencement of any construction related activity • Assess the impact	• Collection of secondary data • Interview with relevant agencies • Field reconnaissance and expert opinion/judgment
3	Waste Management	• Clarify waste management standards including wastewater discharge standards • Predict types and management means of construction related wastes • Assess adequacy of current pigging waste management of the operational system • Assess the impact	• Collection of secondary data • Interview with relevant agencies and expert opinion/judgment
4	Social Aspects	• Public perception of the project in the communities surrounding the project site • Assess the impact	• Sampling interview survey including interview with relevant local government agencies and others
5	Stakeholder Consultation	• Clarify views and opinions of related people about the project • Clarify environmental and social issues that are important to the	• Public perception survey as sampling interview survey • Stakeholder meeting/small group

Environmental and Social Component		Survey Items	Methodology
		people living in the vicinity of the project site • Assess stakeholder interest and needs	discussion/consultation in the form of FGDs (focus group discussion)

Source: JICA Survey Team

With due consideration of the above results of scoping and the TORs, in particular the social aspects of the resettlement requirements (though of small-scale) for the Dhanua-Elenga Project, and also to the fact that conducting an EIA is mandatory for both of these projects (irrespective of their project scale) as per the Environmental Conservation Rules (1997) of Bangladesh (since gas pipeline projects fall under environmental category RED) TOR for the conduct of EIA and ARAP studies in a comprehensive manner under sub-contract was formulated. It is noted that conducting an ARAP is necessary for the Dhanua-Elenga pipeline project since it has small-scale resettlement requirements (so as to conform to the OP 4.12 on involuntary resettlement of WB and also JICA) though it is not mandatory in Bangladesh and not required by DoE for obtaining ECC as noted above.

As such, EIA study reports for both pipeline projects on a draft basis and an ARAP report for the Dhanua-Elenga pipeline project has been formulated with the conducting of necessary surveys and studies by this study under sub-contract. The EIA/ARAP reports will be formulated conforming to both the environmental and social consideration guidelines of DoE and JICA (2010) as appropriate. Accordingly, the draft EIA reports formulated by this study could be utilized by GTCL (Executing Agency of the Project) for obtaining ECC from DoE.

TOR (Terms of Reference) for conducting EIA studies for the 2 relevant project components, which consist of transmission pipelines (Dhanua-Elenga and West Bank of Jamuna Bridge-Nalka) and the ARAP Study only for the relevant project component of the Dhanua-Elenga, under sub-contract with local Consultants of Bangladesh, is given in Appendix 9.

It is noted that the EIA/ARAP studies for these pipeline projects are currently ongoing under subcontract and scheduled to be completed by mid-February 2014. As such, all relevant descriptions made in this Section 6.2.12 are provisional (though mostly complete) and will be updated as appropriate based on the findings of the ongoing EIA/ARAP study in the Final Report.

The most significant technical aspect of the EIA Study is the determination of the surface water quality of the major rivers (determination of baseline surface water environmental condition) targeted for HDD river crossings (baseline surface water environmental condition) for the

Dhanua-Elenga pipeline project. The 6 HDD river-crossing locations are Salda River, Tanki-1 River, Tanki-2 River, Bangshai River, Safai River and Langalia River These 6 Rivers along with the parameters of water quality measurement are given in Table 6.2-16. The evaluation of water quality will be incorporated in the Final Report conforming to the format below in Table 6.2-18.

Table 6.2-18 Evaluation of Water Quality of Rivers for HDD Crossings (Dhanua-Elenga)

Environmental Component	Water Quality Evaluation of 6 target rivers of HDD crossings
Surface River Water quality	Overall water quality of all rivers other than Tanki-2 River meet the required BOD level limitation of 10 mg/l for irrigation use as per inland surface water quality standards of Bangladesh (Schedule 3 of ECR 97). Still with a measured BOD level of around 18 mg/l Tanki-2 River is regarded as slightly polluted with pollution load runoff of domestic origin being the probable source of the pollution.

4) Environmental Impact Evaluation and Mitigation

Potential adverse environmental impacts consequent to the construction/installation of the gas transmission pipelines (by both of these projects) would be limited to the construction/installation stage of the project and would disappear following the backfilling of the pipelines laid underground so as to restore the original condition. This is also evident from the scoping results of Table 6.2-14 and Table 6.2-15. Pigging waste management that has already been ongoing for the existing pipelines of GTCL of more than 1000 km in length (with over 20 years of experience) is the most significant long-term environmental management aspect. Currently, pigging wastes are buried underground by GTCL and the measure is accepted practice and hence would continue as the waste management measure.

Potential adverse effects of the construction/installation stage of the project are evaluated as manageable with the adoption of technically sound construction/installation methods for the pipeline works (adoption of good construction/installation practice) by the construction contractor. Moreover, over 1000 km of such underground gas transmission pipelines have already been installed and are in operation. As such, GTCL has long term experience in managing such pipeline installation works carried out by contractors.

In this respect the construction/installation contractor shall fully commit and adhere to the concept of Safety First as the most import mitigation measure of construction safety.

The other significant mitigation measures of the construction/installation stage include:

- Transportation of material and equipment prone to dust generation in covered vehicles in good operational condition.
- Transportation of machinery/equipment/pipes in duly sized packaging so as not to cause overloading and to ensure safe transportation and not resulting in damage to the transportation roads including temporary access roads established along the ROW.

Moreover, scheduling of all transportation will be duly planned so as to minimize interference with regular road traffic.

- Water spraying of dust prone cleared lands including storage of dust prone material under vinyl sheet covering.
- Good housekeeping of the construction site and worker camp site including maintenance of good sanitary condition and solid waste management system with separation of garbage according to the type of garbage to facilitate effective reuse/recycling as appropriate.
- Limiting activities having potential to cause high noise/vibration to day-time only, in particular considering the rural/farming village set-up of the ROW of the pipeline in case of the Dhanua-Elenga project.

Finally it is noted that all construction/installation works for laying pipes such as trench excavation, pipe-laying, back-filling to restore original ground surface (topography) condition including the removal of excess excavated soil from the work site shall be planned and executed by the contractor so that the entire work could be completed within the one particular dry season.

In this respect top soil from the excavation shall be stored separately and reused as top soil at the end of backfilling work so as not to affect the soil fertility of the ground surface and hence to facilitate prompt restoration of ground surface ecology to its original condition. Implementation of such work plan to restore the ground surface to its original condition within one particular dry season will make sure there would be no runoff erosion of soil during subsequent rainy seasons. Moreover, the rains would also facilitate re-growth of vegetation thereby facilitating prompt restoration of backfilled ground surface to its original condition. This requirement is identified as the most important pipe-laying construction/installation work related management and mitigation measure for the natural environmental restoration of backfilled ground surface (topography).

The overall environmental and social impact mitigation/management plans for both projects are summarized in Appendix 10 (Dhanua-Elenga Project with small-scale resettlement) and Appendix 11 (West Bank of Jamuna Bridge-Nalka project with no resettlement) on a provisional basis that will be updated in the final report based on the final results of ongoing EIA/ARAP studies under subcontract.

Moreover, a comparative evaluation of the scoping results as envisaged and shown in Table 6.2-14 (Dhanua-Elenga) and Table 6.2-15 (West Bank of Jamuna Bridge-Nalka) and as determined by the EIA/ARAP Study are shown below in Table 6.2-19 (Dhanua-Elenga) and Table 6.2-20 (West Bank of Jamuna Bridge-Nalka). The results show no significant deviation from the initial scoping for well-known standard planning and execution procedures for underground gas pipeline construction/installation works and their operation in Bangladesh and elsewhere.

Table 6.2-19 Comparative Evaluation on Results of Scoping (Dhanua-Elenga)

Item		Impact by Scoping		Impact based on Study Results		Reason for Evaluation
		Const.	O/M	Const.	O/M	
Environmental Quality and Pollution Control						
1	Air quality	**B-**	**D**	**B-**	**D**	• Air pollution mainly due to dust during construction works
2	Water quality	**B-**	**D**	**B-**	**D**	• Water pollution mainly due to HDD and other canal pipeline crossings during construction
3	Noise/vibration	**B-**	**D**	**B-**	**D**	• Noise/vibration during construction works
4	Waste	**B-**	**B-/D**	**B-**	**B-/D**	• Waste management during construction works including worker related sanitary and solid waste. Pigging waste management is an operation related long-term requirement.
5	Soil	**B-**	**D**	**B-**	**D**	• Potential degradation in soil fertility due to pipeline trench backfilling work.
6	Climate change factors	**D**	**D**	**D**	**D**	• Insignificant effect due to relatively small scale of the project
Natural Environment						
7	Topography	**D**	**D**	**D**	**D**	• No significant effect on topography
8	Geology	**D**	**D**	**D**	**D**	• No significant effect on geology
9	Hydrology	**D**	**D**	**D**	**D**	• No significant effect on hydrology
10	Ecosystem	**D**	**D**	**D**	**D**	• No significant effect on ecosystem
11	Biodiversity	**D**	**D**	**D**	**D**	• No significant effect on biodiversity
12	Protected areas	**D**	**D**	**D**	**D**	• There are no protected areas in or around the project site
13	Areas of environmental /ecological significance	**D**	**D**	**D**	**D**	• There are no environmentally /ecologically significant protected areas in or around the project site
Social Environment						
14	Local economy	**B+**	**B+**	**B+**	**B+**	• Local work opportunities during construction works and subsequent operation/maintenance of the pipeline system
15	Resettlement	**B-**	**D**	**B-**	**D**	• Resettlement of 28 households (140 people) is involved. Due compensation system conforming to JICA (WB OP 4.12) is planned.
16	Indigenous people	**D**	**D**	**D**	**D**	• There are no indigenous people in or around the project area
17	Cultural heritage	**D**	**D**	**D**	**D**	• There are no cultural heritage sites in or around the project area
18	Health and safety	**B-**	**D**	**B-**	**D**	• Health and safety of construction personnel is very important. No significant safety issues exist in conventional pipeline operation.

Legend:
A+/- : Significant positive/negative impact is expected
B+/- : Positive/negative impact is expected
C+/- : Extent of positive impact/extent of negative impact is unknown (needs further investigation and clarification on whether the impact can be clarified as the ESC Study progresses)
D : No significant impact is expected or no impact at all is expected

Table 6.2-20 Comparative Evaluation on Results of Scoping (West Bank of Jamuna Bridge-Nalka)

Item		Impact by Scoping		Impact based on Study Results		Reason for Evaluation
		Const.	**O/M**	**Const.**	**O/M**	
Environmental Quality and Pollution Control						
1	Air quality	**B-**	**D**	**B-**	**D**	• Air pollution mainly due to dust during construction works
2	Water quality	**D**	**D**	**B-**	**D**	• Potential unscrupulous/illegal waste dumping into nearby ponds needs to be mitigated during construction works
3	Noise/vibration	**B-**	**D**	**B-**	**D**	• Noise/vibration during construction works
4	Waste	**B-**	**B-/D**	**B-**	**B-/D**	• Waste management during construction works including worker related sanitary and solid waste. Pigging waste management is operation related and a long-term requirement.
5	Soil	**B-**	**D**	**B-**	**D**	• Potential degradation in soil fertility due to pipeline trench backfilling work.
6	Climate change factors	**D**	**D**	**D**	**D**	• Insignificant effect due to relatively small scale of the project
Natural Environment						
7	Topography	**D**	**D**	**D**	**D**	• No significant effect on topography
8	Geology	**D**	**D**	**D**	**D**	• No significant effect on geology
9	Hydrology	**D**	**D**	**D**	**D**	• No significant effect on hydrology
10	Ecosystem	**D**	**D**	**D**	**D**	• No significant effect on ecosystem
11	Biodiversity	**D**	**D**	**D**	**D**	• No significant effect on biodiversity
12	Protected areas	**D**	**D**	**D**	**D**	• There are no protected areas in or around the project site
13	Areas of environmental /ecological significance	**D**	**D**	**D**	**D**	• There are no environmentally /ecologically significant protected areas in or around the project site
Social Environment						
14	Local economy	**B+**	**B+**	**B+**	**B+**	• Local work opportunities during construction works and subsequent operation/maintenance of pipeline system
15	Resettlement	**D**	**D**	**D**	**D**	• No resettlement of population is involved
16	Indigenous people	**D**	**D**	**D**	**D**	• There are no indigenous people in or around the project area
17	Cultural heritage	**D**	**D**	**D**	**D**	• There are no cultural heritage sites in or around the project area
18	Health and safety	**B-**	**D**	**B-**	**D**	• Health and safety of construction personnel is very important. No significant safety issue exist in conventional pipeline operation.

Legend:
A+/- : Significant positive/negative impact is expected
B+/- : Positive/negative impact is expected
C+/- : Extent of positive impact/extent of negative impact is unknown (needs further investigation and clarification on whether the impact can be clarified as the ESC Study progresses)
D : No significant impact is expected or no impact at all is expected

5) Environmental Monitoring Plan

Environmental monitoring is regarded as necessary principally for the construction/installation stage of the projects (Dhanua-Elenga and West Bank of Jamuna Bridge-Nalka). The monitoring requirement is simple for the West Bank of the Jamuna Bridge-Nalka sector pipeline project in comparison to Dhanua-Elenga. This is due to the fact that there is no resettlement requirement for the West Bank of the Jamuna Bridge-Nalka sector pipeline project and hence there are no social aspects related monitoring requirements. Accordingly, the monitoring plans for each sector project are delineated separately below.

a) Dhanua-Elenga Project

The monitoring requirements of the construction stage will include both natural and social environmental aspects since small-scale resettlement (estimated at 104 persons) is also involved in the total area of land acquisition (both permanent acquisition and requisition/temporary acquisition during the construction stage) for the ROW of about 120 ha.

The elements of the natural environment identified for monitoring during the construction/installation stage of the project (by the ongoing EIA Study) are ambient air quality, noise/vibration and surface water quality (at the 6 rivers targeted for HDD river crossings namely, Salda River, Tanki-1 River, Tanki-2 River, Bangshai River, Safai River and Langalia River). The construction contractor will be responsible for conducting the monitoring works including other waste management aspects related to the construction workers and construction works.

Concerning the implementation and monitoring activities related to ARAP, the Project Implementation Unit of GTCL will be primarily responsible and all works on physical resettlement of population are planned to be completed before the commencement of construction works by the contractor. In this respect the relevant monitoring systems for both resettlement and livelihood of resettled people are identified by the ongoing ARAP Study and dealt with separately under item (2) of below on Land Acquisition and Resettlement.

The environmental monitoring plan for technical aspects is summarized in Table 6.2-21. The overall monitoring plan in the form of a monitoring form is shown in Appendix 12 and will be updated in the Final Report, as appropriate, following the completion of the ongoing EIA/ARAP Study.

Table 6.2-21 Environmental Monitoring Plan for Dhanua-Elenga Project

Environmental Items	Environmental Parameters/ Monitoring Items	Unit	Bangladesh Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method)	Responsible Agency	Cost of Monitoring (BDT)
Construction/installation stage:							
Air Quality	SPM_{10}	$\mu gm/m^3$	150 (Statutory Rules 2005)	50 (World Bank Guideline) 150 Interim Value	•One Sampling Point near the project site another 1 km. away from the project site. •Per month one 24-hr. day sampling •High Volume Dust Sampler	Contractor	-2000/Set -Included in overall construction cost
	$SPM_{2.5}$	$\mu gm/m^3$	65 (Statutory Rules 2005)	25 (World Bank Guideline) 75 Interim Value	•One Sampling Point near the project site another 1 km. away from the project site. •Per month one 24-hr. day sampling •High Volume Dust Sampler	Contractor	-20000/Set -Included in overall construction cost
Surface Water Quality	pH	-	6.5-8.5 (Fishery use)	6.5-9.0 (USEPA)	•Both river banks (Bangshai, Slada, Safai, Tanki-1, Tanki-2 and Langolia) of the HDD Pipe Crossings •Monthly •pH meter	Contractor	-1500/Sampling Point -Included in overall construction cost
	SS (Suspended Solids)	mg/l	-	-	•Both river banks (Bangshai, Slada, Safai, Tanki-1, Tanki-2 and Langolia) of the HDD Pipe Crossings •Monthly •Filtration	Contractor	-3000/Sampling Point -Included in overall construction cost
	BOD	mg/l	<6 (BOD) (Fishery use)	-	•Both river banks (Bangshai, Slada, Safai, Tanki-1, Tanki-2 and Langolia) of the HDD Pipe Crossings •Monthly •Titration	Contractor	-3000/Sampling Point -Included in overall construction cost
	DO	mg/l	>5 (Fishery use)	3-9.5 (USEPA)	•Both river banks (Bangshai, Slada, Safai, Tanki-1, Tanki-2and Langolia) of the HDD Pipe Crossings	Contractor	-3000/Sampling Point -Included in overall construction cost

Environmental Items	Environmental Parameters/ Monitoring Items	Unit	Bangladesh Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method)	Responsible Agency	Cost of Monitoring (BDT)
					•Monthly •DO meter		
	Oil and Grease	mg/l	-		•Both river banks (Bangshai, Slada, Safai, Tanki-1, Tanki-2 and Langolia) of the HDD Pipe Crossings •Monthly •Gravimetric	Contractor	-3000/Sampling Point -Included in overall construction cost
	Temperature	^{o}C	25 (Fishery use)	-	•Both river banks (Bangshai, Slada, Safai, Tanki-1, Tanki-2 and Langolia) of the HDD Pipe Crossings •Monthly •Thermometer	Contractor	-3000/Sampling Point -Included in overall construction cost
Noise	Noise level (Residential Area)	dB	45 (Night-time)	45 (Night-time) (World Bank)	•50m from the construction site •Per Month one 24-hr. day sampling •Sound level meter	Contractor	-20000/Set -Included in overall construction cost
			55 (Day-time)	55 (Day-time) (World Bank)			
Waste	•Excess borrow pit soil •Generated Solid waste •Sanitary waste •Housekeeping status	-	-	-	Worksite and Camp site (weekly)	Contractor	-Included in overall construction cost
Operation stage:							
Waste	•Management of pigging waste	-	-	-	Worksite (pig launcher and receiver locations)	GTCL	-Included in overall operation cost

Note: For air quality sampling during construction stage radius of 1km distance from the project site is regarded as the limit of area of influence of air pollution

Source: JICA Survey Team

b) West Bank of Jamuna Bridge-Nalka Project

There are no surface water bodies located along the entire 14 km ROW of the pipeline. Moreover, there is no land acquisition or resettlement requirement. As such, surface water quality and social environmental monitoring are not required. Other than these 2 elements the rest of the monitoring plan is similar to the Dhanua-Elenga project above.

As such, the elements of the natural environment identified for monitoring during the construction/installation stage of the project (by the EIA Study) are ambient air quality and noise/vibration only. The construction contractor will be responsible for conducting the monitoring works including other waste management related construction workers and construction works.

The environmental monitoring plan for technical aspects is summarized in Table 6.2-22. The overall monitoring plan in the form of a monitoring form is shown in Appendix 13 and will be updated in the Final Report, as appropriate, following the completion of the ongoing EIA/ARAP Study.

Table 6.2-22 Environmental Monitoring Plan for West Bank of Jamuna Bridge – Nalka Project

Environmental Items	Environmental Parameters/ Monitoring Items	Unit	Bangladesh Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method)	Responsible Agency	Cost of Monitoring (BDT)
Construction/installation stage:							
Air Quality	SPM_{10}	$\mu gm/m^3$	150 (Statutory Rules 2005)	50 (World Bank Guideline) 150 Interim Value	•One Sampling Point near the project site another 1 km. away from the project site. •Per month one 24-hr. day sampling •High Volume Dust Sampler	Contractor	-2000/Set -Included in overall construction cost
	$SPM_{2.5}$	$\mu gm/m^3$	65 (Statutory Rules 2005)	25 (World Bank Guideline) 75 Interim Value	•One Sampling Point near the project site another 1 km. away from the project site. •Per month one 24-hr. day sampling •High Volume Dust Sampler	Contractor	-20000/Set -Included in overall construction cost
Noise	Noise level (Residential Area)	dB	45 (Night-time)	45 (Night-time) (World Bank)	•50m from the construction site •Per Month one 24-hr. day sampling •Sound level meter	Contractor	-20000/Set -Included in overall construction cost
			55 (Day-time)	55 (Day-time) (World Bank)			
Waste	•Excess borrow pit soil •Generated Solid waste •Sanitary waste •Housekeeping status	-	-	-	Worksite and Camp site (weekly)	Contractor	-Included in overall construction cost
Operation stage:							
Waste	•Management of pigging waste	-	-	-	Worksite (pig launcher and receiver locations)	GTCL	-Included in overall operation cost

Note: For air quality sampling during construction stage radius of 1km distance from the project site is regarded as the limit of area of influence of air pollution

Source: JICA Survey Team

6) Environmental Checklist

With due consideration to those aspects described above, environmental checklists were formulated separately for each project since the projects differ quite significantly, in particular concerning the resettlement aspects as also noted above, using the oil and gas pipelines sector checklist of JICA. The completed environmental checklists with reference to the completed EIA Study Reports under sub-contract are given in Appendix 14 (Dhanua-Elenga) and Appendix 15 (West Bank of Jamuna Bridge-Nalka).

It is noted that, in essence, no long-term environmental monitoring (operational stage of projects) is regarded as necessary (for either pipeline since they were laid underground) other than for the management of pigging wastes (already ongoing waste management works for operational gas transmission pipelines of GTCL) as also noted in the environmental checklists.

7) Stakeholder and Public Consultation

Stakeholder consultation targeting all resettlement households (Dhauna-Elenga project) and also those living in the vicinity of the planned ROW (sampling survey) in the form of questionnaire based interview survey and also public consultation (which also amounts to public information disclosure) in the form of an FGD (Focus Group Discussion) and also KII (Key Informant Interview) were conducted by the EIA/ARAP Studies.

Regarding FGDs, in total 12 FGD forums (10 for Dhanua-Elenga project and 2 for the West Bank of Jamuna Bridge-Nalka project) were conducted at different strategic locations along the planned ROW of each project. The participants of such FGDs, presided by the project proponent (GTCL) and moderated/assisted by the EIA/ARAP Study Team, include concerned UNOs (Upazila/Sub-district heads), representatives of the project affected persons (PAP), representative community leaders like school teachers, representatives of women's groups, representatives of local business groups like farmers and others.

a) Summary results of Stakeholder and Public Consultation (Dhanua-Elenga)

a1) Summary of Stakeholder Consultation

There are different types of stakeholders in any development project area. They have different ideas, views and suggestions about the advancement of their locality. The local stakeholders have different needs and understanding regarding the project as well. The PAPs i.e. the directly project affected persons are commonly worried about shifting and or re-building of their residences and structures, the market prices for the same in regard to compensation, hassles during compensation payments, and potential harassment at Land Acquisition (LA) offices. While other local stakeholders are concerned about adequate land price and compensation payment procedures and time frame, community support, income loss and restoration, social rehabilitation etc. The stakeholders of the project area are generally divided into four categories.

- Living Structure Losers (25 resettlement households)
- CBE (Commercial and Business Enterprise) Losers (3 poultry farms)
- Agricultural Land Losers
- Other Stakeholders

Views of Living Structure Losers

In fact, living structure loses for the PAPs are a touchy matter because a lot of memories and sentimental issues including that it was their ancestors' land and homestead and they are closely associated with it. Usually, people have been using these properties from generation to generation.

- People don't want to lose the place and shift elsewhere.
- Some of the land losers felt that they will not be able to purchase any land in the vicinity of their kith and kin with the compensated amount.
- People expected the top up compensation as per market rate.
- People will lose their social network.
- People are worried about DC's payment which may not cover the market price. So they want the real market price in compensation payments.
- People don't want any hassle in the compensation payment
- Project should offer an alternative land option
- They seek job opportunities in GTCL for the affected people
- Payment of compensation should be assured
- Those with concerns of being landless should have special treatment

Views of CBEs Losers

- Provision of Income restoration grant should be included in the project
- People want gas connection for business expansion
- People want Credit Support for resuming their business at a new location
- Provision of income generating training should be included under this project
- Project may damage their livelihood, so care should be taken that there are no serious problems
- Make sure to provide job opportunities in GTCL for the affected people

Views of Agricultural Land Losers

- People need proper compensation for PAPs

- People want gas connection for the locality
- At least PAPs should have the gas connection
- Poor and vulnerable people need special support from GTCL
- Provision of income generating training should be included under this project
- Project activities may hamper their livelihood, so care should be taken so that there are no serious problems
- Make sure the job opportunities are there in GTCL for the affected people
- Project area people are losing their land so their concern of becoming landless should be duly taken into account by the project authority.
- They said, it is irony that who suffer loses for the project don’t get gas connections. People of the community have earlier given their land for gas pipelines but haven’t gotten gas connections yet.

Views of Other Stakeholders

- Since there is a fuel wood problem in the localities, they made it a point that gas connections are indispensable for the local people
- Many handloom industries can be developed in the project area if there is access to gas connections and thus people will be benefited by:
    - New job opportunities and lower production cost for the handloom products
    - Gas fuel is very helpful and cost effective for dying purposes
    - The quality of ‘Sari’ will be enhanced. So, export and income will be increased.
    - Gas connections will create large scale economic development and employment generation in the area through this and other backward linkage industries.
- Local labour will have to be employed by the contractors during construction work
- Damaged roads should be rehabilitated as soon as possible
- Poor and vulnerable people should have special support
- Local people will support the project for the greater interest of the country
- Gas connections in the affected locality are important as it would save natural forest resources and thus the natural beauty of the project area as well.
- Make sure there are job opportunities in GTCL for the affected people
- GTCL will support the development of the project area and its neighbourhood community

a2) Summary Result of Public Consultation

Focus Group Discussion (FGD) Summary

Ten FGDs were conducted along the pipeline route at various locations. Summaries of the results of these FGDs are given below.

- The affected persons should be given employment during the construction period
- Ensure reduced tree and structure loss
- Ensure proper compensation at the rate full replacement cost
- Community and religious sites are to be saved (the planned route has saved them)
- Provide gas connections for the villagers
- Unemployed youths are to be given training and employment.

Key Informant Interview (KII) Summary

Village leaders, school teachers, local government chairman and members were targeted for KII survey. Summary of the result of the KII is given below.

- GTCL should take care about the public safety as well as pipelines at critical locations in order to alleviate any fear of explosion. The authority (GTCL) should exercise adequate care in construction and maintenance of the pipelines.
- Pipelines should be laid and buried properly after welding is over.
- Works should be faster lessening the loss of production of crops.
- The gas should be cheap and available to the limited income group at the earliest possible opportunity and consideration of any subsidy/discount at the initial stage would be highly appreciated and will ensure cordial relations with the stakeholders.
- Ensure use of quality material and best workmanship for safe and durable pipeline system and to provide uninterrupted supply to the consumers.
- Prompt placement of funds by the requiring bodies for quick completion of acquisition and requisition.
- The executing agency (GTCL) should follow all rules, regulations and standards in construction, operation and maintenance of the gas system in terms of public safety and well being of stakeholders.
- Care should be taken for ensuring the least possible damage to Local Government Engineering Department (LGED) built rural roads and structures

during construction of the pipeline and informing them well ahead in crossing such roads.

- Emergency response plan should be in place to meet any eventual accident thereafter.

Gist of Stakeholder and Public Consultation

Overall, people understand the importance of the project for national development and no one opposes the project resolutely and the majority of the surveyed people (70%) living along the planned route of the pipeline are supportive of the project with the provision of due compensation for lost assets based on market price and other support systems. Still, 30% of surveyed people would rather that loss of housing (and resettlement) are avoided. Still considering the small-scale of resettlement of only 25 households this resettlement issue is regarded as being amicably settled with the provision of due compensation based on full replacement cost and other planned support measures as dealt with under item (2) below as ARAP aspects (study results). Moreover, both the stakeholder and public consultation survey results indicate strong desire for gas supply service for those people in the affected locality of the pipeline route.

b) Summary results of Stakeholder and Public Consultation (West Bank of Jamuna Bridge-Nalka)

The issues involved are relatively minor since no significant private sector land acquisition or resettlement of households is required. The salient features as conclusions of the 2 FGDs held along the proposed pipeline route are summarized below.

People understand the importance of the project for national development.

They require employment of local work force by the contractor on a preferential basis including preference to engage local businessmen/contractors depending on their suitability as appropriate

They desire full replacement cost as compensation that has to be paid promptly for any land or property acquired. This aspect is relevant only for the CGS (city gate station) of this project since pipe laying will be in Government owned land under the jurisdiction of Jamuna Bridge Authority. (CGS would require about 1 ha of vacant land, though its location is flexible and has to be determined by GTCL later and hence ownership of land to be acquired is not yet known).

People also emphasized that utmost care has to be taken in the execution of construction works so as to minimize any environmental damage though they understood that most adverse effects would be only temporary in nature.

People strongly desire the provision of gas supply service for the locality affected by the pipeline route.

Overall the desires of the people are quite similar to those of Dhnaua-Elenga project summarized above.

(2) Land Acquisition and Resettlement (ARAP Aspects)

Land acquisition (including temporary acquisition referred to as requisition during the construction stage of the project) and some housing resettlement (estimated at 25 households with the population of 121 persons) and relocation of some CBEs (3 paultry farms) are involved for the Dhaua-Elenga Project only. Hence the description below is focused mainly on the Dhauna-Elenga Project for which ARAP Study was also conducted. Acquistion of vacant land of 1 ha (100m*100m) for the CGS (City Gate Sation) at Nalka is the sole land acquisition requirement for West Bank of Jamuna Bridge-Nalka project. The cost of this land acquisition for the CGS at Nalka is estimated at 49.4 million BDT.

1) Acquired land including resettlement requirement (Dhanua-Elenga)

The total width of ROW necessary for construction/installation of the pipelines is 23m of which 8m of ROW located centred on the underground pipeline will be permanently acquired by the project proponent (GTCL). Accordingly, the total land area acquired during the construction of the project would be about 120 ha for the total length of ROW of 52 km (Dhanua-Elenga).

The ROW passes through 3 districts, Gazipur, Mymenshing (only about 1km portion of ROW) and Tangail (all 3 districts are located in Dhaka Division).

The land-use of the ROW is mostly lowland rice fields and ponds that become wetlands in the rainy season (typical to flood plains of Bangladesh). As such, all pipe construction/installation works will be confined to the dry season only.

In total, 25 households are identified for resettlement and are mostly located along the initial 32 km of the ROW located between Dhanua and Sulgrampur and all resettled households are Muslims. This resettlement requirement is found to be necessary even with all efforts made to minimize such requirement with realignment from the originally planned route of 2005 under ADB project (refer to Table 6.2-10 for comparative evaluation of alternative routes).

2) Framework of land acquisition and resettlement (including ARAP)

The legal (and policy) framework and entitlements adopted are based on national law of Bangladesh (Acquisition and Requisition of Immoveable Property Ordinance of 1982) and policy of JICA on Involuntary Resettlement. At present, in donor financed projects (like those by WB and JICA) there is no major policy difference with the donors in resettling the affected persons. Government is legally bound for payment of cash compensation under the law (CCL) and premium money (50% premium to estimated value). But by administrative means, Bangladesh government is doing all recognized efforts in regaining affected persons' socio economic status and also special attention is given for vulnerable, indigenous people and female-headed households.

Acquisition and Requisition of Immoveable Property Ordinance of 1982 (with its subsequent amendments in 1993 and 1994) covers all cases of acquisition and requisition (temporary acquisition) by the government for public purpose and interest. The legal processes are initiated by the Deputy Commissioner (DC), of the concerned district with a detailed map of the area and a land acquisition plan.

In summary, following measures shall be taken for this project,

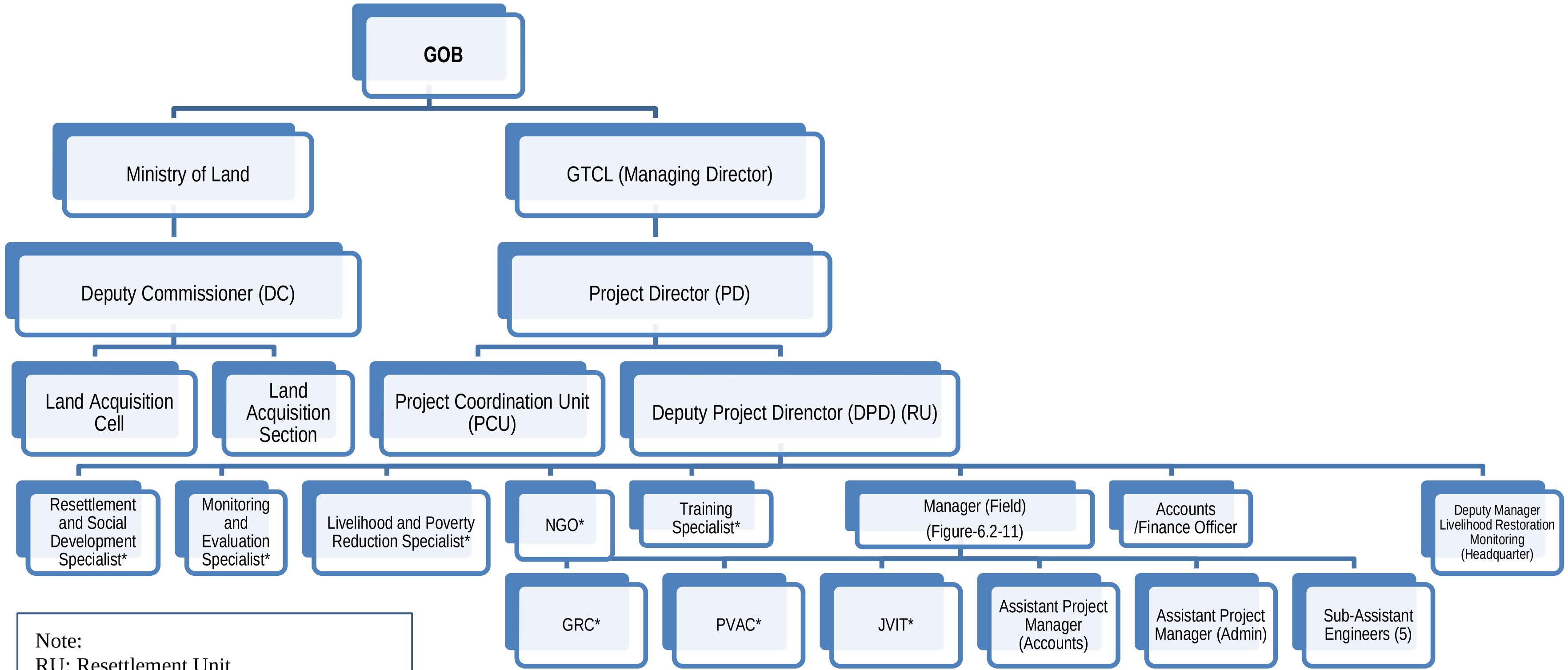
a) Avoiding or minimizing adverse project impacts where possible (that has been done by rerouting the ROW to minimize resettlement requirement)
b) Consulting with project affected people (PAP) in project planning and implementation, including
c) Disclosure of Resettlement Action Plan(RAP) and project related information
d) Payment of compensation for acquired assets at the market/replacement value
e) Resettlement assistance to PAPs, including non-titled persons (informal dwellers/squatters and encroachers);
f) Income restoration and rehabilitation program; and
g) Special attention for vulnerable groups

Consistent with the JICA policy, this policy framework and resettlement procedural guidelines will be applicable for this project. This will ensure that persons affected by land acquisition and resettlement will be eligible for appropriate compensation and rehabilitation assistance. The framework reflects land acquisition and regulation of the Government of Bangladesh as well as Guidelines of JICA for Environmental and Social Considerations (2010) as policy on Involuntary Resettlement and other social safeguard guidelines (such as WB OP 4.12).

It stipulates eligibility and provisions for all types of losses (land, crops/trees, structures, business/employment, and workdays/wages). If land for land is not a feasible option, PAPs will be compensated at full replacement costs. In addition PAPs will receive additional grants to match replacement cost for lost assets (land and houses), transaction costs such as documentation stamps and registration costs (in case of purchase of replacements land), other cash grants and resettlement assistance such as shifting allowances, compensation for loss of workdays/income due to dislocation. Female headed households, indigenous people households (if any) and vulnerable households will be eligible for further cash assistance for relocation and house construction.

In this respect the gaps between JICA Guidelines and the laws of Bangladesh concerned to land acquisition and compensation aspects are given in Appendix 16.

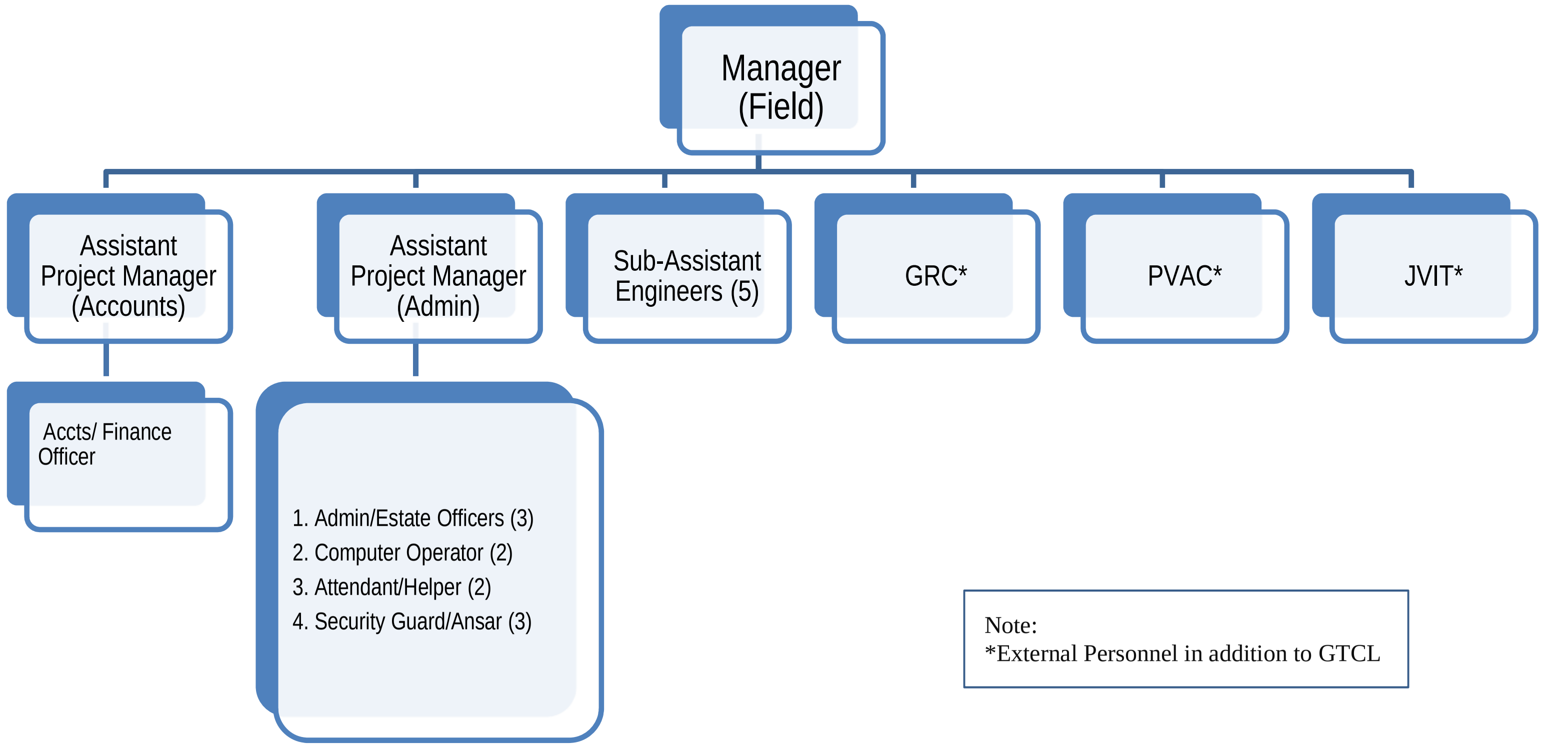
In order to achieve the above mentioned policy objectives a suitable institutional set-up is proposed as an RU (Resettlement Unit) to be headed by a Deputy Project Director assigned under the Project Director in charge of implementation of these 2 pipeline projects by GTCL. This RU will have overall responsibility for the conduct of all activities concerned to land acquisition, resettlement/relocation, compensation, job training, livelihood restoration and monitoring and all other related activities of ARAP. The institutional Set-up Diagram of the Resettlement Unit (RU) as the Land Acquisition and Resettlement Framework proposed by the ARAP Study is shown in Figure 6.2-9 and Figure 6.2-10.



Note:
RU: Resettlement Unit
*External Personnel in addition to GTCL

Source: JICA Survey Team

Figure 6.2-10 Institutional Set-up of Resettlement Unit (RU-GTCL)



Note:
*External Personnel in addition to GTCL

Source: JICA Survey Team

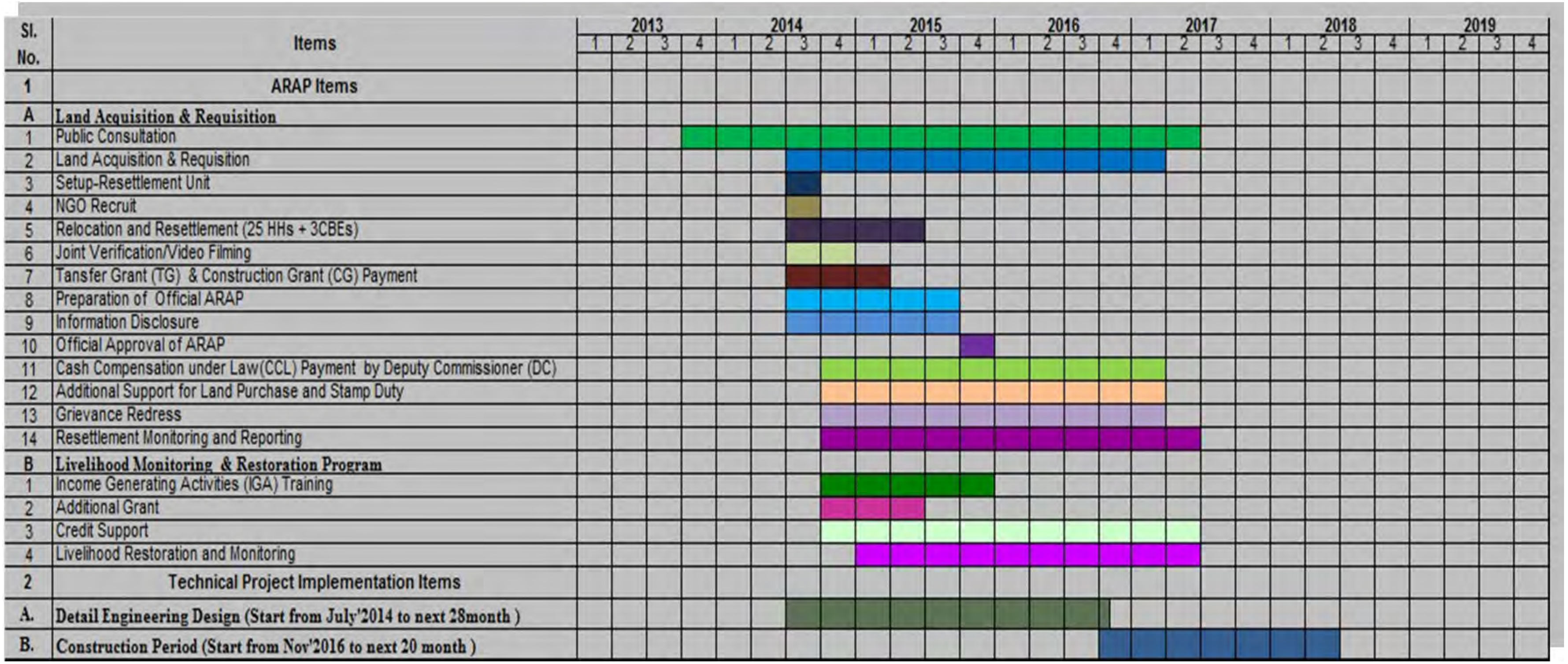
Figure 6.2-11 Institutional Set-up of Deputy Manager (Field)

It is noted that a highly reputed NGO will be employed by RU of GTCL (RU-GTCL) to conduct all resettlement related activities and will be represented in all related teams and committees including the GRC (Grievance Redress Committee), PVAC (Property Valuation Advisory Committee) and JVIT (Joint Verification Inventory Team). Other related external expertise is to be hired for effective functioning of RU-GTCL (by GTCL) and hence the effective implementation of all aspects of ARAP include the following:

- Resettlement and Social Development Specialist
- Monitoring and Evaluation Specialist
- Livelihood and Poverty Reduction Specialist Training Specialist

3) Schedule of ARAP Implementation

All land acquisition and resettlement of population is determined as could be completed in a time frame of one year. The subsequent monitoring of livehood restoration of resettled population is expected to be completed in a time frame of 2 years (minimum requirement as per JICA guidelines) considering the small-scale of resettlement requirement of only 25 households. Accordingly the total estimated timeframe of all ARAP activities including land acquisition and resettlement aspects and related monitoring of livelihood restoration of resettled population is estimated at 3 years. The overall implementation schedule of ARAP, assuming that the project could be commenced from July 2014 is shown in Figure 6.2-12. As per this schedule, all resettlements and relocations (25 households and 3 CBEs as summarized in Table 6.2-24 below) are planned to be completed in the one year period from July 2014 to June 2015. Livelihood restoration and monitoring programs will cover the total period of 2.5 years from January 2015 to June 2017 that will also meet the minimum requirement of 2 years following the completion of all resettlement activities by June 2015.



Source: JICA Survey Team

Figure 6.2-12 Schedule of ARAP Implementation (Dhanua-Elenga)

4) Inventory of affected persons and lost property

A summary of all inventory of affected persons and properties (including households of resettlement) as determined by the inventory survey results of ongoing ARAP Study is given in Table 6.2-23. Details on the lost inventory as the result of land acquisition and resettlement for the ROW of the Dhanua-Elenga pipeline organized according the affected location are summarized in Appendix 17. Appendix 17 also lists the owners and the locations of the 28 affected structures (25 households for resettlement and 3 CBEs in the form of poultry farms for relocation).

It is noted that farmlands are the mostly affected category (due to permanent acquisition and temporary acquisition/requisition of land for the project) accounting for 98% of affected lands that could be reverted to such use after the completion of all construction works with restriction on the type of crops allowed for plantation limited to non-deep-rooted plants (such as rice, vegetables, bananas and others) above the permanently acquired ROW by GTCL (width of 8 m). This is the current practice in the already operational pipeline route of Dhanua-Elenga and elsewhere that is also promoted by GTCL as the effective means to preserve the ROW from any other inappropriate uses. Accordingly, loss of 98% of lands due to the project is regarded as only short-term effect basically confined to the construction period of the pipeline construction/installation works.

Table 6.2-23 Project Affected Units (PAUs) and Affected Persons (APs)-Dhanua-Elenga

Type of Loss		No. of PAUs			No. of APs		
		Legal	Illegal	Total	Legal	Illegal	Total
Required for Displacement							
1	HH (Structure owner on Gov. land)	0	-	-	0	-	0
2	*HH (Structure on Private land)*	*25*	-	-	*121*	-	*121*
3	HH (Tenants)	0	-	-	0	-	0
4	CBEs (Structure owner Gov. land)	0	-	-	0	-	0
5	CBEs (Structure owner on Private land)	3	-	-	13	-	13
6	CBEs (Tenants)	0	-	-	0	-	0
7	Community owned structures including physical cultural resources	0	-	-	0	-	0
Not required for displacement							
8	Land owners	400	-	-	2,000	-	2,000
9	Wage earners	4	-	-	20	-	20
	Grand Total(1-9)	**432**			**2,154**		**2,154**

HH: House Holds, CBEs: Commercial and Business Enterprises: 4 wage earners work in the 3 CBEs

Source: JICA Survey Team

It is noted that as per the Bangladesh system on resettlement related to public sector project land acquisition, official cut-off date for the decision of compensation is only possible following the joint survey of GTCL and DC (Deputy Commissioner) of relevant district. This could be commenced only after the approval of project including funding for implementation. Still, GTCL is recommended to undertake filming of all 25 households targeted for resettlement soon so as to mitigate any fraudulent claims in the future. The personnel of GTCL that patrol to ensure the integrity of the existing pipeline could undertake this task since the proposed route of this new pipeline is basically located nearby the route of the existing pipeline.

5) Budget for ARAP implementation

The total cost for all aspects of ARAP implementation including land acquisition and compensation and all other concerned activities (such as job training, livelihood restoration and monitoring and others) for this Dhanua-Elenga pipeline project is estimated at about 1,697 million BDT. A summary of this budget cost breakdown is shown below in Table 6.2-24.

Table 6.2-24 Summary Budget for ARAP implementation (Dhanua-Elenga)

No.	Items of cost breakdown	Cost (BDT)
1.	Land acquisition & land requisition	1,678,914,097
2.	House and other compensations	17,849,698
3	**Grand total as Budget for ARAP implementation**	**1,696,763,795**

Source: JICA Survey Team

6) Entitlement policy

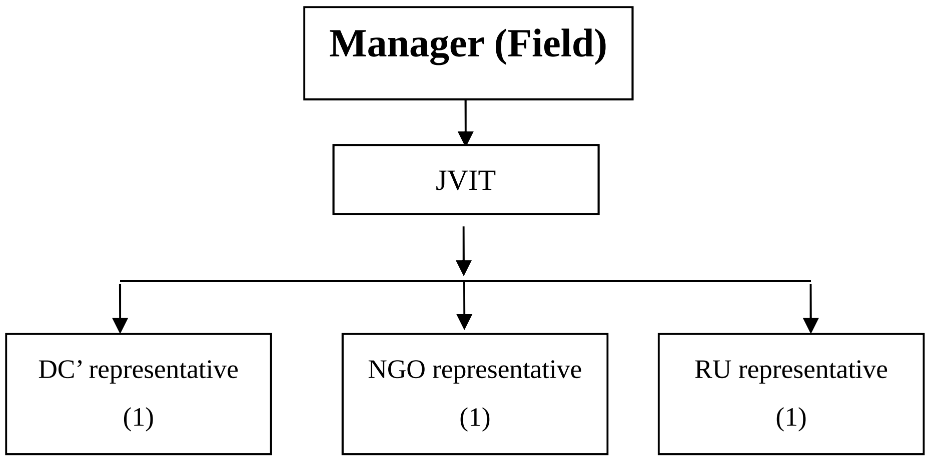
The proposed entitlement policy matrix on land acquisition and resettlement related compensation for this project is given in Appendix 18. The policy matrix identifies the due mechanism for income/livelihood loss related compensation payment consequent to land acquisition and resettlement. With the formulation of Grievance Redress Committee (GRC) and Property Valuation Advisory Committee (PVAC) in addition to the formulation of Joint Verification Inventory Team (JVIT) all significant issues arising during the implementation of land acquisition and resettlement works for the project is expected to be solved in amicable manner (also refer to Figure 6.2-10 and Figure 6.2-11).

7) ARAP implementation and monitoring system

a) Joint Verification Inventory Team (JVIT)

JVIT (refer to Figure 6.2-10 and Figure 6.2-11 for its overall set-up) is the team formed for identification of affected structures consequent to the project and preparation of relevant inventory of assets as the basis for estimation of asset value and related compensation. JVIT will be comprised of one member each from DC (land acquisition officer of DC), RU of GTCL and NGO recruited by RU for the implementation of ARAP as described above. This is for the estimation of official compensation payment by DC with 50% premium as CCL (Cash Compensation under the Law).

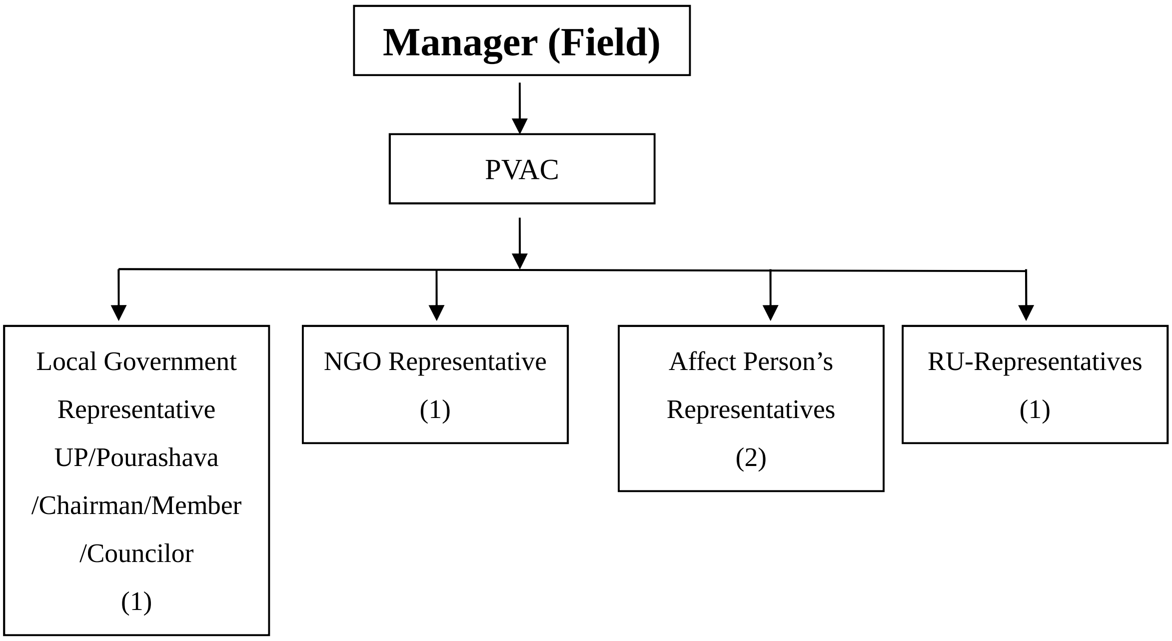
The institutional set-up of JVIT is shown below



b) Property Valuation Advisory Committee (PVAC)

PVAC (refer to Figure Figure 6.2-10 and Figure 6.2-11 for its overall set-up) will play a vital role for the determination of additional compensation payments after payments from DC for PAPs and will be formed with one public representative, one from RU-GTCL, one from NGO and two from affected persons in the concerned union. The committee will be comprised of five members. Here, DC will have no representation since this is for the determination of additional compensation to be made above that of CCL to make up for the replacement cost, The responsibility of DC is limited to the payment of CCL only.

The institutional set-up of PVAC is shown below.

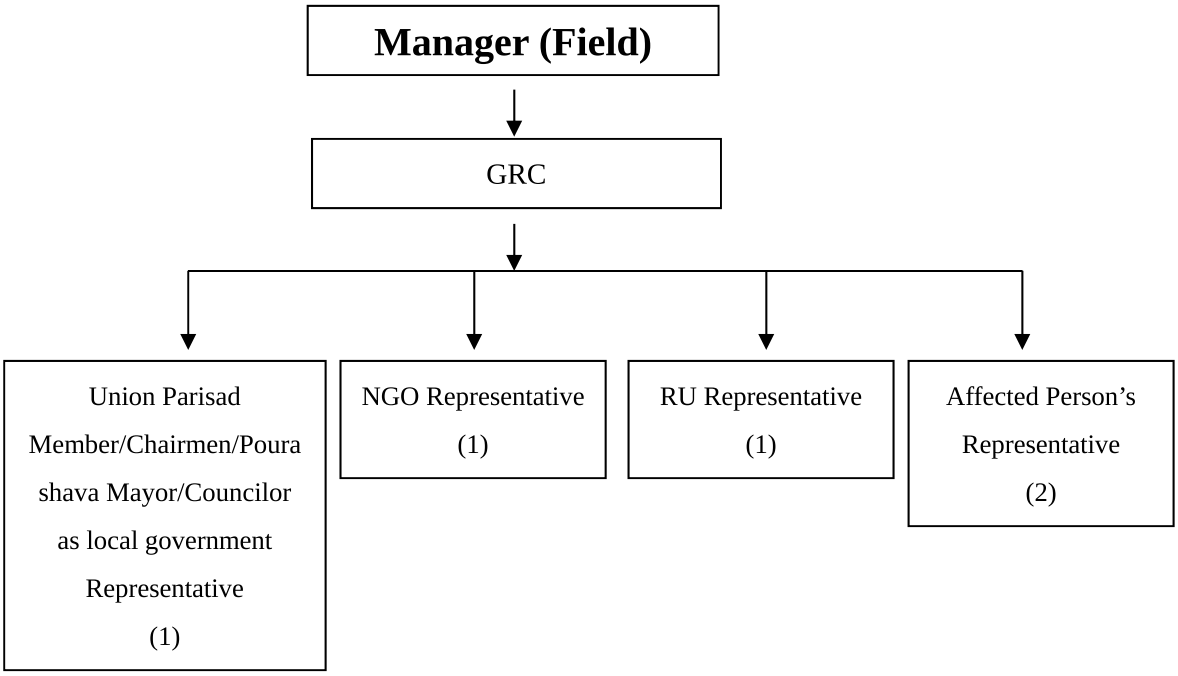


c) Grievance Redress Committee (GRC)

The GRC (refer to Figure Figure 6.2-10 and Figure 6.2-11 for its overall set-up) will be formed as the grievance redress system on a union basis similar to PVAC above and will be comprised of 5 members also with representation similar to PVAC. GRC will play the vital role of attending and amicably solving grievances raised by PAPs related to all resettlement benefits, relocation and other assistance other than for legal disputes relating to ownership rights under court of law.

In principle, GRC committee will receive the application from the affected stakeholders about their grievances and they will solve the grievances on a monthly basis. Other than disputes relating to ownership rights under the court of law as noted above, the GRC will review grievances involving all resettlement benefits, relocation, and other assistance. Grievances will be redressed within 2-4 weeks from the date of lodging the complaints. The PAPs can appeal the decision of the GRC in the appropriate court of law or to DC, depending on the nature of the grievance. All documents of grievances and judgment will be registered and filed both with GRC member of NGO and project office of GTCL in the field and aggrieved PAP will get a copy of such judgment within 30 days of lodging complaint.

The institutional set-up of GRC is shown below.



d) ARAP monitoring form

The ARAP monitoring form formulated by the ARAP Study is given in Appendix 19 that includes both RAP implementation and the subsequent livelihood monitoring of resettled persons (implemented RAP).

e) Livelihood restoration program

Vocational training is identified by the ARAP Study as the best suited training program to facilitate livelihood restoration of PAPs. In this respect PAPs, in particular those that belong to households for resettlement, who do not have definite means of livelihood will be primarily eligible for vocational training. However, those individuals and households who are landless and those who were earlier dependent on wage labour or tenant farming/share cropping, but may not be able to continue with the same activity after relocation would also be eligible. Specific focus groups for vocational training would also include women, educated youths and traditional artisans.

Shown below are broad alternative training modules that were identified by the ARAP Study and are regarded as suited to the locality of the project area. The identified alternative skill training modules below are expected to provide full time employment and would also require relatively long period of training (2-6 months) since they are relatively sophisticated training and new skills.

- Motor/automobile mechanics (especially rural vehicle ‘Nasimon’, tempo, CNG, battery driven Auto rickshaw, Motorcycle etc. ;

- Driving;
- Rickshaw assembling and repairing;
- Secretarial skills/word processing and computer skills;
- Plumbing, electrician, metal works;
- Manufacture of rural sanitary equipment.
- Technician for Mobile repairing
- Biogas Plant technician
- Solar technician
- Technician for Improved Cook Stoves (ICS)
- Poultry Rearing
- Beef fattening
- Tailoring and Sewing Operating
- Mushroom Cultivation
- Pisciculture and Fish breeding technician
- Pearl Culture from Oysters (Technology dissemination from Fishery research Institute of Mymensingh)
- Fish breeding
- Fish Cultivation in Cages in Open water
- Shrimp Cultivation (for fresh water species)
- Food processing
- Furniture technician/Carpentry
- Fish processing
- Food Processing
- Palm tree Cultivation/Palm Oil Processing /Extraction Technician
- Strawberry Cultivation
- Vegetable cultivation/crop diversification;
- Low cost house construction;
- Animal husbandry/dairy;
- Hand looms.
- Electronics technician(Toy making etc)
- Marketing Trade
- Primary Health care
- Mason work/ Construction work

Among the above alternative training modules, fish culture, and poultry farming are in high demand in the project area. Moreover, as a new trade, palm oil cultivation related expertise has high prospects and there is a demand for the technical skills needed in palm oil farms to extract oil. Already in Sakhipur area a large number of oil palm tree farms have been developed. Also as an industrial belt, industrial sewing operators also are in high demand in the project area. The required effective skill training programs will be identified and selected by the Livelihood and Poverty Reduction Specialist and Training Specialist during the implementation of the livelihood restoration program under ARAP (refer to Figure 6.2-10).

It is noted that the above training modules are rather elaborate and should not be the sole focus of livelihood restoration oriented training program. Supplementary income generation oriented training schemes focused on the poor, vulnerable and women PAPs are also very important. Such training schemes would include the following:

- Plant nurseries;
- Tailoring and handicrafts;
- Bee keeping;
- Homestead gardening.

6.2.13 Associated Risks under the Project

Risks to be considered during the construction and operation stage under the project are as follows;

No.	Associated Risk	Responsibility	Mitigation or Counter Measure
1.	**Preparatory Stage**		
1.1	Delay of the project approval	GTCL Related Agencies	1) Early approval of DPP 2) Early contract of SLA
2.	**Implementation Stage**		
2.1	Delay of ROW acquisition due to resistance from inhabitants	GTCL Related Agencies	Continuous monitoring and immediate actions
2.2	Delay of material and equipment supply due to increase of worldwide pipeline projects	GTCL/ Consultant	Procurement planning in basic design stage in consideration of worldwide trend
2.3	Delay of works and completion	GTCL/ Consultant/ Contractor	1) Progress to be closely monitored in order to timely cope with problems (e.g. lack of understanding on contract, Misunderstanding of procurement schedule, inefficient work procedure, inadequate risk assessment and project management, etc.) 2) Confirmation of delivery period for the longest lead item (valve, equipment for metering station, etc.) 3) Contract indicating:

No.	Associated Risk	Responsibility	Mitigation or Counter Measure
			i) Construction deadline ii) Delay Penalty for reasons attributable to the Contractor 4) Scheduling in consideration of possible causes of delay (e.g. Wet season)
2.4	Lack of contractor's ability	GTCL/ Consultant	1) Selection of qualified Consultant who prepares tender documents and evaluates them. 2) Careful check and review of tender documents submitted by the Contractor 3) Execution of company survey for the Contractor's ability as required 4) Contract indicating "contract-out conditions" by reasons attributable to the Contractor (e.g. More than five (5) months schedule delay for major milestone, etc.) 5) Submission of client certificate or contract document for the contractor's project experiences
2.5	Imperfect quality	GTCL/ Consultant/ Contractor	1) Submission of qualification certificates for welding and non-destructive testing activities 2) Sufficient design review of the Contractor's design documents for RMS 3) Check of quality control records prepared by the Contractor 4) Monitoring of all contractor's activities for taking quick countermeasures 5) Establishment of proper acceptance criteria for all contractor's activities 6) Penalizing the Contractor in case of non-fulfilment of equipment performance
2.6	Cost overrun	GTCL/ Consultant	1) Monitoring of all contractor's activities for taking quick countermeasures 2) Preparation of appropriate tender documents for

No.	Associated Risk	Responsibility	Mitigation or Counter Measure
			prevention of unexpected change orders 3) Progress to be closely monitored in order to timely cope with unexpected problems. 4) Securing of contingency
2.7	Accidents during field construction work	GTCL/ Consultant/ Contractor	1) Establishment and execution of EHS program 2) Review of construction procedures for all field construction works 3) Assignment of the staff in charge of EHS issues in GTCL as well as the Contractor 4) Execution of risk assessment for all field construction work procedures and necessary countermeasures against the risks
2.8	Environmental pollution	GTCL/ Consultant/ Contractor	1) Establishment and execution of EHS program 2) Review of environmental protection measures for all field construction works 3) Checking and Monitoring of all waste disposal procedures 4) Assignment of the staff in charge of EHS issues in GTCL as well as the Contractor
3.	**Operation & Maintenance Stage**		
3.1	ROW damage due to abnormal weather condition	GTCL	Regular inspection for precognition of possible ROW damage due to heavy rain or other conditions
3.2	Damage to the pipeline by third party	Third party/ GTCL (for regular inspection)	Regular inspection against illegal activities within the ROW
3.3	Corrosion due to lack of maintenance for Cathodic Protection (CP)	GTCL	Current survey at test box should be carried out in accordance with operation and maintenance manual.
3.4	Condensate accumulation inside pipeline due to lack of pigging operation that may cause trouble in the gas flow	GTCL	Pigging should be performed based on the operation and maintenance manual.
3.5	Incorrect operation	GTCL	Ad hoc meeting in the site operation office and OJT will be important.

6.3 Installation of Pre-Paid Gas Meters for TGTDCL

6.3.1 Scope of the Project

The objective and outline of this project component are described in Section 4.4.1 (1) & (2), and the scope of the project is summarized in the table below.

<table>
<tr><th>No.</th><th>Scope of Works</th><th>Remarks</th></tr>
<tr><td>1.</td><td>Detailed designing and engineering, Sub material procurement, Installation, Commissioning and Testing of Pre-paid Gas Meters and WEB system units with associated materials, consisting of the following equipment:
▪ Pre-paid Gas Meter x 200,000 nos. in Dhaka Metropolitan Area
  ▪ Existing customer Case-A: 93,000 nos
  ▪ Existing customer Case-B: 77,000 nos
  ▪ New town area Case-A: 30,000 nos
▪ WEB system
  ✓ System network server station x 2 (as 1set)
  ✓ Data base system server station x 2 (as 1set)
  ✓ KIOSK (POS) x 100 (back up 50 included)
▪ Detail design work x 1
▪ Construction work for installation of Pre-paid Gas Meters in existing facility x 200,000
  ✓ Modification of existing riser
  ✓ Installation of additional pipe (angle pipe etc.)
  ✓ Installation of Pre-paid Gas Meters
▪ Construction work for installation of WEB system in TGTDCL head office x 1
  ✓ System network server station x 2 (as 1set)
  ✓ Data base system server station x 2 (as 1set)
▪ Construction work for installation of KIOSK (POS) in branch office of TGTDCL x 4
  ✓ Installation of POS (back up as service office) with internet system x 4
▪ Construction work for installation of KIOSK (POS) in proposed sites (bank, supermarket etc. depend on contractor proposal for operation network) x 96
  ✓ Installation of POS with internet system x 96</td><td>Proposed Pre-paid Gas Meters shall comply to OIML Standard R 6, R31, R11 and R 117-1 etc.
WEB system has internet security remote system for communication with the KIOSK as re-charging bill and gas consumption data management for the customers.
IC card communication method shall comply to ISO/IEC 18092
Each facility working condition shall be referred to 6.3.5 (2)</td></tr>
</table>

	▪ All bulk materials required for proposed facility ▪ Relocation works of existing facility (if necessary)	
2.	Preparation and submission of operation manual	
3.	Supply of 1 year spare parts and special tools for proposed facility	As per Manufacturer’s standard
4.	Training of operators (before commissioning)	
5.	Submission of as-built document	To be submitted within 1 month after area wise facility unit handover.
6.	Defect Liability Period	12 months

Further details of the Project are described in Section 6.3.5 below.

6.3.2 Present Status of Other Pre-paid Meter Project

TGTDCL installed 4,500 prototype pre-paid meters at Lalmatia and Mohammadpur. The prototype pre-paid meters were developed and supplied by the Institute of Information and Communication Technology (IICT) and the Bangladesh University of Engineering and Technology (BUET).

Furthermore, the project for the installation of 8,600 pre-paid gas meters in Mohamadpur and Lamatia area funded by ADB is currently under tendering process. This project is also considered as a pilot project, and ADB do not intend to assist further full-scale installation of pre-paid meters.

Therefore, this project component will not overlap with those pilot projects.

6.3.3 Lessons from Pilot Project

As mentioned in the above section, TGTDCL installed 4,500 prototype pre-paid meters in Dhaka, however, after the installation of these prototype meters, TGTDCL suffered from frequent breakdown of the meters due to poor quality such as lack of dustproofing and waterproofing.

Prototype pre-paid meters

Meter breakdown at Mohammadpur area

Therefore, the adoption of reliable and durable meters with high IP rate and contactless IC cards is strongly recommended for this project component.

6.3.4 Public Awareness Campaign and Rise of Gas Price

The most expected impact of the introduction of pre-paid metering system is the decrease of waste in natural gas usage among domestic customers. However, this is highly dependent on the energy saving awareness of domestic customers that would be improved by a campaign and also the rise of gas price.

(1) Public Awareness Campaign

Before and also during the installation of the pre-paid metering system, a public awareness campaign is required by means of:

- Large-scale campaign using mass media
- Lectures directly to domestic customers at the time of activation of the pre-paid metering system.

(2) Rise of Gas Price

According to the interviews with domestic customers who are currently under the pre-paid metering system of a pilot project, it seems that their gas usage pattern is not much different from the one before the metering system was introduced. This is mainly because of the low fixed rate of gas tariff which does not encourage the domestic customers for energy saving. Therefore, the rise of gas price is also indispensable to ensure the decrease of gas usage.

The sudden and sharp rise of gas price for domestic customers will be difficult in consideration of the resistance from customers. However, the progressive charging system (block tariff system) according to the gas usage can be established by the pre-paid metering system without raising the base unit price. This would improve the energy saving awareness of domestic customers. Therefore the pre-paid metering system which is able to set such progressive charging system is recommended for this Project.

6.3.5 Preliminary Design of the Project

(1) Design Life and Warranty of the Entire System

The design life and warranty period of the pre-paid gas metering system should be not less than 20 years and 2 years, respectively.

(2) Pre-Paid Gas Meters

1) Working Conditions

Working Conditions of pre-paid gas meters are recommended as follows in consideration of the environmental conditions and natural gas supply conditions in Bangladesh.

Table 6.3-1 Working Conditions for Pre-Paid Meters

Item	Unit	Condition
Flow range (without water heater)	m3/hr	2.5
Flow range (with water heater)	m3/hr	4.0
Pressure	mbar	75 – 500
Temperature (operation / storage)	deg C	0 – 40 / 0 – 70
Humidity	%	98%

Source: JICA Survey Team

2) Specifications & Requirements

Specifications and requirements of pre-paid gas meters are recommended as follows in consideration of the lessons from pilot project mentioned in above Section 6.3.3.

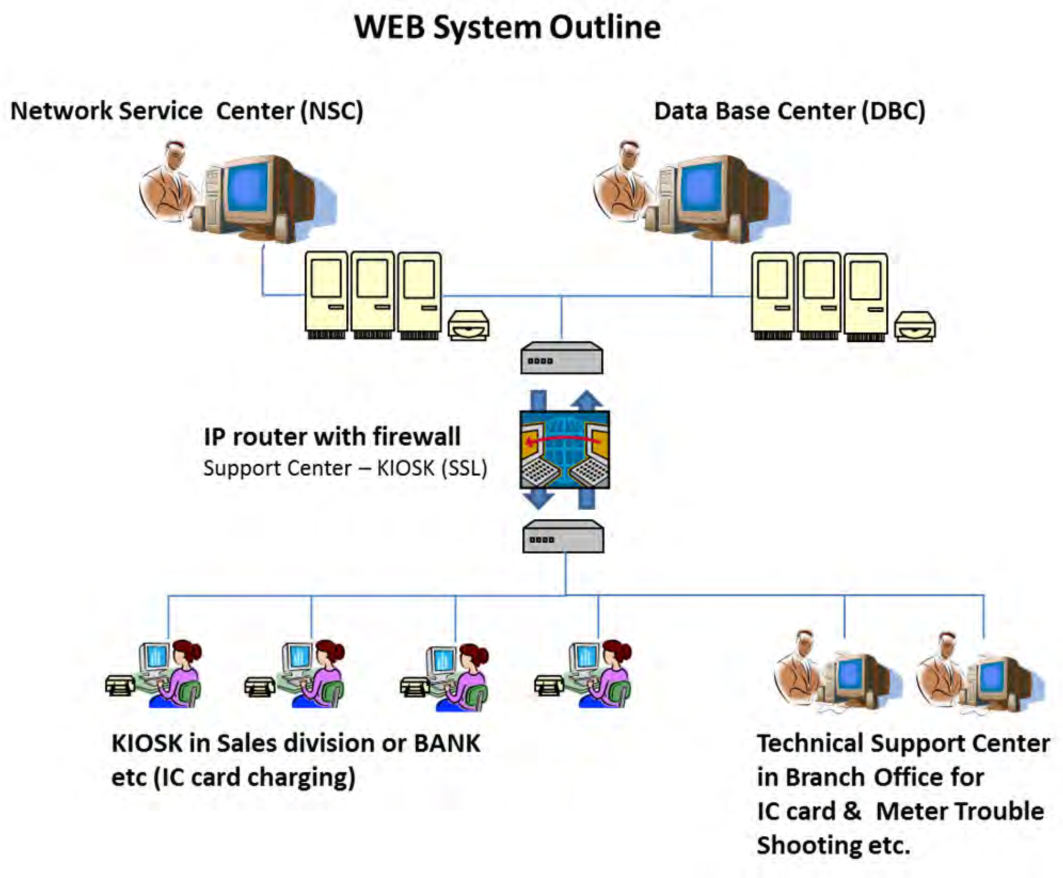
Table 6.3-2 Specifications & Requirements for Pre-Paid Meters

Item	Specification & Requirements
Pre-paid Gas Meter type	Diaphragm or Ultra Sonic
Enclosure protection (IP code)	International Protection (IP) 65 (min. IP 54)
Enclosure case	Die cast Aluminium
Battery Type (Service Life)	Lithium Ion (min 10 years)
IC card	Contactless
Unit price setting	Progressive charging system
Safety functions	Protection device or function against unacceptable situations such as gas leakage, etc.

Source: JICA Survey Team

(3) WEB System (Network Service Centre & Data Base Centre)

The outline of the WEB System is illustrated in the figure below.



Source: JICA Survey Team

Figure 6.3-1 Outline of the WEB System

Domestic customers charge their pre-paid cards in a KIOSK located regionally for easy access, and all payment data is stored in a Data Base Centre with a back-up server that is located in the head office of TGTDCL. The entire WEB system is controlled and maintained by a Network Service Centre also located in the head office in TGTDCL while a Technical Support Centre technically supports regional customers.

A WEB based management system is strongly recommended for the security of customer data, and this system will extract the abnormal data which may correspond to improper usage.

Specifications and requirements of the WEB system are recommended as follows.

Table 6.3-3 Specifications and Requirements for WEB System

Item	Unit	Specifications & Requirements
Network Service Center / Data Base Center	Nos.	2 units with Desk top PC with server, Core router, fire wall, hub, modem
Software	Nos.	Each 1 set with source back up
KIOSK	Nos.	1 center for each 2,000 customers
Technical Support Centre	Nos.	1 center for each regional office of the distribution company
Uninterruptible Power Supply (UPS)	kVA	min 5 for each center
Security with remote system	-	IPsec VPN or IP SSL VPN*
Other units	-	Printer (dot and laser), Wireless broad band modem

*Internet protocol (IP),Virtual private network (VPN),Secure socket layer (SSL)

Source: JICA Survey Team

(4) Numbers of Pre-Paid Meters

The numbers of pre-paid meters is set as follows based on the customer data and discussion with TGTDCL.

1) Existing customer Case-A: 93,000 nos.
2) Existing customer Case-B: 77,000 nos.
3) New town area Case A: 30,000 nos.

However, these figures will be reviewed by the Consultant based on the result of further field surveys and discussions with TGTDCL at the preparatory stage of the project.

6.3.6 Construction Plan

(1) Sequence

Installation of the pre-paid gas metering system will be implemented in the following sequence.

1) Design and Installation of WEB System

First of all, the WEB system will be designed and installed. The Network Service Centre and Data Base Centre will be installed in the head office of TGTDCL, and the KIOSKs and Technical Support Centre will be established for a pilot installation area. Training to IT staffs of TGTDCL will be commenced in this period.

2) Pilot Installation

Since the pre-paid gas metering system is new to TGTDCL, a pilot installation (possibly about 6,000 meters) is recommended. TGTDCL will learn about the installation, operation and maintenance of the system, and determine the issues and their solutions in order to be ready for the succeeding full-scale installation.

3) Full-scale Installation

After the pilot installation period is over, the full-scale installation will be implemented region by region.

a) Case-A:

   Since Case-A has no problem to proceed with the installation, the full-scale installation should be commenced from Case-A.

b) Case-B:

   While meters are installed in Case-A, the internal arrangement for the fair payment between residents and owner should be examined and finalized. Then, the installation of meters in Case-B can be commenced.

c) New Residential Town (Uttara-3, Purbachal, etc.):

   According to the latest development plans of new residential towns, the installation of pre-paid meters in these new towns would commence in 2018. The installation will progress according to the progress of actual development works.

(2) Safety Plan

During the installation of pre-paid gas meters, fire or explosion due to gas leakage is possible. To prevent such incidents, the customer service pipeline (from meter to burner(s)) should be duly tested against gas leakage prior to the meter activation. And also a safety plan should be prepared by the contractor for TGTDCL’s approval prior to the installation works. This plan should include the contractor's safety scheme, safety measures, and communication network in case of accident, etc.

Then, during the installation stage, periodic and also random safety patrols will be carried out by TGTDCL and/or a contractor in order to ensure that all works are carried out in a safe manner according to the said safety plan with a PDCA (Plan-Do-Check-Act) method.

1) Responsibilities of implementation agency for safe construction are as follows.

a) Dissemination of Information

- Details of the Project
- Condition of project site, etc.

b) Confirmation and approval (Evaluates and approves)

- Construction plan by contractor
- Construction schedule by contractor

2) A list of disasters and countermeasures that are possible during the construction period.

a) Use safety equipment at all times and wear appropriate protection, such as:

- Safety helmet properly fastened
- Safety Shoes
- Gloves
- Ear protector
- Dust glasses
- Safety belt and rope

Keep safety equipment properly maintained and in good condition after use.

b) Pay attention to the following:

- Do not run or jump
- Watch your step
- Watch against bumping your head.
- Turn your head when walking backwards.
- Avoid lifting too heavy materials also sensitive equipment (gas meters, etc.)
- Smell for gas leakage.

3) Construction Accident and Control Measures

Construction Accident	Control Measures
Transport Accidents	・Keep within the cargo weight limit. ・ Select the suitable type of cargo based on the property weight. ・Keep people out of the cargo working area. ・Keep the road clean for the Road Authority during construction ・ Set the cargo on level ground not to move with stopper.

Construction Accident	Control Measures
	・ Sign post the instruction area and road clear area.
Electrical Accidents	・Have all electric equipment checked regularly by a qualified electrician. ・All equipment must be in good condition and shall be grounded properly. ・Carry out cable insulating properly. ・Avoid submerging electric cable under water, except for insulated cable when necessary. ・Do not use any electric equipment in poor condition or in wet condition. ・Electric hand tools shall be protected by earth leakage or similar safety cut out switches which activate immediately in case of sudden increase in current.
Welding and Fixing Accidents	・Before work starts, check equipment as follows: ·Acetylene welder – ensure absence of leakage along the hose to be used. ·Electric welder – ensure all insulating systems are in good condition ・Pipe work - ensure all pipes are in good condition. ・Always wear appropriate safety equipment: ・For welding: wear helmet, eye protector, gloves, safety shoes, etc. ・For fixing the pipes: wear helmet, gloves, and safety shoes ・Use grounding for the welding machine ・ Provide adequate air circulation such as a blower during welding . ・Never perform welding near inflammable objects.
Safety for Customers	・ Barricade hazardous areas to keep customers out
Civil works	・The need for adequate support will depend on the type of excavation, the nature of the ground and the ground water conditions. ・Keep machinery, materials and soil heaps at a sufficient distance to avoid collapse of the sides of the excavation ・After rain, check ground condition and report immediately any presence of cracks.

Construction Accident	Control Measures
	・Keep water out of installation area with sheet cover during works.
Fires	・Open fires are prohibited (cigarettes, etc.) ・Know where firefighting equipment is located and be trained on how to use it. ・Never perform welding near inflammable objects. ・All site personnel are required to confirm that there are no live fires left behind before leaving their work place.
Gas leakage	・Use of gas leakage detector tool before/after gas line check. ・Check piping condition thoroughly also customer kitchen burner condition for preventing gas leakage. ・Use of leakage trouble measure manual for maintaining property ・Whenever a suspicious foul smell can be detected, always stop work immediately and investigate the source.

Safety activities of TGTDCL, the executing agency of the prepaid gas meter project are controlled by the Environmental & Safety Section under the Planning Department.

(3) Lessons from previous projects

The cause of major accidents in previous projects in the gas sector was gas leakage due to poor safety management as well as poor workmanship. Therefore, proper safety management according to the safety plan of the project and assignment of trained and skilled workers are essential.

6.3.7 Package for the Procurement for the Project

As a result of a series of discussions among TGTDCL, JICA and Survey Team, all parties agreed to the procurement package for the project as described below.

Contract Package	**Selection Method**
(1) Consulting Service	Short Listing, QBS JICA Standard Request for Proposal(SRFP) [Consultants]
(2) Pre-paid Gas Meter & WEB system	International Competitive Bid(ICB) with PQ 2 envelope 1stage (JICA Standard Bidding Document(SBD) [Plant])

(1) Consulting Service Contract

The consultant will be selected according to the following guidelines and standard documents for bidding prepared by JICA.

- Guidelines for the Employment of Consultants under Japanese ODA loans
- Standard Request For Proposals Under Japanese ODA Loans
  for Selection of Consultants (October 2012)

Selection procedure of Consultant is as follows;

1) Preparation of Terms of Reference (refer to Appendix 4)
2) Preparation of short list of Consultants
   - The consultants have satisfactory overseas experience of the consulting services concerned (e.g., detailed design, supervision)
   - Consultants must have experience in a developing country
   - The number of the short-listed consultants is 3 to 5
3) Preparation of Letter of Invitation
4) Sending of the Letter of Invitation to Consultants
5) Evaluation of Proposals
   - Evaluation of Consultants proposal will be executed based on the evaluation criteria.
   - Final result should be approved by Board and JICA concurrence.
   - Contract negotiation
   - Informing Unsuccessful Consultants

Since the pre-paid gas metering system is still quite new worldwide, the assignment of a highly specialized consultant is needed to manage the project. Therefore, the Quality-Based Selection ("QBS") method is recommended for the consultant selection.

(2) Design and Build contract

TGTDCL will make an Design and Build contract with the selected contractor. It will include the following items:

- Detail design of the entire pre-paid metering system
- Design and installation of WEB system for pre-paid card charging system
- Manufacturing, supply and installation of pre-paid gas meters
- Training for TGTDCL staff
- Supply of spare parts
- Defect liability period

The contractor will be selected by International Competitive Bid (ICB) with single stage two envelope bidding procedure according to the JICA guidelines below

- Guidelines for Procurement under Japanese ODA loans
- Standard Bidding Documents Under Japanese ODA Loans
  for Procurement of Plant Design, Supply and Installation (February 2013)[16]

(3) Possibility for the utilization of local consultants and contractors

Pre-paid meter technology is still new not only to Bangladesh but also to the world. Therefore, the well experienced international consultant as well as contractor is recommended for this project.

(4) Recommended Requirements for the Consultant

It is recommended that the Consultant satisfy the following conditions for successful project implementation.

- The Consulting Firm shall have experience in engineering works for the establishment of facilities related to gas supply systems.
- The Consulting Firm shall have experience in engineering works for the data acquisition system
- The Consulting Firm shall have experience in project management, procurement assistance, engineering and supervision of construction for projects in Bangladesh that were funded by JICA, WB or ADB.
- The Consulting Firm is to be certified by ISO9001.

6.3.8 Consulting Services

The Consultant will keep TGTDCL and JICA fully informed on all matters relating to the Services and the Project at all times during the period of the Services. This can be done through oral communications and will be confirmed by the submission of letters, monthly, weekly and other reports in writing, all as appropriate for the purpose.

(1) Scope of Service

The Consulting services are to be sequentially provided by the selected Consultant according to the following three (3) stages:

- Services for Pre-Construction Stage

[16] This documents is basically prepared for the design, supply and installation of plant, however, it would be applicable for this project component with necessary modifications since the Design and Build contract is recommended.

- Services for Construction Stage
- Services for Post Construction Stage

And the Consulting services at each stage include the following major works necessary for implementation of the Project including but not limited to, the works described below. Details of each work package are described in Section 5 (4) of Appendix 4 "*Terms of Reference (TOR) of Engineering Consultancy Services for the Project of Installation of Pre-paid Gas Meters at Dhaka Metropolitan Area - TGTDCL*".

1) Services for Pre-Construction Stage
   a) Project Management
   b) Update and Upgrade of Data / Information of Existing Studies
   c) Basic Design and Engineering
   d) Procurement Assistance
   e) Institutional Development

2) Services for Construction Stage
   a) Project management at all levels including periodic review of budget estimate and administration of project cash flows. Check of the Contractor's Procurement
   b) Project management for new town area installation and planning coordination with RAJUK etc.
   c) Supervision for Detailed Engineering, Procurement, Installation, Commissioning and Testing
   d) Public Awareness Campaign
   e) Examination of the impact of arise in gas prices
   f) Institutional Development

3) Services for Post Construction Stage
   a) Final Acceptance
   b) Project Completion Report

(2) Reports and Documents

The consultant shall prepare and submit to TGTDCL the following documents and reports.

1) Inception Report (including schedule)

2) Engineering Report (including basic design report)
3) Construction schedule and cost estimate
4) Draft of pre-qualification documents
5) Draft of Bid documents
6) Draft of evaluation criteria and method of pre-qualification
7) Draft of evaluation report of pre-qualification
8) Draft of evaluation criteria and method of international competitive bidding
9) Draft of evaluation report of international competitive bidding
10) Monthly progress report
11) Quarterly progress report
12) Project completion report

(3) Expertise Requirements

The engineering services shall be provided by foreign and local consultants, which shall include but not be limited to the following:

Foreign Consultant

1) Project Manager (Team Leader: Pre-paid gas metering system)
2) Deputy Project Manager (WEB system)
3) Contract Engineer
4) Public Awareness Expert

Local Consultant

1) Deputy Project Manager (Local Team Leader: Pre-paid meters)
2) IT Engineer (WEB system)

(4) Duration of Service

The engineering service shall cover the duration of 87 months, starting from the commencement of consultant services to the completion of the project.

1)	Basic Design & Tender Document Stage	:	6	months
2)	PQ and Tender Stage	:	4	months
3)	Evaluation, Negotiation and Contract Stage	:	5	months
4)	Detailed Design & Manufacturing by Contractor	:	45	months
5)	Procurement of WEB system	:	5	months
6)	Procurement of PGM system (Pilot)	:	4	months
7)	Procurement of PGM system (Full scale)	:	24	months
8)	Construction/Installation Stage	:	47	months

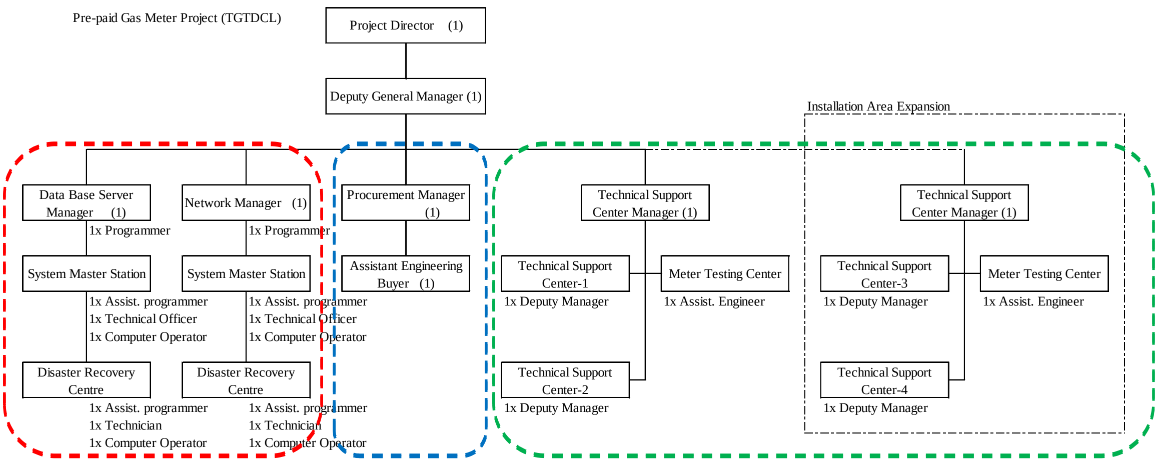
9)	Defect Liability Period	:	12 months
10)	Foreign Consultant	:	72 Man-Months
11)	Local Consultant	:	174 Man-Months

The detail terms of reference (TOR) of Engineering Consultancy Services is given in Appendix 4 of Report.

6.3.9 Organization for the Project Implementation and O&M

(1) Organization for the Project Implementation

TGTDCL explained that their organization for the project implementation would be similar to the one proposed in the Development Project Proposal ("DPP") prepared for the 200,000 pre-paid meters project by their own funds (this is different from this project component). In consideration of the lack of Information Technology staffs as well as the technical skill to install the meters, the organization for the project implementation is proposed as below.



Each red, blue and green dotted enclosure means WEB system team, procurement team and Pre-paid Gas Meter team, respectively.

Source: JICA Survey Team, referring to the existing DPP for 200,000 pre-paid meters project (TGTDCL's fund)

Figure 6.3-2 Organization for the Project Implementation

The organization for the project implementation will be composed of the following three departments under the entire project management by the project director and deputy general manager.

Each position member in the organization chart has the responsibility as shown in the tables below including minor assistant staffs not shown in the organisation chart.

1) Project Director and Deputy General Manager

Position	Number	Responsibility	Assignment Before
Project Director	1	Attend the board meeting as represented opinion position, final budgetary control decision and top leading management of the whole project team	DPP preparation
Deputy General Manager	1	Co-represented position work of director and budgetary control management and negotiation with relational party about top issue of whole project	DPP preparation
Co-ordination Officer	2	Co-ordination for direction operating to inside and/or outside party by making a official letter for announcement etc. fully actual works supporting	DPP preparation
Computer Operator	2		DPP preparation
Driver	2		Consultant Selection
Attendant	2		Consultant Selection
sub-total	10		

2) Database and network managing department for WEB system (red dotted enclosure of Figure 6.3-2)

a) Data base server team

Position	Number	Responsibility	Assignment Before
Data base server team		Database and network managing department for WEB system	
Manager	1	Team management and fully control of implementation for Data base server establishment.	Consultant Selection
Computer Operator	1		Consultant Selection
Driver	1		Consultant Selection
Attendant	1		Consultant Selection
Programmer	1	Database system establishment. Program & technical issue control. Database access security establishment between Database and KIOSK.	Construction
sub-total	5		
System Master Station		Database system establishment team, they have responsible for	
Assist. programmer	1	Data base system installation & operation programming	Construction
Technical Officer	1	Technical support for technical support centre.	ditto
Computer Operator	1		ditto
Attendant	1		ditto
sub-total	4		
Disaster Recovery Centre		Database recovery team, they have responsible for	
Assist. programmer	1	System data recovery & programming	Construction
Technician	1	Technical work assistance for programmer	ditto
Computer Operator	1		ditto
Helper	1		ditto
sub-total	4		

b) Network server team (for Data base, System server and KIOSK security connection)

Position	Number	Responsibility	Assignment Before
Network server team			
Manager	1	Team management and fully control of implementation for Network system establishment.	Consultant Selection
Computer Operator	1		ditto
Driver	1		ditto
Attendant	1		ditto
Programmer	1	All network system establishment with security control. Program, technical issue control & recovery work for KIOSK system operation by technical support team.	Construction
sub-total	5		
System Master Station		Network system establishment team, they have responsible for	
Assist. programmer	1	Network system installation & operation programming	ditto
Technical Officer	1	Technical support for technical support centre establishment	ditto
Computer Operator	1		ditto
Attendant	1		ditto
sub-total	4		
Disaster Recovery Centre		Network recovery team, they have responsible for	
Assist. programmer	1	Network recovery tool & programming skill (technology transferred too)	ditto
Technician	1	Technical work assistance for programmer	ditto
Computer Operator	1		ditto
Helper	1		ditto
sub-total	4		

3) Procurement department for tendering and making the contract (blue dotted enclosure of Figure 6.3-2)

Position	Number	Responsibility	Assignment Before
Procurement department			
Procurement Manager	1	Team management and fully control of implementation for Whole planned cost item procurement execution.	Consultant Selection
		Whole management of tender control, contract and negotiation, disbursement management of each phase on project and custom duty clearance control.	ditto
Technical buyer	1	Whole evaluation (Technical and Cost), technical issue control. Tender specification preparation with each team manager, tendering, negotiation and making the contract with general technical	Contractor Selection
Computer Operator	1		Consultant Selection
Driver	1		Contractor Selection
Attendant	1		Contractor Selection
sub-total	5		

4) Technical Support department for KIOSK & Pre-paid gas meter services (green dotted enclosure of Figure 6.3-2)

a) Technical support center team

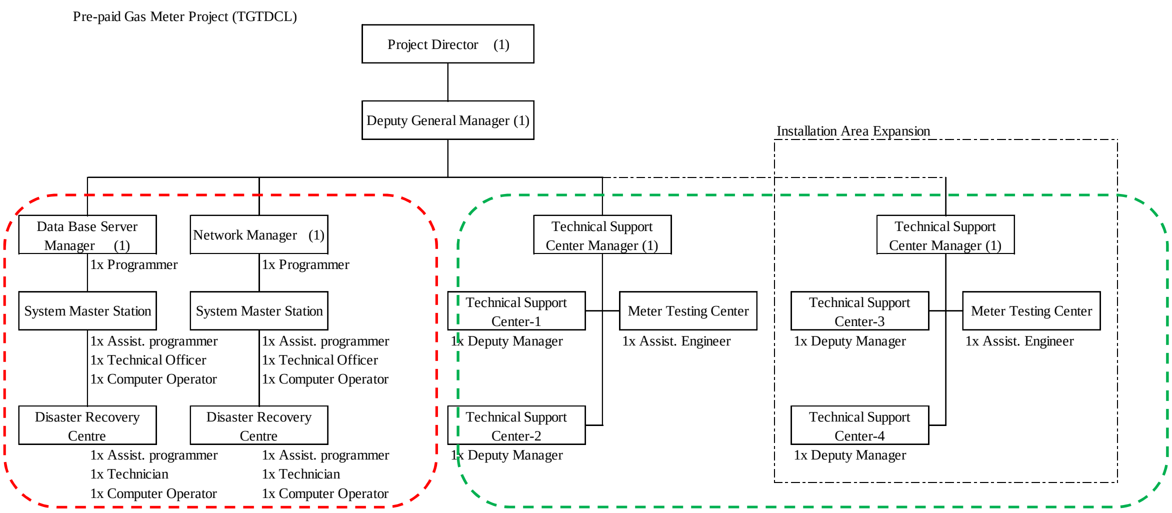
Position	Number	Responsibility	Assignment Before
Technical support center team			
Manager	1	Responsible area's two team management and fully control of establishment for KIOSK & Pre-paid meter installation in candidate site.	Consultant Selection
		Contract sign and team budgetary control.	ditto
Deputy manager	2	Customer data security management	Construction
		Establishment plan execution of Technical Support Centre & KIOSK	ditto
		Entire control of Pre-paid meter installation. (area wise)	ditto
Computer Operator	1		Consultant Selection
Driver	1		Consultant Selection
Attendant	1		Consultant Selection
sub-total	6		
a) Point of Sales System (POS)			
Asst. Account Officer (AAO)	50	Operation for accounting works for bill collection and/or pre-paid card charges etc. in KIOSK	Construction
Account Asst.	50	Assistant for accounting works for bill collection and/or pre-paid card charges etc. in KIOSK	ditto
b) Technical support			
Asst. Engineer	4	Technical support for pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	Construction
Helper	2		ditto
c) Contractor Supervision			
Asst. Engineer	5	Supervisory and management works for contractor	Construction
d) Replacement			
Asst. Engineer	1	Assist for replacement works of pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	Construction
Sub Asst. Engineer	1	Sub Assist for replacement works of pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	ditto
Technician	1	Technical support for replacement works.	ditto
Helper	1		ditto
e) Card Print			
Asst. Engineer	1	Assist for card printing works of pre-paid card system etc.	Construction
Sub Asst. Engineer	1	Sub Assist for card printing works of pre-paid card system etc.	ditto
Technician	1	Technical support for replacement works.	ditto
Helper	1		ditto
sub-total	125		

b) Pre-paid Gas Meter Testing Center team

Position	Number	Responsibility	Assignment Before
Pre-paid Gas Meter Testing center team			
Manager	1	Team management and fully control of implementation for pre-paid Gas Meter Quality control section (Inspection and Calibration management	Construction
Assist. Engineer	1	Meter test & Quality control.	ditto
sub-total	2		

(2) Organization for O & M

After the installation of the pre-paid metering system is completed, the procurement department will be dissolved, and two other departments will form the organization for O&M as shown below.



Each red and green dotted enclosure means WEB system team and Pre-paid Gas Meter team, respectively.

Source: JICA Survey Team, referring to the existing DPP for 200,000 pre-paid meters project (TGTDCL's fund)

Figure 6.3-3 Organization for Operation & Maintenance

The organization for the project O&M will be composed of the following two departments under entire project management by the project director and deputy general manager.

Each position member in the organization chart has the responsibility as shown in the tables below including minor assistant staffs not shown in the organisation chart.

1) Project Director and Deputy General Manager

Position	Number	Responsibility	Assignment Before
Project Director	1	Attend the board meeting as represented opinion position, final budgetary control decision and top leading management of the whole project team	DPP preparation
Deputy General Manager	1	Co-represented position work of director and budgetary control management and negotiation with relational party about top issue of whole project	DPP preparation
Co-ordination Officer	2	Co-ordination for direction operating to inside and/or outside party by making a official letter for announcement etc. fully actual works supporting	DPP preparation
Computer Operator	2		DPP preparation
Driver	2		Consultant Selection
Attendant	2		Consultant Selection
sub-total	10		

2) Database and network managing department for WEB system

a) Data base server team

Position	Number	Responsibility	Assignment Before
Data base server team		Database and network managing department for WEB system	
Manager	1	Team management and fully control of implementation for Data base server establishment.	Consultant Selection
Computer Operator	1		Consultant Selection
Driver	1		Consultant Selection
Attendant	1		Consultant Selection
Programmer	1	Database system establishment. Program & technical issue control. Database access security establishment between Database and KIOSK.	Construction
sub-total	5		
System Master Station		Database system establishment team, they have responsible for	
Assist. programmer	1	Data base system installation & operation programming	Construction
Technical Officer	1	Technical support for technical support centre.	ditto
Computer Operator	1		ditto
Attendant	1		ditto
sub-total	4		
Disaster Recovery Centre		Database recovery team, they have responsible for	
Assist. programmer	1	System data recovery & programming	Construction
Technician	1	Technical work assistance for programmer	ditto
Computer Operator	1		ditto
Helper	1		ditto
sub-total	4		

b) Network server team (for Data base, System server and KIOSK security connection)

Position	Number	Responsibility	Assignment Before
Network server team			
Manager	1	Team management and fully control of implementation for Network system establishment.	Consultant Selection
Computer Operator	1		ditto
Driver	1		ditto
Attendant	1		ditto
Programmer	1	All network system establishment with security control. Program, technical issue control & recovery work for KIOSK system operation by technical support team.	Construction
sub-total	5		
System Master Station		Network system establishment team, they have responsible for	
Assist. programmer	1	Network system installation & operation programming	ditto
Technical Officer	1	Technical support for technical support centre establishment	ditto
Computer Operator	1		ditto
Attendant	1		ditto
sub-total	4		
Disaster Recovery Centre		Network recovery team, they have responsible for	
Assist. programmer	1	Network recovery tool & programming skill (technology transferred too)	ditto
Technician	1	Technical work assistance for programmer	ditto
Computer Operator	1		ditto
Helper	1		ditto
sub-total	4		

3) Technical Support department for KIOSK & Pre-paid gas meter services

a) Technical support center team

Position	Number	Responsibility	Assignment Before
Technical support center team			
Manager	1	Responsible area's two team management and fully control of establishment for KIOSK & Pre-paid meter installation in candidate site.	Consultant Selection
		Contract sign and team budgetary control.	ditto
Deputy manager	2	Customer data security management	Construction
		Establishment plan execution of Technical Support Centre & KIOSK	ditto
		Entire control of Pre-paid meter installation. (area wise)	ditto
Computer Operator	1		Consultant Selection
Driver	1		Consultant Selection
Attendant	1		Consultant Selection
sub-total	6		
a) Point of Sales System (POS)			
Asst. Account Officer (AAO)	50	Operation for accounting works for bill collection and/or pre-paid card charges etc. in KIOSK	Construction
Account Asst.	50	Assistant for accounting works for bill collection and/or pre-paid card charges etc. in KIOSK	ditto
b) Technical support			
Asst. Engineer	4	Technical support for pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	Construction
Helper	2		ditto
c) Contractor Supervision			
Asst. Engineer	5	Supervisory and management works for contractor	Construction
d) Replacement			
Asst. Engineer	1	Assist for replacement works of pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	Construction
Sub Asst. Engineer	1	Sub Assist for replacement works of pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	ditto
Technician	1	Technical support for replacement works.	ditto
Helper	1		ditto
e) Card Print			
Asst. Engineer	1	Assist for card printing works of pre-paid card system etc.	Construction
Sub Asst. Engineer	1	Sub Assist for card printing works of pre-paid card system etc.	ditto
Technician	1	Technical support for replacement works.	ditto
Helper	1		ditto
sub-total	125		

b) Pre-paid Gas Meter Testing team

Position	Number	Responsibility	Assignment Before
Pre-paid Gas Meter Testing center team			
Manager	1	Team management and fully control of implementation for pre-paid Gas Meter Quality control section (Inspection and Calibration management	Construction
Assist. Engineer	1	Meter test & Quality control.	ditto
sub-total	2		

(3) Assignment of Project Staffs

- All staffs for Project Implementation and O&M are full-time workers.
- Basically, all staffs could be arranged from existing manpower except for the following full-time skilled IT staffs to be newly employed due to lack of IT skill prior to the detail design of WEB system.

IT Manager	1×Data Base Server Manager, 1×Network Manager
Programmer	2×Programmer for above section
Asst. Programmer	4×Asst. Programmer for above section

- It is recommended to assign the staffs who have experience with pre-paid metering systems in the pilot project.
- It is recommended that Deputy Project Director and Deputy General Manager are assigned from the DPP preparation stage, and other members will be assigned according to the progress and requirements of the project.
- If the KIOSK operation is outsourced based on a commission which will be charged to the customers, project staff assignment at the KIOSK would be avoided. This issue should be taken into consideration during the preparatory stage.

6.3.10 Training

- TGTDCL staffs will be thoroughly trained by means of On the Job Training (OJT) for the operation and maintenance of pre-paid meters as well as the WEB system.
  The consultant will guide the contractor to prepare the following training item packages and periods.

Contents of Training	Training Period	
	WEB system	Pre-paid Gas Meter
Contractor WEB system & Meter Installation Demonstration	1 month	1 month
Monitoring with Training for Other Candidate Constructors	3 months	3 months
General Design, Instruction manual lecturing and maintenance guidance (with BUET capacity building)	1 month	1 month
Contractor Supporting Structure & Supply Chain Management Works	1 month	1 month
Gas usage monitoring & analysis guidance (with BUET capacity building	-	2 months
Energy conservation awareness program guidance and Work monitoring	1 month	4 months

- Especially for the WEB system including the KIOSK, the Data base & Network server team as well as the Technical support team with KISOK POS members will be thoroughly trained for the following items prior to activation of the Pre-paid Gas Meters. The details of the training scheme should be proposed by the Contractor.

  1) Training to Database server and Network server team
     a) Computer and Server operation
     b) Trouble shooting for computer and server
     c) Management of customers, revenue and improper usage
     d) Customer registration and IC card issuing

  2) Training to KIOSK POS members and Technical support team
     a) Computer basic operation
     b) Software and hardware operation for IC card charging
     c) Table shooting for KIOSK POS system
     d) Customer dealing

6.3.11 Project Implementation Schedule

The Project Implementation Schedule is proposed as shown in Figure 6.3-4, and the schedule of each phase of the Project is explained below.

(1) Preparatory Phase

TGTDCL should prepare the DPP and obtain approval from the government prior to the loan agreement.

(2) Implementation Phase-1 (Procurement)

1) Selection of Consultant

After the loan agreement in concluded, TGTDCL will select a consultant. Nine months will be needed for the selection of a consultant in consideration of the necessary processes such as preparation of the terms of reference (“TOR”), tender, evaluation and contract.

2) Selection of Contractor

TGTDCL and the consultant will select a contractor by international competitive bidding. Fifteen months will be needed for the selection of the contractor in consideration of the necessary processes such as detail design, preparation of tender documents, prequalification (“PQ”), tender, evaluation, negotiation and contract.

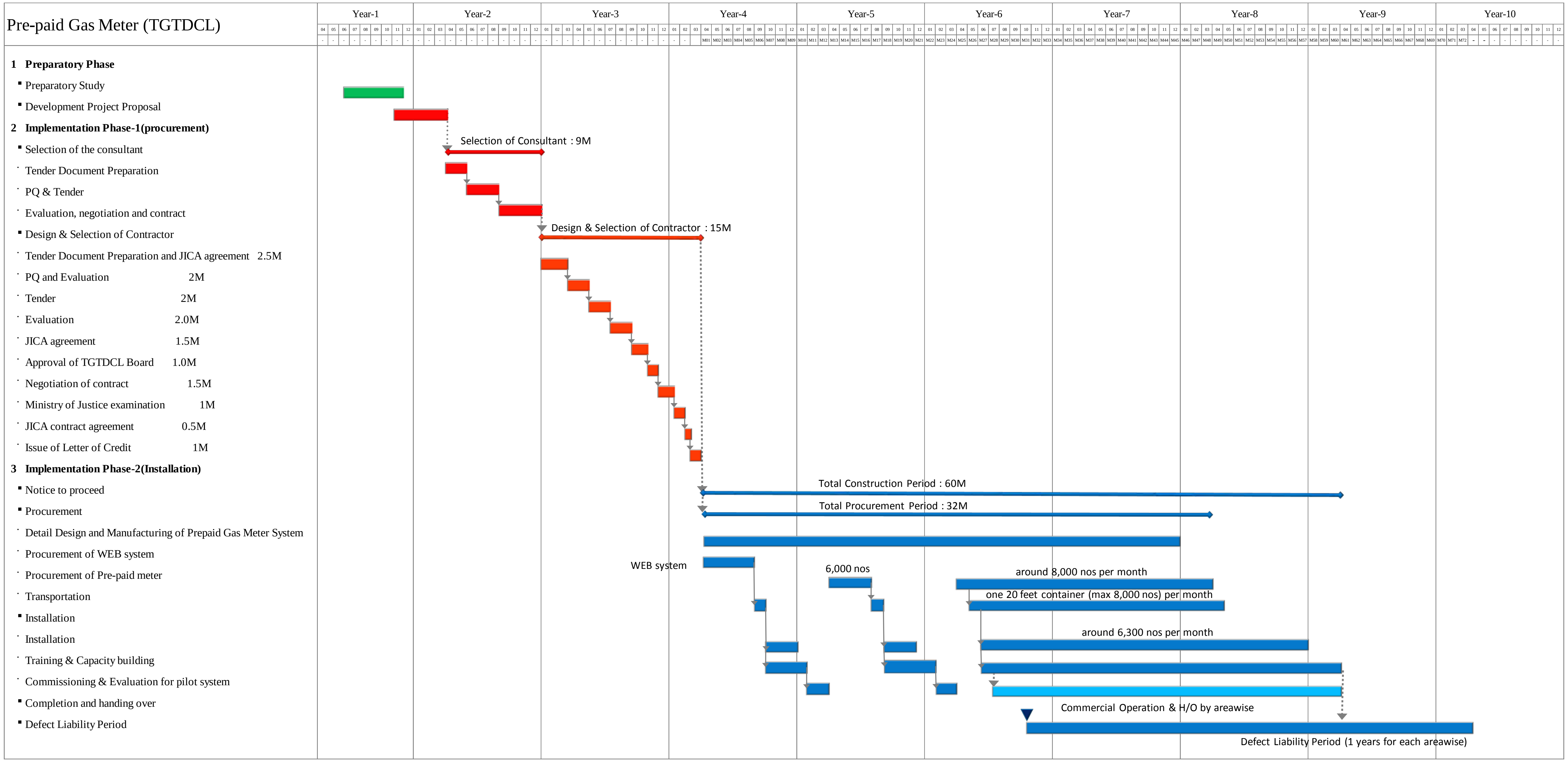
(3) Implementation Phase-2 (Detail Design & Installation)

The total duration of the installation of the pre-paid metering system is estimated at 5 years (60 months) as below:

1) Design and establishment of WEB system: 12 months
2) Pilot installation (6,000 meters recommended) with monitoring and training: 12 months
3) Full-scale installation: 36 months

(4) Additional Survey

In case an additional survey is carried out to solve the problems in the installation for Case-B mentioned in Section 4.4.1 (3), the pilot installation might be omitted to reduce the project duration



Source: JICA Survey Team

Figure 6.3-4 Project Implementation Schedule of Pre-paid Gas Meters (TGTDCL)

6.3.12 Project Cost

The Project Cost is composed of following items:

Table 6.3-4 Composition of Project Cost for Pre-paid Gas Meters (TGTDCL)

No.	Item	Remarks
A	Eligible for ODA loan	
1)	Construction cost of Pre Paid Gas Meter (Design and Build cost)	
2)	Project management cost (cost for consulting service)	
3)	Dispute Board Fee	
B	Non-eligible for ODA loan	
1)	TGTDCL's administration cost	
2)	Bank charge cost	
3)	VAT and Custom duties	

The following unit prices and conditions are adopted for the estimation of Project Cost.

Table 6.3-5 The Unit prices and Conditions for Pre-paid Gas Meters (TGTDCL)

No.	Item	Unit price & Condition
1)	Manufacturing and supply of pre-paid gas meters	JPY 18,000 per meter
2)	Installation of pre-paid gas meters	JPY 3,000 per meter
3)	Number of pre-paid meters	200,000 meters
4)	Number of Network Service Centres	1 centre
5)	Number of Data Base Centres	1 centre
6)	Number of KIOSKs	100 stations
7)	Number of Technical support centres	4 centre

The following rates are adopted in this estimate based on the survey and recent project data in Bangladesh.

Table 6.3-6 Precondition of Cost Estimate for Pre-paid Gas Meters (TGTDCL)

No.	Item	Rate
1.	Price escalation (Foreign Portion)	1.3%
	Price escalation (Local Portion)	3.4%
2.	Physical Contingency	5%
3.	Interest during construction	0.01%
4.	TAX	25% (VAT: 15% + AIT: 10%)
5.	Custom Duty	31.3% on Cost Freight Value
6.	Administration cost	4% of the Project cost
7.	Bank charge cost	1% of the Project cost

The exchange rates used in this estimate are as follows:

1)	1 USD=99.7 JPY
2)	1 USD=77.8 BDT
3)	1 BDT=1.28 JPY

According to the above composition, unit prices and preconditions, the total Project cost is estimated based on the Project implementation schedule "Figure 6.3-4" in Section 6.3.11 as well as the results of studies described in other chapters. Table 6.3-7 is the summary sheet of the total Project cost estimate.

Table 6.3-7 Project Cost of Pre-paid Gas Meters (TGTDCL)

	Item	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local
		[1,000 JPY]			[1,000 BDT]			[1,000 USD]		
	Eligible Portion									
a	Pre-paid Gas Meter (a1+a2+a3+a4)	4,632,103	4,032,103	600,000	3,618,830	3,150,080	468,750	46,460	40,442	6,018
a1	Web System	400,000	400,000		312,500	312,500		4,012	4,012	
a2	Pre-paid Gas Meter (for Pilot)	126,000	108,000	18,000	98,438	84,375	14,063	1,264	1,083	181
a3	Pre-paid Gas Meter (for Full installation)	4,074,000	3,492,000	582,000	3,182,813	2,728,125	454,688	40,863	35,025	5,838
a4	Dispute Board	32,103	32,103		25,080	25,080		322	322	
b	Contingency (b1+b2)	703,471	530,729	172,742	549,587	414,632	134,955	7,056	5,323	1,733
b1	Price Contingency on A F 1.3% L 3.4%	449,396	313,451	135,945	351,091	244,884	106,207	4,507	3,144	1,364
b2	Physical Contingency on A 5.0%	254,075	217,278	36,797	198,496	169,748	28,748	2,548	2,179	369
c	Consulting Service	395,440	217,034	178,406	308,938	169,558	139,380	3,966	2,177	1,789
d	Contingency (d1+d2)	68,741	24,739	44,002	53,704	19,327	34,377	689	248	441
d1	Price Contingency on C F 1.3% L 3.4%	46,637	13,226	33,411	36,435	10,333	26,103	468	133	335
d2	Physical Contingency on C 5.0%	22,104	11,513	10,591	17,269	8,995	8,274	222	115	106
A	**Total of Eligible Portion (a+b+c+d)**	5,799,756	4,804,605	995,151	4,531,059	3,753,598	777,462	58,172	48,191	9,981
	Non Eligible Portion									
e	Administration Cost (including Bank Charge 1%) 5%	289,988		289,988	226,553		226,553	2,909		2,909
f	Custom Duties、VAT and AIT (f1+f2)	2,866,738		2,866,738	2,239,639		2,239,639	28,754		28,754
f1	VAT : 15% & AIT: 10%	1,449,939		1,449,939	1,132,765		1,132,765	14,543		14,543
f2	Custom Duties on Foreign Portion of A 31.3%	1,416,799		1,416,799	1,106,875		1,106,875	14,211		14,211
g	Interest During Construction 0.01%	2,450	2,450		1,914	1,914		25	25	
B	**Total of Non Eligible Portion (e+f+g)**	3,159,176	2,450	3,156,726	2,468,107	1,914	2,466,192	31,687	25	31,662
	Grand Total (A+B)	8,958,932	4,807,055	4,151,877	6,999,166	3,755,512	3,243,654	89,859	48,215	41,644

Source: JICA Survey Team

6.3.13 Economic and Financial Analyses

(1) Outline of Economic and Financial Analyses of the Project

The evaluation and computation of the financial internal rate of return (FIRR) and economic internal rate of return (EIRR) including sensitivity analysis were carried out for the Project on an incremental basis of the comparison between “with project” and “without project” scenarios. The cash flow is projected and the financial and economic viability of the Project are examined.

(2) Key Assumptions Used for Financial Analysis

1) Inflation

- Price escalation for the foreign currency components: 1.3 % per annum
- Price escalation for the domestic currency components: 3.4 % per annum

2) Increase of gas price

It is assumed that the gas price will have increased for the project implementation at 8% every year, as the average increase rate in gas price for last 25 years was 8%.

3) With-project and Without-project Scenarios

The financial analysis considered only the increase in revenues and costs directly associated with each project component. Therefore, the revenues and costs of existing systems are not considered.

4) Financing

It is assumed that the majority of the total initial investment cost including IDC will be financed with a yen-denominated soft loan from JICA, which is sublet to executing agencies from GOB on the basis of the Subsidiary Loan Agreement. These loan conditions are given below:

a) Yen-denominated soft loan

- Interest rate: 0.01 % per annum
- Repayment period: 40 years including 10 year grace period (The grace period starts in the year of the first disbursement of the loan.)

b) Subsidiary Loan to each executing agency from MOF

Conditions of the SLA such as interest rate, repayment period including grace period and debt equity ratio for each executing agency are described in the Section on the financial analysis for the Project.

(3) Key Assumptions Used for Economic Analysis

1) Economic costs

In the economic analysis, we use true economic prices instead of often-distorted financial or market prices. For this purpose, we disregard all transfer payments within the country, such as taxes and duties. Then, we convert the distorted market prices into economic prices by multiplying them by conversion factors. As far as the Project is concerned, while no “border distortion” is assumed, domestic currency components of initial capital investment are expected to be subject to domestic distortion. In particular, wage rates of unskilled labour tend to exceed “opportunity-cost” wages. For simplicity, we use the standard conversion factor of 0.97[17] in our calculations, to be applied to market prices of all domestic currency components.

[17] The standard conversion factor of 0.97 is used, referring to ADB report, “Third Natural Gas Development Project”

2) Economic Discount Rate

A 12% economic discount rate[18] is used as a cut-off rate for the Project to evaluate whether the Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

(4) Financial Analysis for Pre-paid Gas Meters for TGTDCL

The introduction of pre-paid gas meters contributes to improving energy efficiency.

1) Initial Investment Costs

As described earlier in this report, the total cost of the eligible portion for the pre-paid gas meters, including consulting service, is estimated at approximately US$ 58 million. With administration cost, VAT & AIT and custom duties, the total initial investment cost (excluding IDC) is estimated at approximately US$ 89 million. Table 6.3-7 in Section 6.3.12 shows the estimate of initial investment costs.

2) O&M Costs

The estimated amount necessary for O&M works of the Project, excluding price escalation, will be around BDT 35 million per year. Approximate operating expenditures include personnel positioning and staff assignment, administration costs and spare parts. The breakdown of O&M costs is as follows:

Table 6.3-8 Breakdown of O&M Costs for Pre-paid Gas Meters for TGTDCL

(Unit: 1,000 BDT/year)

Work Item	Annual Cost
Personnel positioning and staff assignment	10,800
Administration costs	20,500
Spare parts	3,400
Total	34,700

Source: JICA Survey Team

3) Conditions of SLA

- Interest rate: 1% per annum
- Repayment period 20 years including 8 years grace period
- Currency: Bangladesh Taka
- Debt equity ratio: 60 : 40[19]

[18] The 12% economic discount rate is used, referring to ADB report, “Natural Gas Access Improvement Project”

[19] This is the information referring to MoF's "Lending and Relending Terms of Local/Foreign Currency Loans" for Petrobangla.

4) Others

Other key assumptions used in our analysis are as follows:

- Depreciation: 20-year straight line
- Corporate income tax: 27.5%

Property taxes or working capital requirements are not considered in projecting the cash outflow stream. Potential revenues other than sales revenue, such as interest earnings, are not taken into account either, since they will be comparatively small.

5) Gas Tariff Collection System for Domestic Customers

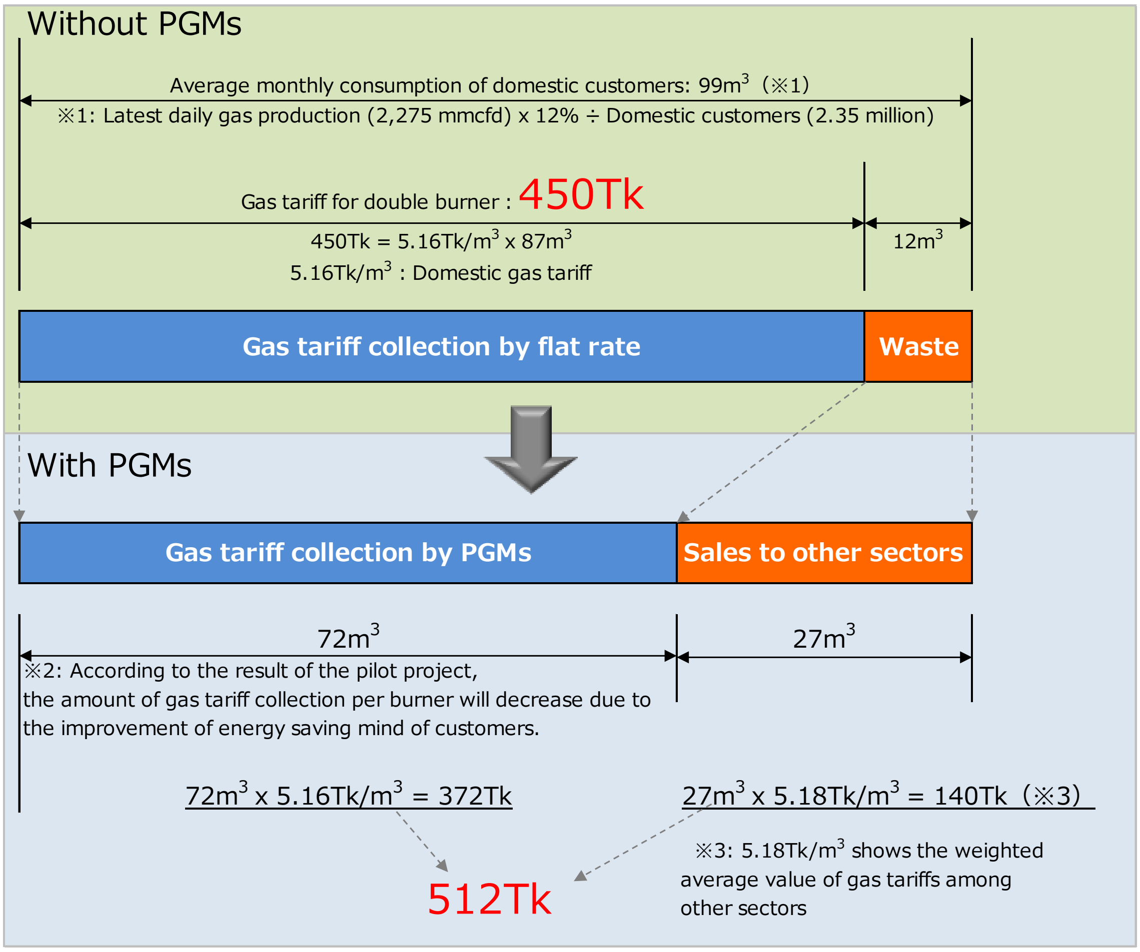
Since the gas tariff of domestic customers is collected at a flat rate (450 Tk/month for double burner), domestic customers do not care about energy saving and therefore waste natural gas. The installation of pre-paid gas meters will enable the gas tariff collection by measured quantity, and this will improve the energy saving mind-set of domestic customers and consequently reduce the waste in gas usage. Furthermore the pre-paid metering system will allow the gas tariff collection in advance and that will be a financial benefit to TGTDCL.

6) Elimination of Waste

The introduction of pre-paid meters will reduce the gas consumption of domestic customers and also eliminate unaccounted waste. This will increase the gas supply to other sectors.

Such changes in sales revenue of the “with project” and “without project” scenarios are indicated in the following figure[20].

[20] The values in this figure are anecdotal. The evidence submitted by TGTDCL does not show sufficient valid data of current gas usage volume of a domestic double burner stove. Such gas volume is assumed by the JICA Survey Team. Therefore, it would be recommended that a further survey for gas consumption volume is carried out.



Source: JICA Survey Team

Figure 6.3-5 Changes in Sales Revenue after Installation of Pre-paid Gas Meters

7) Interest from Tariff Collection in Advance

According to the Annual Report 2011-2012 of TGTDCL, on average, the duration of outstanding arrears for domestic accounts is 4.94 months. Successful implementation of the project will not allow any arrears. TGTDCL will be able to gain the revenue about 5 months earlier.

8) Weighted Average Cost of Capital

Refer to 6.1.10 (4) 7) for the explanation of WACC.

The following are the assumptions that are laid down for the project:

- Cost of Equity = 17% p.a. (before tax)
- Equity／(Equity + Debt) = 14%
- Debt Cost = 1% p.a.

- Debt／(Equity + Debt) = 86%
- Corporate Tax Rate = 27.5%

Those assumed figures are inserted into the formulae to draw the output rates for WACC as follows;

WACC = 4.16%

As a result of the above exercise, the weighted average of capital costs is 4.16% before tax. We conclude this section by confirming that the project is to be deemed viable when the project FIRR will be found above the WACC of 4.16%.

(5) FIRR on the Total Investment Cost (Project FIRR)

To confirm the underlying financial viability or the true soundness of the Project, the financial internal rate of return (FIRR) of the Project was calculated. The revenue and costs for pre-paid gas meters are summarized in the below table.

Table 6.3-9 Costs and Revenue of Pre-paid Gas Meters for Financial Analysis

Costs:	Construction cost of pre-paid meter, project management cost, dispute board fee, executing agency's administration cost, taxes, IDC and operation & maintenance
Revenue:	Gas sales revenue from domestic customers and other sectors by reducing the waste in gas usage and interest from tariff collection in advance due to installation of pre-paid gas meters

Source: JICA Survey Team

The result of the calculation of the FIRR is as follows:

FIRR: 2.29%

The FIRR is at 2.29%, which does not exceed the 4.16%, WACC. Therefore the Project is not regarded as financially viable. However, the annual cash balance of the Project will not go into the red, since terms and conditions of the SLA are set to form a high concession. Thus, the executing agency will be able to maintain financial soundness in management.

Table 6.3-10 Project FIRR for Pre-paid Gas Meters for TGTDCL

(Thousand USD)

Project Year	Project Life	Cash Inflow					Cash Outflow							Net Cash Flow for		
		Owned Capital	Foreign Loan	Domestic Loan	Operating Revenue	Total Revenue	Capital Costs	O&M Costs	Interest Foreign Loan	Interest Domestic Loan	Repay Foreign Loan	Repay Domestic Loan	Total Cost	Cash Balance	Project IRR	Cumulative Cash Balance
3		178	819	267	0	1,264	1,264						1,264	0	-1,264	0
4		1,109	5,095	1,664	0	7,868	7,868						7,868	0	-7,868	0
5		443	2,035	664	51	3,193	3,142						3,142	51	-3,091	51
6		2,448	11,244	3,672	753	18,117	17,363	623					17,987	130	-17,233	181
7	1	4,129	18,966	6,193	2,191	31,479	29,289	659					29,948	1,532	-27,757	1,713
8	2	4,189	19,241	6,283	3,823	33,536	29,713	695	0	0	0	0	30,407	3,128	-26,584	4,841
9	3	105	480	157	4,473	5,215	741	730	0	0	0	0	1,472	3,743	3,002	8,584
10	4	64	294	96	4,760	5,214	454	766	0	0	0	0	1,220	3,995	3,541	12,579
11	5				5,054	5,054		802	607	198	3,034	991	5,631	-577	4,252	12,002
12	6				5,354	5,354		837	576	188	3,034	991	5,626	-272	4,517	11,730
13	7				5,660	5,660		873	546	178	3,034	991	5,621	39	4,787	11,769
14	8				5,973	5,973		908	516	168	3,034	991	5,617	356	5,065	12,125
15	9				6,292	6,292		944	485	159	3,034	991	5,612	680	5,348	12,805
16	10				6,618	6,618		980	455	149	3,034	991	5,608	1,010	5,638	13,815
17	11				6,950	6,950		1,015	425	139	3,034	991	5,603	1,347	5,934	15,162
18	12				7,288	7,288		1,051	394	129	3,034	991	5,598	1,690	6,237	16,851
19	13				7,633	7,633		1,086	364	119	3,034	991	5,594	2,039	6,546	18,890
20	14				7,984	7,984		1,122	334	109	3,034	991	5,589	2,395	6,862	21,285
21	15				8,341	8,341		1,158	303	99	3,034	991	5,584	2,757	7,184	24,042
22	16				8,705	8,705		1,193	273	89	3,034	991	5,580	3,126	7,512	27,168
23	17				9,076	9,076		1,229	243	79	3,034	991	5,575	3,501	7,847	30,668
24	18				9,453	9,453		1,265	212	69	3,034	991	5,571	3,882	8,188	34,550
25	19				9,836	9,836		1,300	182	59	3,034	991	5,566	4,270	8,536	38,820
26	20				10,225	10,225		1,336	243	79	6,067	1,981	9,706	519	8,890	39,339
Total		12,664	58,173	18,996	136,493	226,326	89,833	20,572	6,158	2,011	51,572	16,841	186,987	**39,339**	26,087	
FIRR															**2.29%**	

Source: JICA Survey Team

(6) Sensitivity to FIRRs

1) Sensitivity Analysis on Changes of Costs and Revenue

Separate analyses were carried out to examine the sensitivity of projected financial returns to adverse changes in key variables. The risks involved in the Project in terms of financial viability are the future uncertainty of the initial investment cost and the exchange rate between the local currency and the US dollar. Hence, the variables considered for the sensitivity analyses were as follows;

a) 10% higher cost of eligible portion in initial investment cost

b) 20% higher cost of eligible portion in initial investment cost

c) 10% lower exchange rate than assumed, i.e., 85.58 BDT/USD

d) 20% lower exchange rate than assumed, i.e., 93.36 BDT/USD

The results of the above sensitivity test are summarized below:

Table 6.3-11 Results of Sensitivity Analysis on FIRR for Prepaid Meters

	Item	Project FIRR
1	10% higher cost of eligible portion in initial investment cost	1.41%
2	20% higher cost of eligible portion in initial investment cost	0.63%
3	10% lower exchange rate	1.14%
4	20% lower exchange rate	-0.12%

Source: JICA Survey Team

The above sensitivity analysis indicates that all the FIRRs, for 10% and 20% higher costs of the eligible portion and 10% and 20% lower exchange rates, show lower values than the 4.16% of the WACC, the cut off rate. Therefore, the financial feasibility of the Project is deemed to be low as a component of the natural gas efficiency project.

Two other sensitivity analyses for the FIRR were made as references in order to confirm the further underlying financial viability or soundness as follows.

2) Meter Rent Fee

In order to rise the value of the FIRRs, instigating a meter rent fee[21] would make it possible for TGTDCL to include it in its revenues. The meter rent fee, cost of manufacturing and supply of pre-paid gas meter, is estimated around 60 BDT per month per meter. Given that TGTDCL would include this meter rent fee in its revenue, the value of the FIRR would be improved. The result of the calculation of the FIRR including meter rental fee is as follows:

FIRR including meter rental fee: 5.82%

The FIRR including meter rental fee is at 5.82%, which exceeds 4.16%, WACC. Therefore the Project is regarded as financially viable. However, it is recommended that the introduction of meter rental fee is sufficiently considered on the basis of close consultations with the relevant organisations, because this introduction gives rise to a burden as an additional charge to customers.

3) Appropriate Raise in Gas Price

In order to make the value of the FIRRs appropriate, it would be necessary to review the gas tariff and set a more appropriate gas tariff in this country as a reference, since the gas tariff in this country is far from the international gas tariff. It is hoped that the appropriate raise in the gas sales price is put in force. Hence, the sensitivity analysis for the phased introduction of appropriate raises in gas sales price was carried out. A certain ratio of the phased raises in the

[21] Meter rent fee means that the cost of manufacturing and supply of pre-paid gas meters is added to gas sales revenue. In other words, the ownership of the pre-paid gas meters themselves belongs not to the customers but to TGTDCL.

gas sales price to exceed 4.17% of cut off rate for financial feasibility of this component would be as follows:

Phased raise in gas sales price: 11% every year

If the 5.16 taka/m^3 current gas sale price for domestic customers increases 11% every year, the FIRR will be 4.96%, which exceeds the 4.16% cut off rate. The gas price in the final year of the Project will be 19.4 taka/m^3, which is nearly four times the current gas sales price for domestic customers. The suggested raise in gas sales price is shown as follows:

Table 6.3-12 Raise in Gas Sales Price for Domestic Customers

Year	0	1	2	3	・・・	23	24	25
Increase rate	—	11%.	22%	33%	・・・	253%	264%	275%
Gas sales price (taka/m^3)	5.16	5.73	6.30	6.87	・・・	18.23	18.80	19.37

Source: JICA Survey Team

Considering the phased raise in gas sales price of 11% every year, it can be said that the Project will be financially feasible. Yet, it is difficult for an executing agency to put the phased raise in gas sales price of 11% every year in force. Therefore, it is hoped that the gas tariff issue is discussed in the Steering Committee of the Project.

(7) Conclusion on Financial Viability

The project FIRR of the base case is 2.29%, which does not exceed 4.16%, the WACC. Therefore, the Project is not regarded as financially viable or a sound investment. However, the annual cash balance of the Project will not go into the red, since terms and conditions of the SLA are set to be a high concession. Thus, the executing agency will be able to maintain financial soundness in management.

Considering the sensitivity of the FIRRs, the financial feasibility of the Project is considerably low, because the FIRR of the base case does not exceed the 4.16% cut off rate. The main reason for this is that meter rent fee is not included in its revenues. Another reason is that the current gas sales price is set quite low.

The result of the calculation of the FIRR including meter rental fee is at 5.82% which exceeds 4.16%, WACC. Therefore the Project is regarded as financially viable. However, it is recommended that the introduction of the meter rental fee is sufficiently considered on the basis of close consultations with the relevant organisations, because this introduction gives rise to a burden as an additional charge to customers.

As for gas sales price, it is recommended that TGTDCL carries out a further study to revise and possibly raise the current gas sales price for domestic customers. It is expected that the Project FIRR will be higher, provided that the revision and increase of gas sales price are carried out in the near future, which would contribute to higher financial viability of the Project. In this regard, the FIRR of the Project will be 4.96% and financially feasible due to being above the cut off rate, given that the phased raise in gas sales price of 11% every year is put into effect. To sum up, it is deemed that the Project is not financially feasible in the base case. On the other hand, considering a phased raise in gas sales price of 11% every year, it can be said that the Project will be financially feasible. Yet, it is difficult for an executing agency to put the phased raise in gas sales price of 11% every year in force. Therefore, it is hoped that the gas tariff issue is discussed in Steering Committee of the Project.

(8) Economic Analysis for Pre-paid Gas Meters for TGTDCL

1) Economic benefit

Reduction of gas usage, consequently the saving of gas, among domestic customers due to the introduction of a pre-paid metering system will increase the gas supply to other sectors, whereas the whole volume of gas supply to society will be constant from a national point of view. Hence, it will replace expensive imported energy such as crude oil and LNG.

The calculation for the economic benefit of the Project is as follows;

Economic benefit = (the saved gas volume) x {(imported LNG price) – (average gas price in Bangladesh)}

(9) EIRR

The benefit and costs of pre-paid gas meters are summarized in the below table.

Table 6.3-13 Costs and Benefits of Pre-paid Gas Meters for Economic Analysis

Costs:	Construction cost of pre-paid meter, project management cost, dispute board fee, executing agency's administration cost and operation & maintenance (excluding taxes and IDC)
Benefits:	Cost saving in replacing import energy. Reduction of gas usage, consequently the saving of gas among domestic customers due to the introduction of pre-paid metering system will increase the gas supply to other sectors, and it will substitute expensive import energy.

Source: JICA Survey Team

Table 6.3-14 exhibits the calculation of the EIRR of the Project based on the economic benefits and costs discussed earlier. The EIRR is calculated at 50.77%, which clearly supports the economic viability of the Project, because the 50.77% EIRR is above the 12%, cut off rate of the evaluation criteria for economic analysis.

Table 6.3-14 EIRR of the Project for TGTDCL

(Thousand USD)

Project Year	Project Life	Cash Inflow		Cash Outflow			Net Cash Flow for	
		Benefits	Total Benefit	Capital Costs	O&M Costs	Total Cost	Cash Balance	Cumulative Cash Balance
3		0	0	1,011		1,011	-1,011	-1,011
4		0	0	5,232		5,232	-5,232	-6,242
5		442	442	2,216		2,216	-1,774	-8,016
6		6,067	6,067	11,710	623	12,333	-6,266	-14,283
7	1	16,398	16,398	19,643	659	20,302	-3,905	-18,187
8	2	26,679	26,679	19,931	695	20,626	6,052	-12,135
9	3	29,188	29,188	588	730	1,319	27,869	15,734
10	4	29,117	29,117	363	766	1,129	27,989	43,723
11	5	29,047	29,047		802	802	28,245	71,968
12	6	28,976	28,976		837	837	28,139	100,107
13	7	28,906	28,906		873	873	28,033	128,140
14	8	28,835	28,835		908	908	27,927	156,067
15	9	28,764	28,764		944	944	27,820	183,887
16	10	28,694	28,694		980	980	27,714	211,602
17	11	28,623	28,623		1,015	1,015	27,608	239,210
18	12	28,553	28,553		1,051	1,051	27,502	266,711
19	13	28,482	28,482		1,086	1,086	27,396	294,107
20	14	28,411	28,411		1,122	1,122	27,289	321,396
21	15	28,341	28,341		1,158	1,158	27,183	348,579
22	16	28,270	28,270		1,193	1,193	27,077	375,656
23	17	28,200	28,200		1,229	1,229	26,971	402,627
24	18	28,129	28,129		1,265	1,265	26,864	429,492
25	19	28,058	28,058		1,300	1,300	26,758	456,250
26	20	27,988	27,988		1,336	1,336	26,652	482,902
Total		564,168	564,168	60,694	20,572	81,266	**482,902**	
EIRR							**50.77%**	

Source: JICA Survey Team

(10) Sensitivity Analysis of the EIRRs

A sensitivity test was performed on the EIRR for the initial investment cost only, which is the largest foreign cost component. The results of the test are as follows:

Table 6.3-15 Results of EIRR Sensitivity Analysis for TGTDCL

	Scenario	EIRR of the Project
1	10% higher initial investment cost	46.21%
2	20% higher initial investment cost	42.35%

Source: JICA Survey Team

A substantial cost overrun of the initial investment cost could not undermine the Project's viability. As a result of this sensitivity analysis, the EIRRs are over 12% in the cases of a 10 % and 20 % higher initial investment. Thus, it can be said that the Project is economically viable.

(11) Conclusion on Economic Feasibility

It can be concluded that the Project is sufficiently viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

6.3.14 Operation and Effect Indicators

(1) Operation Indicator

Gas meters should be almost free from malfunctions for continuous supply to customers. Therefore the operation indicator and its target value are recommended as below.

Indicator	Target	Remarks
Number of outages due to meter defects	0.1% of installed meters	Outage due to other reasons such as piping defects should not be counted.

(2) Effect Indicator

Introduction of a pre-paid metering system will improve the energy saving mind-set of domestic customers and will reduce the waste in their natural gas usage. Therefore, the effective indicator of the introduction of pre-paid metering system will be the gas consumption volume of domestic customers. The method of measurement of gas consumption volume as an effect indicator is recommended as follows.

1) Select 1,000 customers from the initial pilot meters installation

2) After the installation of pre-paid gas meters, the actual gas consumption will be measured prior to the activation of the pre-paid metering system for at least two months. (Customers will still pay according to the fixed rate in this period.)

3) After collecting the actual gas consumption data before the activation of the pre-paid metering system, pre-paid cards will be handed over to the customers and the pre-paid metering system will be activated. Then, the actual gas consumption data after the activation of the metering system will be collected and stored in the Data Base Centre.

4) The difference in the gas consumption volume between before and after the activation of the metering system will be periodically monitored as an effect indicator.

5) The target value is tentatively recommended as below.

Indicator	Base	Target
Average monthly consumption of domestic customer (after 2 years operation)	99 m3/month*	72 m3/month**

* The base is tentatively set at 99m3 based on the information from the Petrobangla annual report 2011 as well as latest gas production volume, and it should be re-set based on the actual measurement of pilot installations prior to the activation of the pre-paid gas metering system.

** The target value is also tentatively set at 72m3 based on the data from the 4,500 meter pilot project, and it should be re-set based on the actual measurement of pilot installations as well as the latest gas price policy.

6.3.15 Environmental and Social Considerations

In the overall sense, both projects involve installation of pre-paid gas meters for existing domestic gas customers (gas served households) in Dhaka (TGTDCL franchise area) and Chittagong (KGDCL franchise area). The projects are individually extremely small-scale focussed on gas served households and basically aimed at promoting efficient use of gas by domestic customers with charge being based on the quantity of gas consumed instead of the current flat charge system that encourages waste of gas.

As such, the project has no significant environmental effects and has the major beneficial effect of promoting energy efficiency with efficient use of gas, which is a non-renewable natural resource. Moreover, the land acquisition and resettlement aspect is not relevant.

Therefore, these 2 projects fall under the GREEN category or even under no category as per the Environmental Conservation Rules of 2007 (since installation of prepaid gas meters could be regarded as non-industrial as well). In fact, DoE categorized this project as even below Green category and does not require any permit (no project screening or ECC from DoE) for the execution of these 2 projects by the project proponents (TGTDCL and KGDCL).

(1) Prepaid Gas Meter Project Rationale

The project is basically aimed at promoting efficient use of gas by domestic customers with the installation of prepaid gas meters by which charge for use of gas will be based on the quantity of gas consumed instead of the current flat charge system that encourages wastage of gas as also noted under Section 4.4.1 of Chapter 4 (in both TDTDCL and KGDCL franchise areas of Dhaka and Chittagong). Such gas wastage by domestic customers includes using gas (intended for cooking purpose) to dry clothes and also for heating of the house in the winter season. Moreover, charging based on actual quantity of consumption is an equitable tariff system where people consuming more gas will pay more.

As such, the project has no significant adverse environmental effects and has the major beneficial effect of promoting energy efficiency with efficient use of gas, which is a non-renewable natural resource. Moreover, the land acquisition and resettlement aspect is irrelevant to this project component.

Therefore, this project will fall under the GREEN category as per the Environmental Conservation Rules of 2007; hence, conduct of an EIA is not necessary. In fact, DoE does not require any registration or ECC requirement for these 2 prepaid meter projects (in Dhaka and Chittagong) as also noted under Section 2.7 of Chapter 2 since individual installation of prepaid meters in households is an extremely small-scale project that won’t cause any significant adverse impacts.

Still insignificance of adverse impacts and other related aspects consequent to the installation of prepaid meters in households is justified comprehensively for both project areas (Dhaka and Chittagong) in the following sections starting from alternative consideration of the projects followed with environmental scoping in accordance with the JICA Guidelines on Category B projects. Scoping results clearly identified the project to be, at worst, Category C and not Category B and no further consideration on environmental or social aspects is necessary as was also decided by DoE.

(2) Alternative Considerations including Zero Option

1) Alternatives

The project has basically 2 alternatives with respect to installation of gas meters in households. They are prepaid and post-paid meters with the former focused on advance payment and the later on post payment of the gas bills.

Major reasons for the selection of the prepaid meter system that justifies the selection of the prepaid gas meter system for domestic consumers against a post-paid system for these 2 projects as also noted under Item (2) of Section 4.4.1 of Chapter 4 are given below.

- Prevention of incorrect meter-reading
- Financial merit for executing agency from early tariff collection
- No cost for meter-reading

2) Zero option

The Zero option will always be a viable option that represents the present status of a flat tariff system for gas consumption by domestic customers in both Dhaka (TGTDCL franchise area) and Chittagong (KGDCL franchise area) that results in wastage of gas and also is unfair to those consumers who do not waste gas. As such, a tariff system based on actual consumption is not only fair and equitable but also would contribute to instil an energy saving mind set to gas consumers that justifies the selection of the project option against the zero (no project) option.

(3) Environmental Scoping

Scoping for significant environmental and social aspects for the projects in this survey, in which all projects basically belong to the industrial sector, was conducted based on the typical environmental and social components relevant to the industrial sector (classified into 3 environmental groups, namely, Environmental quality and pollution control, Natural environment and Social environment) as already illustrated under Item (3) of Section 6.1.12.

The scoping was conducted comprehensively for both projects (prepaid meters for domestic customers in Dhaka and Chittagong) since the project activity for individual household installations is very similar.

The results of the scoping with evaluations separated between positive (beneficial) and negative (adverse) effects with 4 ranking grades of A, B, C and D along with due reasoning for such ranking are given in Table 6.3-16.

Table 6.3-16 Environmental Scoping for Installation of Prepaid Gas Meters for Domestic Customers in Dhaka (TGTDCL) and Chittagong (KGDCL)

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
Environment quality and pollution control	Air quality	D	D	Installation of prepaid gas meters for domestic customers is individually an extremely small-scale project and there is no significant air pollution source.
	Water quality	D	D	As mentioned above, individually the project is too extremely small-scale to interfere with any water sources.
	Noise/vibration	D	D	Some noise and vibration during installation of prepaid meters is inevitable. However, considering the extremely small-scale nature of the works on an individual house basis, potential short-term adverse effects due to noise/vibration is regarded as tolerable and insignificant. There are no significant moving parts in prepaid meter to result in any significant generation of noise/vibration consequent to its operation.
	Waste	D	D	There is no significant waste generation either during installation or operation of the prepaid gas meters for domestic customers.
	Soil	D	D	In consideration of the extremely small-scale nature of the project and its installation to an existing gas service line there would be no significant adverse effect on soil.
	Climate change Factors	D	D	Efficient use of natural gas by domestic customers is expected consequent to metering. This would also result in less emission of CO_2 in comparison to the prior to metering condition. Still, considering the small-scale nature of domestic gas consumption by individual customers any such beneficial effects consequent to efficient use of natural gas on overall climate change factors is regarded as not significant.
Natural Environment	Topography	D	D	As also noted above (under air quality), the project is extremely small-scale focused on individual domestic customers and will not cause any significant effect on topography.
	Geology	D	D	Similar to the topography case above, the project is too extremely small-scale to cause any significant effect on geology.
	Hydrology	D	D	Similar to the topography case above, the project is too extremely small-scale to cause any significant effect on hydrology.
	Ecosystem	D	D	As also noted above, the project is too extremely small-scale, focused on individual domestic customers, to cause

Classification of Environment	Environmental Element	Impact Evaluation		Reasons for Evaluation
		Construction Stage	Operation and Maintenance Stage	
				any significant effect on the ecosystem
	Biodiversity	D	D	Similar to the ecosystem case above, no significant adverse effect on biodiversity consequent to the installation of prepaid gas meters for domestic customers is anticipated.
	Protected areas	D	D	Similar to the ecosystem case above, no significant adverse effect on any protected areas consequent to the installation of prepaid gas meters for domestic customers is anticipated.
	Areas of environmental /ecological significance	D	D	Similar to the ecosystem case above, no significant adverse effect on areas of environmental/ecological significance consequent to the installation of prepaid gas meters for domestic customers is anticipated.
Social Environment	Local Economy	B+	B+	Prepaid gas meter installation work would generate some employment opportunity for local labourers. Moreover, maintenance monitoring and repair related works on operational prepaid meters and also the operation of the web system for prepaid meters would provide some long-term employment opportunities.
	Resettlement	D	D	Resettlement is irrelevant to the installation of prepaid gas meters for domestic customers.
	Indigenous people	D	D	Similar to the resettlement case of above, indigenous people aspect is irrelevant to the installation of prepaid gas meters to domestic customers.
	Cultural Heritage	D	D	Similar to the resettlement case above, the cultural heritage aspect is irrelevant to the installation of prepaid gas meters for domestic customers.
	Health and Safety	D	D	Installation of prepaid gas meters for domestic customers and its subsequent operation (by itself) is an individually too extremely small-scale project to cause any significant health or safety issues to either installation workers or domestic gas users (customers).

Legend:
A+/- : Significant positive/negative impact is expected
B+/- : Positive/negative impact is expected
C+/- : Extent of positive impact/extent of negative impact is unknown (needs further investigation on whether the impact can be clarified as the ESC Study progresses)
D : No significant impact is expected or no impact at all is expected

The results of the above scoping indicate that there are no significant adverse effects consequent to the prepaid gas meter installation (for domestic customers) projects on any environmental elements (ranked D) other than for potential beneficial effects on the local economy (ranked B+). Consequently, both projects could be categorized as Category C thereby also justifying the decision by DoE for the non-requirement of an environmental process including project registration or ECC by the project proponents (TGTDCL and KGDCL).

As such, no further consideration on environmental or social aspects is regarded as necessary for either of these projects on prepaid gas meter installation for domestic consumers.

6.3.16 Associated Risks under the Project

Associated risks during the project implementation period are summarized below.

Basically, the Implementation Agency is responsible for these risks. In order to avoid these risks, the following actions will be required.

No.	Associated Risk	Responsibility	Measures
1.	**Preparatory Stage**		
1.1	Overall schedule delay due to project approval delay by GOB	TGTDCL	1) Early approval of DPP 2) Early contract of SLA
1.2	Delay of Site (household) Selection	TGTDCL Consultant	Detail site investigation and planning before Contractor's detail design stage in consideration of various installation cases
1.3	Resistance of domestic customers	TGTDCL Consultant	Meeting with pilot area candidate customers to come to a mutual understanding for gas saving. Public Awareness Campaign is prior to the installation of meters.
1.4	Time delay for new town installation	TGTDCL Consultant	The schedule of the development plan and gas supply for new town areas may change, and it may affect the project implementation plan. So, meet with related authorities as well as customers during preparation stage.
2.	**Implementation Stage**		
2.1	Lack of Contractor's Ability	TGTDCL Consultant	1) Selection of qualified Consultant who prepares tender documents and evaluates them. 2) Careful check and review of tender documents submitted by the Contractor 3) Execution of company survey for the

No.	Associated Risk	Responsibility	Measures
			Contractor's ability as required 4) Contract indicating "contract-out condition" by reasons attributable to the Contractor in the termination clause. 5) Submission of client certificate or contract document for the contractor's project experiences
2.2	Delay of works and completion	TGTDCL Consultant Contractor	1) Progress to be closely monitored in order to timely cope with problems (e.g. lack of understanding on contract, Misunderstanding of procurement schedule, inefficient work procedure, inadequate risk assessment and project management, etc.) 2) Confirmation of delivery period for the longest lead items 3) Contract indicating: i) Construction deadline ii) Delay Penalty for reasons attributable to the Contractor 4) Scheduling in consideration of possible causes of delay (e.g. Wet season)
2.3	Imperfect quality	TGTDCL Consultant	1) Submission of qualification certificates for piping and installation works and non-destructive testing activities. 2) Sufficient design review of the Contractor's design documents 3) Check of quality control records prepared by the Contractor 4) Monitoring of all the contractor's activities for taking quick countermeasures 5) Establishment of proper acceptance criteria for all the contractor's activities 6) Penalizing the Contractor in case of non-fulfilment of equipment performance.
2.4	Cost overrun	TGTDCL Consultant	1) Monitoring of all contractor's activities for taking quick countermeasures 2) Preparation of appropriate tender documents for prevention of unexpected change orders 3) Progress to be closely monitored in order to timely cope with unexpected

No.	Associated Risk	Responsibility	Measures
			problems. 4) Securing of contingency
2.5	Conflict between house owner and customer	TGTDCL Consultant	Some kind of agreement between the house owner and residents should be made for fair tariff collection in Case-B (just like a water supply bill is commonly collected from the house owner at a fixed rate). However, it is possible that such agreement cannot be made due to different opinions among the concerned people. So, guidance meetings and/or announcing of these new contract schemes shall be needed as a public awareness campaign supported by the consultant
2.6	Fewer gas meter installations	TGTDCL Consultant	The estimated quantity of pre-paid meters in Case-B would include common kitchens of old apartments for low-income people that might include unauthorized burners and illegal branch piping connections that are not suitable for pre-paid meter installation. Therefore, it is possible that the total quantity of meters would be less than 200,000. So, further detail site investigations are needed for Case-B site planning before the Contractor's detail design stage begins in consideration of unauthorized burners etc. to determine its feasibility.
3.	**Operation & Maintenance**		
3.1	Gas leakage trouble due to lack of O&M skill (or poor installation etc.) that may cause troubles with the gas supply	TGTDCL	1) Proper Operation & Maintenance based on O&M manual provided by the Contractor. 2) Appropriate budget allocation for O&M activities specified in O&M manual provided by the Contractor.
3.2	Incorrect operation	TGTDCL	Ensure sufficient training for operators by the Contractor under the consultant's assistance during the project implementation stage.
3.3	Damage to piping work due to poor maintenance	TGTDCL	Regular patrols and inspections for precognition of possible pipe work damage due to poor maintenance
3.4	Damage to the pipeline by third party	Third party TGTDCL	Regular patrols and inspections to find unauthorized piping works.

6.4 Installation of Pre-Paid Gas Meters for KGDCL

6.4.1 Scope of the Project

The objective and outline of this project component are described in Section 4.4.2 (1) & (2), and the scope of the project is summarized in the table below.

No.	Scope of Works	Remarks
1.	Detailed designing and engineering, Sub material procurement, Installation, Commissioning and Testing of Pre-paid Gas Meters and WEB system units with associated materials, consisting of the following equipment: ▪ Pre-paid Gas Meters x 60,000 nos. in Chittagong Area ✓ Existing customers Case-A: 35,000 nos ✓ Existing customers Case-B: 25,000 nos ▪ WEB system ✓ System network server station x 2 (as 1set) ✓ Data base system server station x 2 (as 1set) ✓ KIOSK (POS) x 30 (back up 15 included) ▪ Detail design work x 1 ▪ Construction work for installation of Pre-paid Gas Meters in existing facilities x 60,000 ✓ Modification of existing risers ✓ Installation of additional pipe (angle pipe etc.) ✓ Installation of Pre-paid Gas Meters ▪ Construction work for installation of WEB system in KGDCL head office x 1 ✓ System network server station x 2 (as 1set) ✓ Data base system server station x 2 (as 1set) ▪ Construction work for installation of KIOSK (POS) in branch office of KGDCL x 2 ✓ Installation of POS (back up as service office) with internet system x 2 ▪ Construction work for installation of KIOSK (POS) in proposed sites (bank, supermarket etc. depend on contractor proposal for operation network) x 28 ✓ Installation of POS with internet system x 28 ▪ All bulk materials required for proposed facility ▪ Relocation works of existing facility (if necessary)	Proposed Pre-paid Gas Meter shall comply to OIML Standard R 6, R31, R11 and R 117-1 etc. WEB system has internet security remote system for communication of KIOSK as re-charging bill and gas consumption data management of customer. IC card communication method shall comply to ISO/IEC 18092 Each facility working condition shall be referred to 6.3.5 (2)
2.	Preparation and submission of operation manual	
3.	Supply of 1 year spare parts and special tools for proposed facility	As per Manufacturer’s standard
4.	Training of operators (before commissioning)	

No.	Scope of Works	Remarks
5.	Submission of as-built documents	To be submitted within 1 month after area wise facility unit handover.
6.	Defect Liability Period	12 months

Further details of the Project are described in Section 6.4.5 below.

6.4.2 Present Status of Other Pre-paid Meter Projects

KGDCL is currently planning a 5,000 meter pilot project for the pre-paid gas metering system with assistance from IICT & BUET, and is awaiting approval from the government for implementation of the project.

6.4.3 Lessons from Pilot Project of KGDCL

Lessons from the pilot project of TGTDCL described in previous Section 6.3.3 should be shared for the smooth implementation of this project component.

6.4.4 Public Awareness Campaign and Rise of Gas Price

The most expected impact of the introduction of a pre-paid metering system is the decrease of waste in natural gas usage among domestic customers. However, this is highly dependent on the energy saving awareness of domestic customers that would be improved by a campaign and also the rise of gas price.

(1) Public Awareness Campaign

Before and also during the installation of the pre-paid metering system, a public awareness campaign is required by means of:

- Large-scale campaign using mass media
- Lectures directly to domestic customers at the time of activation of the pre-paid metering system.

(2) Rise of Gas Price

According to the interviews with domestic customers who are currently under the pre-paid metering system of a pilot project, it seems that their gas usage pattern is not much different than what it was before the metering system was introduced. This is mainly because of the low fixed rate of gas tariff which does not encourage the domestic customers for energy saving. Therefore, the rise of gas price is also indispensable to ensure the decrease of gas usage.

The sudden and sharp rise of gas price for domestic customers will be difficult in consideration of the resistance from customers. However, the progressive charging system (block tariff system) according to the gas usage can be established by the pre-paid metering system without raising the base unit price. This would improve the energy saving awareness of domestic customers. Therefore a pre-paid metering system which is able to set such progressive charging system is recommended for this Project.

6.4.5 Preliminary Design of the Project

(1) Design Life and Warranty of the Entire System

The design life and warranty period of the pre-paid gas metering system should be not less than 20 years and 2 years, respectively.

(2) Pre-Paid Gas Meters

1) Working Conditions

Working Conditions of the pre-paid gas meters are recommended as follows in consideration of the environmental conditions and natural gas supply conditions in Bangladesh.

Table 6.4-1 Working Conditions for Pre-Paid Meters

Item	Unit	Condition
Flow range (without water heater)	m3/hr	2.5
Flow range (with water heater)	m3/hr	4.0
Pressure	mbar	75 – 500
Temperature (operation / storage)	deg C	0 – 40 / 0 – 70
Humidity	%	98%

Source: JICA Survey Team

2) Specifications & Requirements

Specifications and requirements of the pre-paid gas meters are recommended as follows in consideration of the lessons from the pilot project of TGTDCL mentioned in the previous Section 6.3.3.

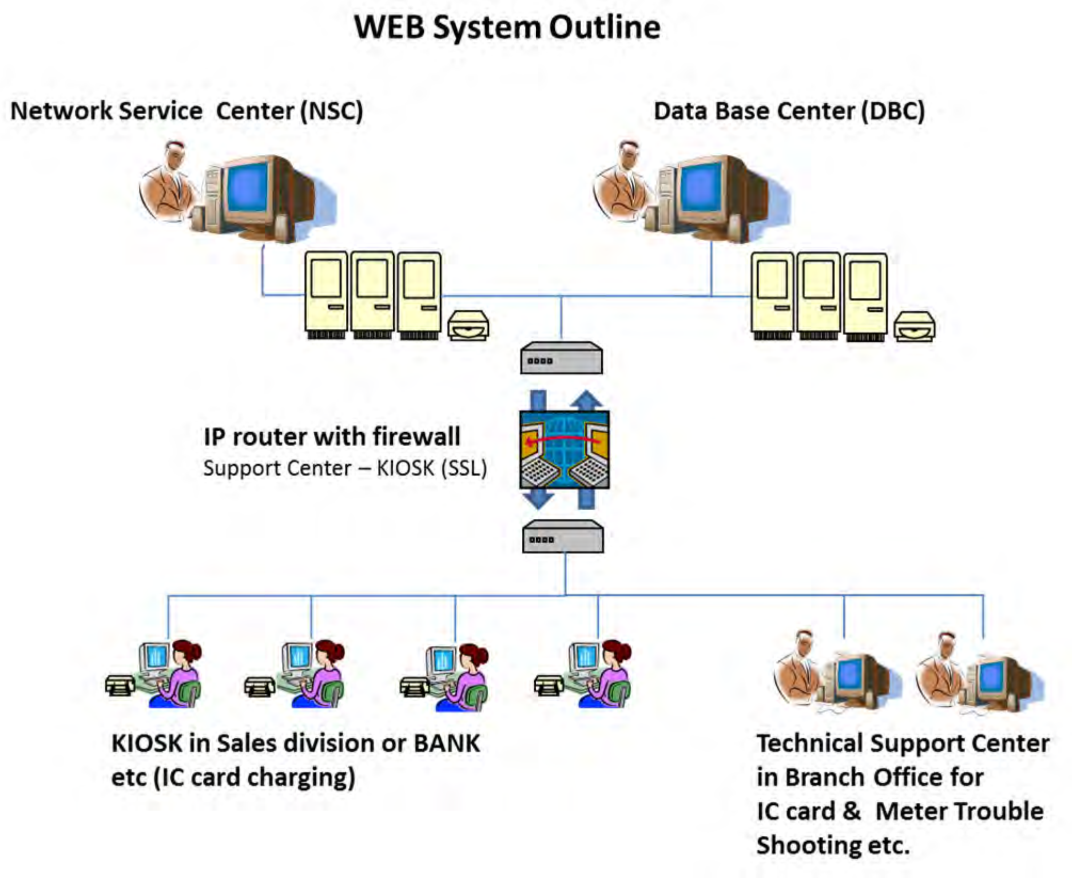
Table 6.4-2 Specifications & Requirements for Pre-Paid Meters

Item	Specification & Requirements
Pre-paid Gas Meter type	Diaphragm or Ultra Sonic
Enclosure protection (IP code)	IP 65 (min. IP 54)
Enclosure case	Die cast Aluminium
Battery Type (Service Life)	Lithium Ion (min 10 years)
IC card	Contactless
Unit price setting	Progressive charging system
Safety functions	Protection device or function against unacceptable situations such as gas leakage, etc.

Source: JICA Survey Team

(3) WEB System (Network Service Centre & Data Base Centre)

The outline of the WEB System is illustrated in the figure below.



Source: JICA Survey Team

Figure 6.4-1 Outline of the WEB System

Domestic customers charge their pre-paid cards in a KIOSK located regionally for easy access, and all payment data is stored in the Data Base Centre with a back-up server that is located in the head office of KGDCL. The entire WEB system is controlled and maintained by the Network Service Centre also located in the head office in KGDCL while the Technical Support Centre technically supports regional customers.

A WEB based management system is strongly recommended for the security of customer data, and this system will extract any abnormal data which may correspond to improper usage.

Specifications and requirements of the WEB system are recommended as follows.

Table 6.4-3 Specifications and Requirements for WEB System

Item	Unit	Specifications & Requirements
Network Service Center / Data Base Center	Nos.	2 units with Desk top PC with server, Core router, fire wall, hub, modem
Software	Nos.	Each 1 set with source back up
KIOSK	Nos.	1 center for each 2,000 customers
Technical Support Centre	Nos.	1 center for each regional office of the distribution company
Uninterruptible Power Supply (UPS)	kVA	min 5 for each center
Security with remote system	-	IPsec VPN or IP SSL VPN
Other units	-	Printer (dot and laser), Wireless broad band modem

(4) Number of Pre-Paid Meters

The number of pre-paid meters is set as follows based on the customer data and discussion with TGTDCL.

1) Existing customers Case-A: 35,000 nos.
2) Existing customers Case-B: 25,000 nos.

However, these figures will be reviewed by the Consultant based on the result of further field surveys and discussions with KGDCL at the preparatory stage of the project.

6.4.6 Construction Plan

(1) Construction Sequence

Installation of the pre-paid gas metering system will be implemented in the following sequence.

1) Design and Installation of WEB System

First of all, the WEB system will be designed and installed. The Network Service Centre and Data Base Centre will be installed in the head office of KGDCL, and the KIOSKs and Technical Support Centre will be established for the pilot installation area. Training for IT staffs of KGDCL will be commenced in this period.

2) Pilot Installation

Since the pre-paid gas metering system is new to KGDCL, a pilot installation (possibly about 3,000 meters) is recommended. KGDCL will learn about the installation, operation and maintenance of the system, and determine the issues and their solutions in order to be ready for the succeeding full-scale installation.

3) Full-scale Installation

After the pilot installation period is over, the full-scale installation will be implemented region by region.

a) Case-A:

Since Case-A has no problem to proceed with the installation, the full-scale installation should be commenced from Case-A.

b) Case-B:

While meters are installed in Case-A, the internal arrangement for the fair payment between residents and owners should be examined and finalized. Then, the installation of meters in Case-B can be commenced.

(2) Safety Plan

During the installation of pre-paid gas meters, fire or explosion due to gas leakage is possible. To prevent such incidents, the customer service pipeline (from meter to burner(s)) should be duly tested against gas leakage prior to the meter activation. And also a safety plan should be prepared by the contractor for KGDCL's approval prior to the installation works. This plan should include contractor's safety scheme, safety measures, communication network in case of accident, etc.

Then, during the installation stage, periodic and also random safety patrols will be carried out by KGDCL and/or a contractor in order to ensure that all works are carried out in a safe manner according to the said safety plan with a PDCA (Plan-Do-Check-Act) method.

1) Responsibilities of the implementation agency for safe construction are as follows.

a) Dissemination of Information

- Details of the Project
- Condition of project site, etc.

b) Confirmation and approval (Evaluates and approves)

・Construction plan by contractor

・Construction schedule by contractor

2) A list of disasters and countermeasures that are possible during the construction period.

a) Use safety equipment at all times and wear appropriate protection, such as:

・Safety helmet properly fastened

・Safety Shoes

・Gloves

・Ear protectors

・Dust glasses

・Safety belt and rope

Keep safety equipment properly maintained and in good condition after use.

b) Pay attention to the following:

・Do not run or jump

・Watch your step

・Watch against bumping your head.

・Turn your head when walking backwards.

・Avoid lifting too heavy materials also sensitive equipment (gas meters, etc..)

・Smell for gas leakage.

3) Construction Accident and Control Measures

Construction Accident	Control Measures
Transport Accidents	・Keep within the cargo weight limit. ・ Select the suitable type of cargo based on the proper weight. ・ Keep people out of the cargo working area. ・Clean the roads for the Road Authority during construction ・ Set the cargo level on the ground and do not to move with a stopper. ・ Sign post the instruction area & road clear area.
Electrical Accidents	・Have all electric equipment checked regularly by a qualified electrician. ・All equipment must be in good condition and shall be grounded properly. ・Carry out cable insulating properly. ・Avoid submerging electric cable under water except for insulated cable when necessary. ・Do not use any electric equipment in poor condition or in wet condition.

Construction Accident	Control Measures
	・Electric hand tools shall be protected by earth leakage or similar safety cut out switches which activate immediately in case of sudden increase in current.
Welding and Fixing Accidents	・Before work starts, check equipment as follows: ·Acetylene welder – ensure absence of leakage along the hose to be used. ·Electric welder – ensure all insulating systems are in good condition ・Piping work - ensure all pipes are in good condition. ・Always wear appropriate safety equipment: ・For welding: wear helmet, eye protector, gloves, safety shoes, etc. ・For fixing the pipe: wear helmet, gloves, and safety shoes ・Use grounding for welding machine ・ Provide adequate air circulation such as a blower during welding. ・Never perform welding near inflammable objects.
Safety for Customers	・ Barricade hazardous areas to keep customers out
Civil works	・The need for adequate support will depend on the type of excavation, the nature of the ground and the ground water conditions. ・Keep machinery, material and soil piles at sufficient distance to avoid collapse of the sides of the excavation ・After rain, check ground condition and report immediately any presence of cracks. ・Keep water out of installation area with sheet cover during works.
Fires	・Open fires are prohibited (cigarettes, etc.) ・Know where firefighting equipment is located and be trained on how to use it. ・Never perform welding near inflammable objects. ・All site personnel are required to confirm that there are no live fires left behind before leaving their working place.
Gas leakage	・Use of gas leakage detector tool before/after gas line check. ・Check thoroughly piping condition and also the customer's kitchen burner condition for preventing gas leakage.

Construction Accident	Control Measures
	・Use of leakage trouble measure manual for maintaining properly ・Whenever suspicious foul smell can be detected, always stop works immediately and investigate the source.

Safety activities of KGDCL, the executing agency of the gas prepaid gas meter project are controlled by the Safety and Environmental section.

(3) Lessons from previous projects

The cause of major accidents in previous projects in the gas sector is gas leakage due to poor safety management as well as poor workmanship. Therefore, proper safety management according to the safety plan of the project and assignment of trained and skilled workers are essential.

6.4.7 Package for the Procurement for the Project

As a result of a series of discussions among KGDCL, JICA and the Survey Team, all parties agreed to the procurement package for the project as described below.

Contract Package	Selection Method
(1) Consulting Service	Short Listing, QBS JICA Standard Request for Proposal (SRFP) [Consultants]
(2) Pre-paid Gas Meter & WEB system	International Competitive Bid (ICB) with PQ 2 envelopes 1 stage (JICA Standard Bidding Document (SBD) [Plant])

(1) Consulting Service Contract

The consultant will be selected according to the following guidelines and standard documents for bidding prepared by JICA.

- Guidelines for the Employment of Consultants under Japanese ODA loans
- Standard Request For Proposals Under Japanese ODA Loans
  for Selection of Consultants (October 2012)

Selection procedure of the Consultant is as follows;

1) Preparation of Terms of Reference (refer to Appendix 5)
2) Preparation of Short List of Consultants
- The consultants have satisfactory overseas experience of the consulting services concerned (e.g., detailed design, supervision)
- Consultants must have experience in a developing country

- The number of the short-listed consultants is 3 to 5

3) Preparation of Letter of Invitation
4) Sending of the Letter of Invitation to Consultants
5) Evaluation of Proposals

- Evaluation of Consultants’ proposals will be executed based on the evaluation criteria.
- Final result should be approved by the Board and JICA’s concurrence.
- Contract Negotiation
- Informing Unsuccessful Consultants

Since the pre-paid gas metering system is still quite new worldwide, the assignment of a highly specialized consultant is needed to manage the project. Therefore, the Quality-Based Selection (“QBS”) method is recommended for the consultant selection.

(2) Design and Build contract

KGDCL will enter into a Design and Build contract with the selected contractor. It will include the following items:

- Detail design of the entire pre-paid metering system
- Design and installation of the WEB system for the pre-paid card charging system
- Manufacturing, supply and installation of pre-paid gas meters
- Training for KGDCL staff
- Supply of spare parts
- Defect liability period

The contractor will be selected by International Competitive Bid (ICB) with single stage two envelope bedding procedure according to the JICA guidelines below.

- Guidelines for Procurement under Japanese ODA loans
- Standard Bidding Documents Under Japanese ODA Loans
  for Procurement of Plant Design, Supply and Installation (February 2013)[22]

(3) Possibility of the Utilization of Local Consultants and Contractors

Pre-paid meter technology is still new not only to Bangladesh but also to the world. Therefore, well experienced international consultants and contractors are recommended for this project.

(4) Recommended Requirements for the Consultant

It is recommended that the Consultant satisfy the following conditions for successful project

[22] This documents is basically prepared for the design, supply and installation of plant, however, it would be applicable for this project component with necessary modifications since a Design and Build contract is recommended.

implementation.

- The Consulting Firm shall have experience in engineering works for the establishment of facilities related to gas supply systems.
- The Consulting Firm shall have experience in engineering works for the data acquisition system
- The Consulting Firm shall have experience in project management, procurement assistance, engineering and supervision of construction for projects in Bangladesh that were funded by JICA, WB or ADB.
- The Consulting Firm is to be certified by ISO9001.

6.4.8 Consulting Services

The Consultant will keep KGDCL and JICA fully informed on all matters relating to the Services and the Project at all times during the period of the Services. This can be done through oral communications and will be confirmed by the submission of letters, monthly, weekly and other reports in writing, all as appropriate for the purpose.

(1) Scope of Service

The Consulting services are to be sequentially provided by the selected Consultant according to the following three (3) stages:

- Services for Pre-Construction Stage
- Services for Construction Stage
- Services for Post Construction Stage

And the Consulting services at each stage include the following major works necessary for implementation of the Project including but not limited to, the works described below. Details of the each work package are described in Section 5 (5) of Appendix 5 "*Terms of Reference (TOR) of Engineering Consultancy Services for the Project of Installation of Pre-paid Gas Meters at Dhaka Metropolitan Area - KGDCL*".

1) Services for Construction Stage
    a) Project Management
    b) Update and Upgrade of Data / Information of Existing Studies
    c) Basic Design and Engineering
    d) Procurement Assistance
    e) Institutional Development

2) Services for Construction Stage
   a) Project management at all levels including periodic review of budget estimate and administration of project cash flows and check of the Contractor’s Procurement
   b) Project management for installation area on planning coordination with City Government Office and BUET etc.
   c) Supervision for Detailed Engineering, Procurement, Installation, Commissioning and Testing
   d) Public Awareness Campaign
   e) Examination of the impact of a rise in gas prices
   f) Institutional Development

3) Services for Post Construction Stage
   a) Final Acceptance
   b) Project Completion Report

(2) Reports and Documents

The consultant shall prepare and submit to KGDCL the following documents and reports.

1) Inception Report (including schedule)
2) Engineering Report (including basic design report)
3) Construction schedule and cost estimate
4) Draft of pre-qualification documents
5) Draft of Bid documents
6) Draft of evaluation criteria and method of pre-qualification
7) Draft of evaluation report of pre-qualification
8) Draft of evaluation criteria and method of international competitive bidding
9) Draft of evaluation report of international competitive bidding
10) Monthly progress report
11) Quarterly progress report
12) Project completion report

(3) Expertise Requirements

The engineering services shall be provided by foreign and local consultants, which shall include but not be limited to the following:

Foreign Consultant

1) Project Manager (Team Leader: Pre-paid gas metering system)
2) Deputy Project Manager (WEB system)
3) Contract Engineer
4) Public Awareness Expert

Local Consultant

1) Deputy Project Manager (Local Team Leader: Pre-paid meters)
2) IT Engineer (WEB system)

(4) Duration of Service

The engineering service shall cover the duration of 87 months, starting from the commencement of consultant services to the completion of the project.

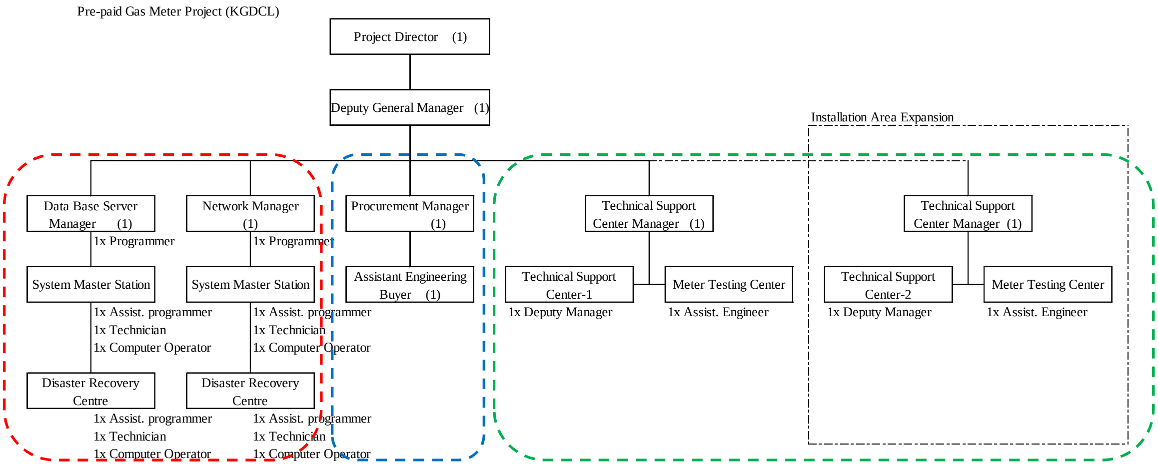
1)	Basic Design & Tender Document Stage	:	6	months
2)	PQ and Tender Stage	:	4	months
3)	Evaluation, Negotiation and Contract Stage	:	5	months
4)	Detailed Design & Manufacturing by Contractor	:	33	months
5)	Procurement of WEB system	:	5	months
6)	Procurement of PGM system (Pilot)	:	4	months
7)	Procurement of PGM system (Full scale)	:	19	months
8)	Construction/Installation Stage	:	32	months
9)	Defect Liability Period	:	12	months
10)	Foreign Consultant	:	56	Man-Months
11)	Local Consultant	:	120	Man-Months

The detail terms of reference (TOR) for Engineering Consultancy Services are given in Appendix 5 of this Report.

6.4.9 Organization for the Project Implementation and O&M

(1) Organization for the Project Implementation

Organization for the project implementation is proposed as shown below based on the discussions with KGDCL.



Each red, blue and green dotted enclosure represents the WEB system team, procurement team and Pre-paid Gas Meter team, respectively.

Other than major staffs mentioned in the above chart, the following assistant staffs will also be required.

Each Position or Section	Number and Type of Staff
Project Director, Deputy General Manager	1×Co-ordination Officer, 1×Computer Operator, 1×Driver, 1×Attendant for each
Manager	1×Computer Operator, 1×Driver, 1×Attendant for each
System Master Station	1×Attendant
Disaster Recovery Centre	1×Helper
Technical Support Centre ※	a) POS at head office 15×AAO, 15×Account Asst. b) Technical support 4×Asst. Engineer, 2×Helper c) Contractor Supervision 5×AE d) Replacement 1×Asst. Engineer, 1×SAE, 1×Technician, 1×Helper e) Card Print 1×Asst. Engineer, 1×SAE, 1×Technician, 1×Helper
Meter Testing Centre	1×Helper

Source: JICA Survey Team

Figure 6.4-2 Organization for the Project Implementation

The organization for the project implementation will be composed of the following three departments under entire project management by the project director and deputy general manager.

Each position member in the organization chart has the responsibility as shown below.

1) Project Director and Deputy General Manager

Position	Number	Responsibility	Assignment Before
Project Director	1	Attend the board meeting as represented opinion position, final budgetary control decision and top leading management of the whole project team	DPP preparation
Deputy General Manager	1	Co-represented position work of director and budgetary control management and negotiation with relational party about top issue of whole project	DPP preparation
Co-ordination Officer	2	Co-ordination for direction operating to inside and/or outside party by making a official letter for announcement etc. fully actual works supporting	DPP preparation
Computer Operator	2		DPP preparation
Driver	2		Consultant Selection
Attendant	2		Consultant Selection
sub-total	10		

2) Database and Network Managing Department for WEB System (Red Dotted Enclosure of Figure 6.4-2)

a) Data base server team

Position	Number	Responsibility	Assignment Before
Data base server team		Database and network managing department for WEB system	
Manager	1	Team management and fully control of implementation for Data base server establishment.	Consultant Selection
Computer Operator	1		Consultant Selection
Driver	1		Consultant Selection
Attendant	1		Consultant Selection
Programmer	1	Database system establishment. Program & technical issue control. Database access security establishment between Database and KIOSK.	Construction
sub-total	5		
System Master Station		Database system establishment team, they have responsible for	
Assist. programmer	1	Data base system installation & operation programming	Construction
Technical Officer	1	Technical support for technical support centre.	ditto
Computer Operator	1		ditto
Attendant	1		ditto
sub-total	4		
Disaster Recovery Centre		Database recovery team, they have responsible for	
Assist. programmer	1	System data recovery & programming	Construction
Technician	1	Technical work assistance for programmer	ditto
Computer Operator	1		ditto
Helper	1		ditto
sub-total	4		

b) Network server team (for Data base, System server and KIOSK security connection)

Position	Number	Responsibility	Assignment Before
Network server team			
Manager	1	Team management and fully control of implementation for Network system establishment.	Consultant Selection
Computer Operator	1		ditto
Driver	1		ditto
Attendant	1		ditto
Programmer	1	All network system establishment with security control. Program, technical issue control & recovery work for KIOSK system operation by technical support team.	Construction
sub-total	5		
System Master Station		Network system establishment team, they have responsible for	
Assist. programmer	1	Network system installation & operation programming	ditto
Technical Officer	1	Technical support for technical support centre establishment	ditto
Computer Operator	1		ditto
Attendant	1		ditto
sub-total	4		
Disaster Recovery Centre		Network recovery team, they have responsible for	
Assist. programmer	1	Network recovery tool & programming skill (technology transferred too)	ditto
Technician	1	Technical work assistance for programmer	ditto
Computer Operator	1		ditto
Helper	1		ditto
sub-total	4		

3) Procurement Department for Tendering and Making the Contract (Blue Dotted Enclosure of Figure 6.4-2)

Position	Number	Responsibility	Assignment Before
Procurement department			
Procurement Manager	1	Team management and fully control of implementation for Whole planned cost item procurement execution.	Consultant Selection
		Whole management of tender control, contract and negotiation, disbursement management of each phase on project and custom duty clearance control.	ditto
Technical buyer	1	Whole evaluation (Technical and Cost), technical issue control. Tender specification preparation with each team manager, tendering, negotiation and making the contract with general technical	Contractor Selection
Computer Operator	1		Consultant Selection
Driver	1		Contractor Selection
Attendant	1		Contractor Selection
sub-total	5		

4) Technical Support Department for KIOSKs & Pre-paid Gas Meter Services (Green Dotted Enclosure of Figure 6.4-2)

a) Technical support center team

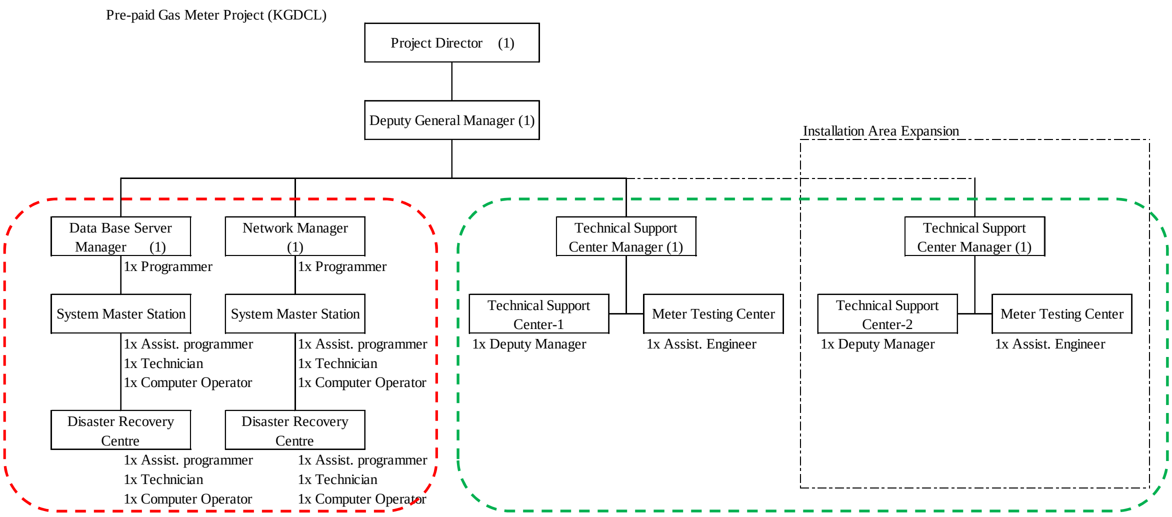
Position	Number	Responsibility	Assignment Before
Technical support center team			
Manager	1	Responsible area's two team management and fully control of establishment for KIOSK & Pre-paid meter installation in candidate site.	Consultant Selection
		Contract sign and team budgetary control.	ditto
Deputy manager	2	Customer data security management	Construction
		Establishment plan execution of Technical Support Centre & KIOSK	ditto
		Entire control of Pre-paid meter installation. (area wise)	ditto
Computer Operator	1		Consultant Selection
Driver	1		Consultant Selection
Attendant	1		Consultant Selection
sub-total	6		
a) Point of Sales System (POS)			
Asst. Account Officer (AAO)	15	Operation for accounting works for bill collection and/or pre-paid card charges etc. in KIOSK	Construction
Account Asst.	15	Assistant for accounting works for bill collection and/or pre-paid card charges etc. in KIOSK	ditto
b) Technical support			
Asst. Engineer	2	Technical support for pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	Construction
Helper	1		ditto
c) Contractor Supervision			
Asst. Engineer	2	Supervisory and management works for contractor	Construction
d) Replacement			
Asst. Engineer	1	Assist for replacement works of pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	Construction
Sub Asst. Engineer	1	Sub Assist for replacement works of pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	ditto
Technician	1	Technical support for replacement works.	ditto
Helper	1		ditto
e) Card Print			
Asst. Engineer	1	Assist for card printing works of pre-paid card system etc.	Construction
Sub Asst. Engineer	1	Sub Assist for card printing works of pre-paid card system etc.	ditto
Technician	1	Technical support for replacement works.	ditto
Helper	1		ditto
sub-total	49		

b) Pre-paid Gas Meter Testing team

Position	Number	Responsibility	Assignment Before
Pre-paid Gas Meter Testing center team			
Manager	1	Team management and fully control of implementation for pre-paid Gas Meter Quality control section (Inspection and Calibration management	Construction
Assist. Engineer	1	Meter test & Quality control.	ditto
sub-total	2		

(2) Organization for O & M

After the installation of the pre-paid metering system is completed, the procurement department will be dissolved, and two other departments will form the organization for O&M as shown below.



Each red and green dotted enclosure represents the WEB system team and Pre-paid Gas Meter team, respectively

Other than the major staffs mentioned in the above chart, the following assistant staffs will also be required.

Each Position or Section	Number and Type of Staff
Project Director, Deputy General Manager	1×Co-ordination Officer, 1×Computer Operator, 1×Driver, 1×Attendant for each
Manager	1×Computer Operator, 1×Driver, 1×Attendant for each
System Master Station	1×Attendant
Disaster Recovery Centre	1×Helper
Technical support Centre ※	a) POS at head office 15×AAO, 15×Account Asst. b) Technical support 4×Asst. Engineer, 2×Helper c) Contractor Supervision 5×AE d) Replacement 1×Asst. Engineer, 1×SAE, 1×Technician, 1×Helper e) Card Print 1×Asst. Engineer, 1×SAE, 1×Technician, 1×Helper
Meter Testing Centre	1×Helper

Source: JICA Survey Team

Figure 6.4-3 Organization for Operation & Maintenance

The organization for the project O&M will be composed of the following two departments under entire project management by the project director and deputy general manager.

Each position member in the organization chart has responsibility as shown below.

1) Project Director and Deputy General Manager

Position	Number	Responsibility	Assignment Before
Project Director	1	Attend the board meeting as represented opinion position, final budgetary control decision and top leading management of the whole project team	DPP preparation
Deputy General Manager	1	Co-represented position work of director and budgetary control management and negotiation with relational party about top issue of whole project	DPP preparation
Co-ordination Officer	2	Co-ordination for direction operating to inside and/or outside party by making a official letter for announcement etc. fully actual works supporting	DPP preparation
Computer Operator	2		DPP preparation
Driver	2		Consultant Selection
Attendant	2		Consultant Selection
sub-total	10		

2) Database and network managing department for WEB system

a) Data base server team

Position	Number	Responsibility	Assignment Before
Data base server team		Database and network managing department for WEB system	
Manager	1	Team management and fully control of implementation for Data base server establishment.	Consultant Selection
Computer Operator	1		Consultant Selection
Driver	1		Consultant Selection
Attendant	1		Consultant Selection
Programmer	1	Database system establishment. Program & technical issue control. Database access security establishment between Database and KIOSK.	Construction
sub-total	5		
System Master Station		Database system establishment team, they have responsible for	
Assist. programmer	1	Data base system installation & operation programming	Construction
Technical Officer	1	Technical support for technical support centre.	ditto
Computer Operator	1		ditto
Attendant	1		ditto
sub-total	4		
Disaster Recovery Centre		Database recovery team, they have responsible for	
Assist. programmer	1	System data recovery & programming	Construction
Technician	1	Technical work assistance for programmer	ditto
Computer Operator	1		ditto
Helper	1		ditto
sub-total	4		

b) Network server team (for Data base, System server and KIOSK security connection)

Position	Number	Responsibility	Assignment Before
Network server team			
Manager	1	Team management and fully control of implementation for Network system establishment.	Consultant Selection
Computer Operator	1		ditto
Driver	1		ditto
Attendant	1		ditto
Programmer	1	All network system establishment with security control. Program, technical issue control & recovery work for KIOSK system operation by technical support team.	Construction
sub-total	5		
System Master Station		Network system establishment team, they have responsible for	
Assist. programmer	1	Network system installation & operation programming	ditto
Technical Officer	1	Technical support for technical support centre establishment	ditto
Computer Operator	1		ditto
Attendant	1		ditto
sub-total	4		
Disaster Recovery Centre		Network recovery team, they have responsible for	
Assist. programmer	1	Network recovery tool & programming skill (technology transferred too)	ditto
Technician	1	Technical work assistance for programmer	ditto
Computer Operator	1		ditto
Helper	1		ditto
sub-total	4		

3) Technical Support department for KIOSK & Pre-paid gas meter services

a) Technical support center team

Position	Number	Responsibility	Assignment Before
Technical support center team			
Manager	1	Responsible area's two team management and fully control of establishment for KIOSK & Pre-paid meter installation in candidate site.	Consultant Selection
		Contract sign and team budgetary control.	ditto
Deputy manager	2	Customer data security management	Construction
		Establishment plan execution of Technical Support Centre & KIOSK	ditto
		Entire control of Pre-paid meter installation. (area wise)	ditto
Computer Operator	1		Consultant Selection
Driver	1		Consultant Selection
Attendant	1		Consultant Selection
sub-total	6		
a) Point of Sales System (POS)			
Asst. Account Officer (AAO)	15	Operation for accounting works for bill collection and/or pre-paid card charges etc. in KIOSK	Construction
Account Asst.	15	Assistant for accounting works for bill collection and/or pre-paid card charges etc. in KIOSK	ditto
b) Technical support			
Asst. Engineer	2	Technical support for pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	Construction
Helper	1		ditto
c) Contractor Supervision			
Asst. Engineer	2	Supervisory and management works for contractor	Construction
d) Replacement			
Asst. Engineer	1	Assist for replacement works of pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	Construction
Sub Asst. Engineer	1	Sub Assist for replacement works of pre-paid meter system, KIOSK services and WEB system for bill collection and/or pre-paid card charges etc.	ditto
Technician	1	Technical support for replacement works.	ditto
Helper	1		ditto
e) Card Print			
Asst. Engineer	1	Assist for card printing works of pre-paid card system etc.	Construction
Sub Asst. Engineer	1	Sub Assist for card printing works of pre-paid card system etc.	ditto
Technician	1	Technical support for replacement works.	ditto
Helper	1		ditto
sub-total	49		

b) Pre-paid Gas Meter Testing Center team

Position	Number	Responsibility	Assignment Before
Pre-paid Gas Meter Testing center team			
Manager	1	Team management and fully control of implementation for pre-paid Gas Meter Quality control section (Inspection and Calibration management	Construction
Assist. Engineer	1	Meter test & Quality control.	ditto
sub-total	2		

(3) Assignment of Project Staffs

- All staffs for Project Implementation and O&M are full-time workers.
- Basically all staffs could be arranged from the existing manpower except for the following full-time skilled IT staffs to be newly employed due to lack of IT skill prior to the detail design of the WEB system.

IT Manager	1×Data Base Server Manager, 1×Network Manager
Programmer	2×Programmer for above section
Asst. Programmer	4×Asst. Programmer for above section

- It is recommended to assign the staffs who have experience with pre-paid metering systems in the pilot project.
- It is recommended that the Deputy Project Director and Deputy General Manager are assigned from the DPP preparation stage, and other members will be assigned according to the progress and requirements of the project.
- In case the KIOSK operation is outsourced with commission which will be charged to customers, the project staff assignment at KIOSK would be avoided. This issue should be taken into consideration during the preparatory stage.

6.4.10 Training

- KGDCL staffs will be thoroughly trained by means of On the Job Training (OJT) for the operation and maintenance of pre-paid meters as well as the WEB system.

The consultant will guide the contractor to prepare the following training item packages and periods.

Training Package & period	WEB system	Pre-paid Gas Meter
Contractor WEB system & Meter Installation Demonstration	1month	1month
Monitoring with Training for Other Candidate Constructors	3months	3months
General Design, Instruction manual lecturing and maintenance guidance (with BUET capacity building)	1month	1month
Contractor Supporting Structure & Supply Chain Management Works	1month	1month
Gas usage monitoring & analysis guidance (with BUET capacity building	-	2months
Energy conservation awareness program guidance and Work monitoring	1month	4months

- Especially for the WEB system, including the KIOSK, Data base, and Network server team as well as the Technical support team for the KISOK POS, members will be thoroughly trained regarding the following items prior to activation of the Pre-paid Gas Meters. The details of the training scheme should be proposed by the Contractor.

1) Training to Database server and Network server team
   a) Computer and Server operation
   b) Trouble shooting for computer and server
   c) Management of customers, revenue and improper usage
   d) Customer registration and IC card issuing

2) Training for KIOSK POS members and Technical support team
   a) Computer basic operation
   b) Software and hardware operation for IC card charging
   c) Trouble shooting for KIOSK POS system
   d) Customer dealing

6.4.11 Project Implementation Schedule

The Project Implementation Schedule is proposed as shown in Figure 6.4-4, and the schedule of each phase of the Project is explained below.

(1) Preparatory Phase

KGDCL should prepare the DPP and obtain approval from the government prior to the loan agreement.

(2) Implementation Phase-1 (Procurement)

1) Selection of Consultant

After the loan agreement in concluded, KGDCL will select a consultant. Nine months will be needed for the selection of a consultant in consideration of the necessary processes such as preparation of the terms of reference (“TOR”), tender, evaluation and contract.

2) Selection of Contractor

KGDCL and the consultant will select a contractor by international competitive bidding. Fifteen months will be needed for the selection of the contractor in consideration of the necessary processes such as detail design, preparation of tender documents, prequalification (“PQ”), tender, evaluation, negotiation and contract.

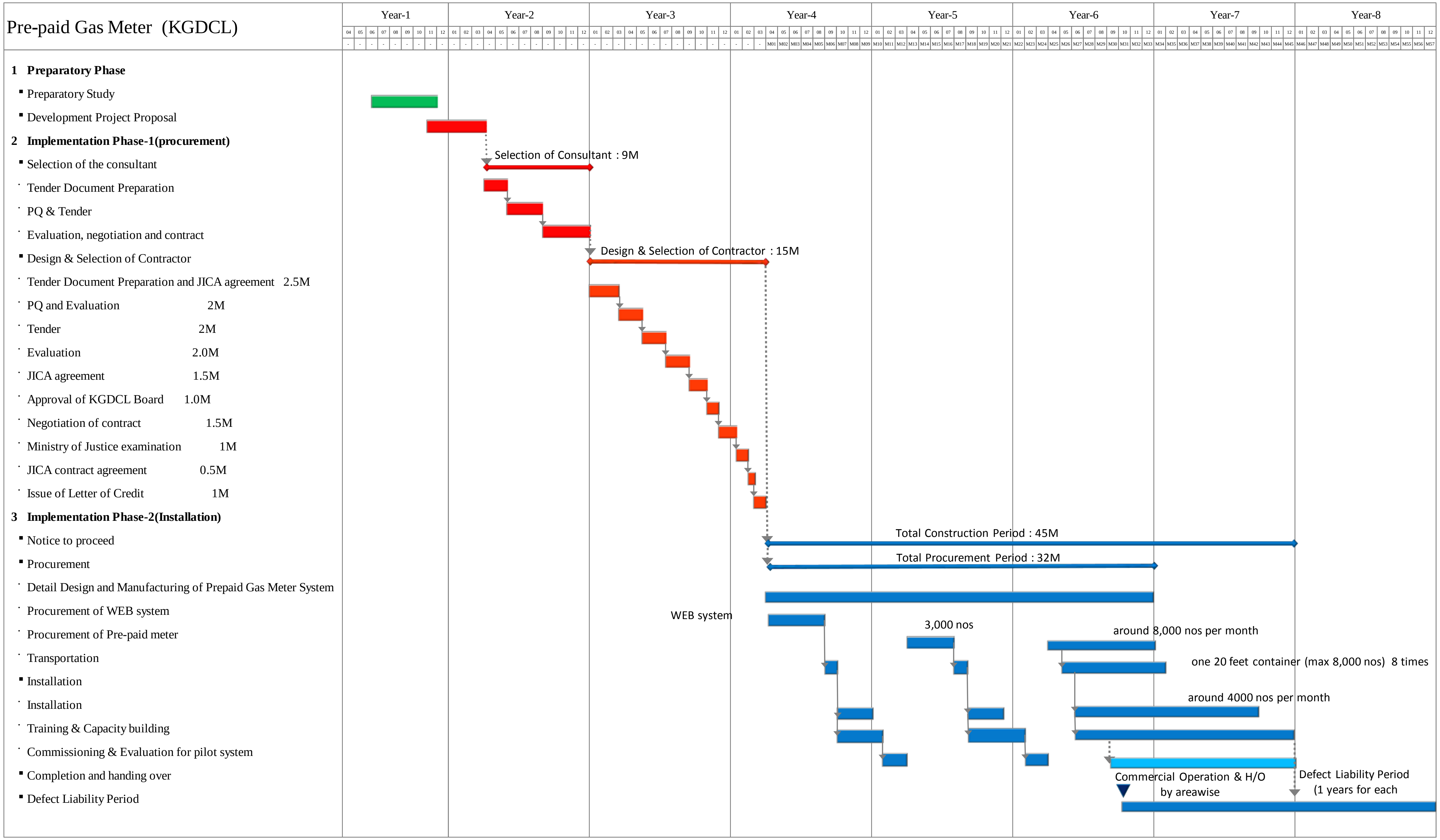
(3) Implementation Phase-2 (Detail Design & Installation)

The total duration of the installation of the pre-paid metering system is estimated at 3.75 years (45 months) as below:

1) Design and establishment of WEB system: 12 months
2) Pilot installation (3,000 meters recommended) with monitoring and training: 12 months
3) Full-scale installation: 21 months

(4) Additional Survey

In case any additional survey is carried out to solve the problems in the installation for Case-B mentioned in Section 4.4.1 (3), the pilot installation might be omitted to reduce the project duration.



Source: JICA Survey Team

Figure 6.4-4 Project Implementation Schedule for the Pre-paid Gas Meters (KGDCL)

6.4.12 Project Cost

The Project Cost is composed of the following items:

Table 6.4-4 Composition of Project Cost for Pre-paid Gas Meters (KGDCL)

No.	Item	Remarks
A	Eligible for ODA loan	
1)	Construction cost of Pre Paid Gas Meter (Design and Build cost）	
2)	Project management cost (cost for consulting service)	
3)	Dispute Board Fee	
B	Non-eligible for ODA loan	
1)	KGDCL’s administration cost	
2)	Bank charge cost	
3)	VAT and Custom duties	

The following unit prices and conditions are adopted for the estimation of Project Cost.

Table 6.4-5 The Unit prices and Conditions for Pre-paid Gas Meters (KGDCL)

No.	Item	Unit price & Conditions
1)	Establishment of WEB system	JPY 162,000,000 Lump sum
2)	Manufacturing and supply of pre-paid gas meters	JPY 18,000 per meter
3)	Installation of pre-paid gas meters	JPY 3,000 per meter
4)	Number of pre-paid meters	60,000 meters
5)	Number of Network Service Centres	1 centre
6)	Number of Data Base Centres	1 centre
7)	Number of KIOSKs	30 stations
8)	Number of Technical support centres	1 centre

The following rates are adopted in this estimate based on the survey and recent project data in Bangladesh.

Table 6.4-6 Preconditions of Cost Estimate for Pre-paid Gas Meters (KGDCL)

No.	Item	Rate
1.	Price escalation Foreign Portion	1.3%
	Price escalation Local Portion	3.4%
2.	Physical Contingency	5%
3.	Interest during construction	0.01%
4.	TAX	25% (VAT: 15% + AIT: 10%)
5.	Custom Duty	31.3% on Cost Freight Value
6.	Administration cost	4% of the Project cost
7.	Bank charge cost	1% of the Project cost

The exchange rates used in this estimate are as follows:

1)	1 USD=99.7 JPY
2)	1 USD=77.8 BDT
3)	1 BDT=1.28 JPY

According to the above composition, unit prices and preconditions, the total Project cost is estimated based on the Project implementation schedule “Figure 6.4-4” in Section 6.4.11 as well as the results of studies described in other chapters. Table 6.4-7 is the summary sheet of the total Project cost estimate.

Table 6.4-7 Project Cost of Pre-paid Gas Meters (KGDCL)

	Item	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local
			[1,000 JPY]			[1,000 BDT]			[1,000 USD]	
	Eligible Portion									
a	Pre-paid Gas Meter (a1+a2+a3+a4)	1,440,754	1,260,754	180,000	1,125,589	984,964	140,625	14,451	12,645	1,805
a1	Web System	162,000	162,000		126,563	126,563		1,625	1,625	
a2	Pre-paid Gas Meter (for Pilot)	63,000	54,000	9,000	49,219	42,188	7,031	632	542	90
a3	Pre-paid Gas Meter	1,197,000	1,026,000	171,000	935,156	801,563	133,594	12,006	10,291	1,715
a4	Dispute Board	18,754	18,754		14,652	14,652		188	188	
b	Contingency (b1+b2)	201,464	154,382	47,082	157,394	120,611	36,783	2,021	1,548	472
b1	Price Contingency on A F 1.3% L 3.4%	123,263	86,995	36,268	96,300	67,965	28,335	1,236	873	364
b2	Physical Contingency on A 5.0%	78,201	67,387	10,813	61,094	52,646	8,448	784	676	108
c	Consulting Service	288,757	163,880	124,877	225,591	128,031	97,560	2,896	1,644	1,253
d	Contingency (d1+d2)	42,638	17,424	25,213	33,311	13,613	19,698	428	175	253
d1	Price Contingency on C F 1.3% L 3.4%	26,857	8,791	18,066	20,982	6,868	14,114	269	88	181
d2	Physical Contingency on C 5.0%	15,781	8,634	7,147	12,329	6,745	5,584	158	87	72
A	**Total of Eligible Portion (a++b+c+d)**	1,973,613	1,596,441	377,172	1,541,885	1,247,219	294,666	19,796	16,012	3,783
	Non Eligible Portion									
e	Administration Cost (including Bank Charge 1%) 5%	98,681		98,681	77,094		77,094	990		990
f	Custom Duties、 VAT and AIT (f1+f2)	929,756		929,756	726,372		726,372	9,326		9,326
f1	VAT : 15% & AIT: 10%	493,403		493,403	385,471		385,471	4,949		4,949
f2	Custom Duties on Foreign Portion of A 31.3%	436,353		436,353	340,901		340,901	4,377		4,377
g	Interest During Construction 0.01%	587	587		459	459		6	6	
B	**Total of Non Eligible Portion (e+f+g)**	1,029,024	587	1,028,437	803,925	459	803,466	10,321	6	10,315
	Grand Total (A+B)	3,002,637	1,597,028	1,405,609	2,345,810	1,247,678	1,098,132	30,117	16,018	14,098

Source: JICA Survey Team

6.4.13 Economic and Financial Analyses

(1) Outline of Economic and Financial Analyses of the Project

The evaluation and computation of the financial internal rate of return (FIRR) and economic internal rate of return (EIRR) including sensitivity analysis were carried out for the Project on an incremental basis for the comparison between “with project” and “without project” scenarios. The cash flow is projected and the financial and economic viability of the Project are examined.

(2) Key Assumptions Used for Financial Analysis

1) Inflation

- Price escalation for the foreign currency components: 1.3 % per annum
- Price escalation for the domestic currency components: 3.4 % per annum

2) Increase of gas price

Apart from price escalation, it is assumed that the gas price will have increased for the project implementation at 8% every year, as the average increase rate in gas price for last 25 years was 8%.

3) With-project and Without-project Scenarios

The financial analysis considered only the increase in revenues and costs directly associated with each project component. Therefore, the revenues and costs of existing systems are not considered.

4) Financing

It is assumed that the majority of the total initial investment cost including IDC will be financed with a yen-denominated soft loan from JICA, which is sublet to executing agencies from GOB on the basis of the Subsidiary Loan Agreement. These loan conditions are given below:

a) Yen-denominated soft loan

- Interest rate: 0.01 % per annum
- Repayment period: 40 years including 10 year grace period (The grace period starts in the year of the first disbursement of the loan.)

b) Subsidiary Loan to each executing agency from MOF

Conditions of SLA such as interest rate, repayment period including grace period and debt equity ratio for each executing agency are described in the Section of the financial analysis for the Project.

(3) Key Assumptions Used for Economic Analysis

1) Economic costs

In the economic analysis, we use true economic prices instead of often-distorted financial or market prices. For this purpose, we disregard all transfer payments within the country, such as taxes and duties. Then, we convert distorted market prices into economic prices by multiplying them by conversion factors. As far as the Project is concerned, while no “border distortion” is assumed, domestic currency components of initial capital investment are expected to be subject to domestic distortion. In particular, wage rates of unskilled labourers tend to exceed “opportunity-cost” wages. For simplicity, we use the standard conversion factor of 0.97[23] in our calculations, to be applied to market prices of all domestic currency components.

2) Economic Discount Rate

A 12% economic discount rate[24] is used as a cut-off rate for the Project to evaluate whether the Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

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[23] The standard conversion factor of 0.97 is used, referring to ADB report, “Third Natural Gas Development Project”

[24] The 12% economic discount rate is used, referring to ADB report, “Natural Gas Access Improvement Project”

(4) Financial Analysis for Pre-paid Gas Meters for KGDCL

The introduction of pre-paid gas meters contributes to improving energy efficiency.

1) Initial Investment Costs

As described earlier in this report, the total cost of the eligible portion for the pre-paid gas meters including consulting service is estimated at approximately US$ 20 million. With administration cost, VAT & AIT and custom duties, the total initial investment cost (excluding IDC) is estimated at approximately US$ 30 million. Table 6.4-7 in Section 6.4.12 shows the estimate of initial investment costs.

2) O&M Costs

The estimated amount necessary for O&M works of the Project, excluding price escalation, will be around BDT 20 million per year. Approximate operating expenditures include personnel positioning and staff assignment, administration costs and spare parts. The breakdown of O&M costs is as follows:

Table 6.4-8 Breakdown of O&M Costs for Pre-paid Gas Meters for KGDCL

(Unit: 1,000 BDT/year)

Work Item	Annual Cost
Personnel positioning and staff assignment	9,200
Administration costs	8,100
Spare Parts	2,500
Total	19,800

Source: JICA Survey Team

3) Conditions of SLA

- Interest rate: 1% per annum
- Repayment period 20 years including 8 years grace period
- Currency: Bangladesh Taka
- Debt equity ratio: 60 : 40[25]

4) Others

Other key assumptions used in our analysis are as follows:

- Depreciation: 20-year straight line
- Corporate income tax: 37.5%

[25] This is the information referring to MoF's "Lending and Relending Terms of Local/Foreign Currency Loans" for Petrobangla.

Property taxes or working capital requirements are not considered in projecting the cash outflow stream. Potential revenues other than sales revenue, such as interest earnings, are not taken into account either, since they will be comparatively small.

5) Gas Tariff Collection System for Domestic Customers

Refer to Section 6.3.13 (1) 5)

6) Elimination of Waste

Refer to Section 6.3.13 (1) 6)

7) Interest from tariff collection in advance

Referring to Section 6.3.13 (1) 7), it is assumed that the time period for outstanding arrears for the domestic customers of KGDCL is on average 4.94 months. Successful implementation of the project will not allow any arrears. KGDCL will be able to gain the revenue about 5 months earlier.

8) Weighted Average Cost of Capital

Refer to 6.1.10 (4) 7) for the explanation of WACC.

The following are the assumptions that are laid down for the project:

- Cost of Equity = 17% p.a. (before tax)
- Equity／(Equity + Debt) = 14%
- Debt Cost = 1% p.a.
- Debt／(Equity + Debt) = 86%
- Corporate Tax Rate = 37.5%

Those assumed figures are inserted into the formulae to draw the output rates for WACC as follows;

WACC = 4.59%

As a result of the above exercise, the weighted average of capital costs is 4.59% before tax. We conclude this section by confirming that the project is to be deemed viable when the project FIRR will be found above the WACC of 4.59%.

(5) FIRR on the Total Investment Cost (Project FIRR)

To confirm the underlying financial viability or the true soundness of the Project, the financial internal rate of return (FIRR) of the Project was calculated. The result of the calculation of the FIRR is as follows:

FIRR: 0.06%

The FIRR is at 0.06%, which does not exceed 4.59%, WACC. Therefore the Project is not regarded as financially viable. However, the annual cash balance of the Project will not go into the red, since terms and conditions of SLA are set to be a high concession. Thus, the executing agency will be able to maintain financial soundness in management.

Table 6.4-9 Project FIRR for Pre-paid Gas Meters for KGDCL

(Thousand USD)

Project Year	Project Life	Cash Inflow					Cash Outflow							Net Cash Flow for		
		Owned Capital	Foreign Loan	Domestic Loan	Operating Revenue	Total Revenue	Capital Costs	O&M Costs	Interest Foreign Loan	Interest Domestic Loan	Repay Foreign Loan	Repay Domestic Loan	Total Cost	Cash Balance	Project IRR	Cumulative Cash Balance
3		123	591	185	0	899	899						899	0	-899	0
4		489	2,347	734	0	3,570	3,570						3,570	0	-3,570	0
5		288	1,383	432	25	2,129	2,104						2,104	25	-2,079	25
6		1,408	6,757	2,112	185	10,462	10,277	0	0	0	0	0	10,277	185	-10,093	210
7	1	1,809	8,678	2,713	617	13,818	13,200	0	0	0	0	0	13,200	617	-12,583	827
8	2	8	39	12	1,258	1,317	59	0	0	0	0	0	59	1,258	1,199	2,085
9	3	0	0	0	1,342	1,342	0	418	0	0	0	0	418	924	924	3,009
10	4	0	0	0	1,428	1,428	0	439	0	0	0	0	439	990	990	3,999
11	5				1,516	1,516		459	208	65	1,040	325	2,097	-581	1,057	3,418
12	6				1,606	1,606		479	198	62	1,040	325	2,104	-497	1,127	2,920
13	7				1,698	1,698		500	187	59	1,040	325	2,110	-412	1,198	2,508
14	8				1,792	1,792		520	177	55	1,040	325	2,117	-325	1,272	2,183
15	9				1,888	1,888		541	166	52	1,040	325	2,124	-236	1,347	1,946
16	10				1,985	1,985		561	156	49	1,040	325	2,131	-145	1,424	1,801
17	11				2,085	2,085		581	146	46	1,040	325	2,137	-53	1,504	1,749
18	12				2,186	2,186		602	135	42	1,040	325	2,144	42	1,585	1,791
19	13				2,290	2,290		622	125	39	1,040	325	2,151	139	1,668	1,930
20	14				2,395	2,395		643	114	36	1,040	325	2,158	237	1,753	2,167
21	15				2,502	2,502		663	104	33	1,040	325	2,164	338	1,839	2,505
22	16				2,612	2,612		683	94	29	1,040	325	2,171	440	1,928	2,946
23	17				2,723	2,723		704	83	26	1,040	325	2,178	545	2,019	3,490
24	18				2,836	2,836		724	73	23	1,040	325	2,185	651	2,112	4,142
25	19				2,951	2,951		745	62	20	1,040	325	2,191	759	2,206	4,901
26	20				3,068	3,068		765	52	16	5,199	1,626	7,658	-4,590	2,303	311
Total		4,126	19,796	6,189	40,988	71,098	30,111	10,648	2,080	650	20,797	6,502	70,788	**311**	229	
FIRR															**0.06%**	

Source: JICA Survey Team

(6) Sensitivity to FIRRs

1) Sensitivity Analysis on Changes of Costs and Revenue

Separate analyses were carried out to examine the sensitivity of the projected financial returns to adverse changes in key variables. The risks involved in the Project in terms of financial viability are the future uncertainty of the initial investment cost and the exchange rate between the local currency and the US dollar. Hence, the variables considered for the sensitivity analyses were as follows;

a) 10% higher cost of eligible portion in initial investment cost

b) 20% higher cost of eligible portion in initial investment cost

c) 10% lower exchange rate than assumed, i.e., 85.58 BDT/USD

d) 20% lower exchange rate than assumed, i.e., 93.36 BDT/USD

The results of the above sensitivity tests are summarized below:

Table 6.4-10 Results of Sensitivity Analysis on FIRR for Compressors

	Item	Project FIRR
1	10% higher cost of eligible portion in initial investment cost	0.72%
2	20% higher cost of eligible portion in initial investment cost	-1.41%
3	10% lower exchange rate	-1.12%
4	20% lower exchange rate	-2.45%

Source: JICA Survey Team

The above sensitivity analysis indicates that all the FIRRs, in the cases of 10% and 20% higher costs of eligible portion and 10% and 20% lower exchange rates, show lower values than the 4.59% WACC, the cut off rate. Therefore, the financial feasibility of the Project is deemed to be low as a component of the natural gas efficiency project.

Two other sensitivity analyses for the FIRR were made as references in order to confirm the further underlying financial viability or soundness as follows.

2) Meter Rent Fee

In order to increase the value of the FIRRs, charging a meter rent fee[26] would make it possible for KGDCL to include it as one of its revenues. The meter rent fee, cost of manufacturing and supply of pre-paid gas meters, is estimated around 60 BDT per month per meter. Given that KGDCL includes this meter rent fee as its revenue, the value of the FIRR would be improved. The result of the calculation of the FIRR including meter rental fee is as follows:

FIRR including meter rental fee: 3.46%

The FIRR including meter rental fee is at 3.46%, which is close to 4.59%, WACC. It is confirmed that the FIRR including meter rental fee was improved, although the FIRR of the Project does not exceed 4.59%, WACC. Furthermore, the annual cumulative cash balance of the Project will never go into the red so that the executing agency will be able to maintain financial soundness in management.

However, it is recommended that the introduction of a meter rental fee is sufficiently considered on the basis of close consultations with the relevant organisations, because this introduction gives rise to a burden as an additional charge to customers.

3) Appropriate Raise in Gas Price

In order to make the value of the FIRRs appropriate, it would be necessary to review the gas tariff and set a more appropriate gas tariff in this country as a reference, since the gas tariff in

[26] Meter rent fee means that the cost of manufacturing and supply of pre-paid gas meters is added to gas sales revenue. In other words, the ownership of the pre-paid gas meters themselves belongs not to customers but to KGDCL.

this country is far from the international gas tariff. It is hoped that the appropriate raise in the gas sales price is put in force. Hence, the sensitivity analysis for the phased installation of appropriate raises in gas sales price was carried out. A certain ratio of the phased raise in the gas sales price to exceed the 4.59% cut off rate for financial feasibility of this component would be as follows:

Phased raise in gas sales price: 14% every year

If the 5.16 taka/m^3 current gas sale price for domestic customers increases 14% every year, the FIRR is to be 4.82% and exceeds the 4.59% cut off rate. Such gas price in the final year of the Project will be 23.24 taka/m^3, which is nearly four times the current gas sales price for domestic customers. The suggested raise in gas sales price is shown as follows:

Table 6.4-11 Raise in Gas Sales Price for Domestic Customers

Year	0	1	2	3	・・・	23	24	25
Increase	—	14%.	28%	42%	・・・	322%	336%	350%
Gas sales price (taka/m^3)	5.16	5.89	6.61	7.33	・・・	21.80	22.52	23.24

Source: JICA Survey Team

Considering the phased raise in gas sales price of 14% every year, it can be said that the Project will be financially feasible. Yet, it would be difficult for an executing agency to put the phased raise in gas sales price of 11% every year in force. Therefore, it is hoped that the gas tariff issue is discussed in the Steering Committee of the Project.

(7) Conclusion on Financial Viability

The project FIRR of the base case is at 0.06%, which does not exceed 4.59%, the WACC. Therefore, the Project is not regarded as financially viable or a sound investment. However, the annual cash balance of the Project will not go into the red, since the terms and conditions of the SLA are set to be a high concession. Thus, the executing agency will be able to maintain financial soundness in management.

Considering the sensitivity of the FIRRs, the financial feasibility of the Project is considerably low, because the FIRR of the base case does not exceed the 4.59% cut off rate. The main reason for this is that meter rent fee is not included as one of its revenues. Furthermore, another reason is that the current gas sales price is set quite low.

The result of the calculation of the FIRR including meter rental fee is at 3.46% which is close to 4.59%, WACC. It is confirmed that the FIRR including meter rental fee was improved, although the FIRR of the Project does not exceed 4.59% WACC. Furthermore, the annual cumulative cash balance of the Project will never go into the red so that the executing agency will be able to maintain financial soundness in management. However, it is recommended that the introduction of a meter rental fee is sufficiently considered on the basis of close consultations with the relevant organisations, because this introduction gives rise to a burden as an additional charge to customers.

As for gas sales price, it is recommended that KGDCL carries out a further study to revise and possibly raise the current gas sales price for domestic customers. It is expected that the Project FIRR will be higher, provided that the revision and increase of gas sales price are carried out in the near future, which would contribute to higher financial viability of the Project. In this regard, the FIRR of the Project will be 4.82% and financially feasible due to being above the cut off rate, given that the phased raise in gas sales price of 14% every year is put into effect. To sum up, it is deemed that the Project is not financially feasible in the base case. On the other hand, considering a phased raise in gas sales price of 14% every year, it can be said that the Project will be financially feasible. Yet, it would be difficult for an executing agency to put the phased raise in gas sales price of 11% every year in force. Therefore, it is hoped that the gas tariff issue is discussed in the Steering Committee of the Project.

(8) Economic Analysis for Pre-paid Gas Meters for KGDCL

1) Economic benefit

Refer to Section 6.3.13 (5) 1)

(9) EIRR

Table 6.4-12 exhibits the calculation of the EIRR of the Project based on the economic benefits and costs discussed earlier. The EIRR is calculated at 37.67%, which clearly supports the economic viability of the Project, because the 37.67% of the EIRR is above the 12%, cut off rate of the evaluation criteria for economic analysis.

Table 6.4-12 EIRR of the Project for KGDCL

(Thousand USD)

Project Year	Project Life	Cash Inflow		Cash Outflow			Net Cash Flow for	
		Benefits	Total Benefit	Capital Costs	O&M Costs	Total Cost	Cash Balance	Cumulative Cash Balance
3		0	0	717		717	-717	-717
4		0	0	2,424		2,424	-2,424	-3,141
5		201	201	1,533		1,533	-1,332	-4,473
6		1,355	1,355	6,979	0	6,979	-5,623	-10,096
7	1	8,012	8,012	8,942	0	8,942	-929	-11,025
8	2	7,993	7,993	48	0	48	7,945	-3,080
9	3	7,974	7,974	0	418	418	7,556	4,476
10	4	7,955	7,955	0	439	439	7,516	11,992
11	5	7,935	7,935		459	459	7,476	19,468
12	6	7,916	7,916		479	479	7,437	26,905
13	7	7,897	7,897		500	500	7,397	34,302
14	8	7,877	7,877		520	520	7,357	41,659
15	9	7,858	7,858		541	541	7,318	48,976
16	10	7,839	7,839		561	561	7,278	56,254
17	11	7,820	7,820		581	581	7,238	63,493
18	12	7,800	7,800		602	602	7,199	70,691
19	13	7,781	7,781		622	622	7,159	77,850
20	14	7,762	7,762		643	643	7,119	84,969
21	15	7,742	7,742		663	663	7,079	92,049
22	16	7,723	7,723		683	683	7,040	99,088
23	17	7,704	7,704		704	704	7,000	106,088
24	18	7,685	7,685		724	724	6,960	113,049
25	19	7,665	7,665		745	745	6,921	119,970
26	20	7,646	7,646		765	765	6,881	126,851
Total		158,140	158,140	20,642	10,648	31,290	**126,851**	
EIRR							**37.67%**	

Source: JICA Survey Team

(10) Sensitivity Analysis for the EIRRs

A sensitivity test was performed on the EIRR for the initial investment cost only, which is the largest foreign cost component. The results of the test are as follows:

Table 6.4-13 Results of EIRR Sensitivity Analysis for KGDCL

	Scenario	EIRR of the Project
1	10% higher initial investment cost	34.27%
2	20% higher initial investment cost	31.39%

Source: JICA Survey Team

A substantial cost overrun of the initial investment cost could not undermine the Project's viability caused by higher initial investment cost. As a result of this sensitivity analysis, the EIRRs are over 12% in the cases of a 10 % and 20 % higher initial investment. Thus, it can be said that the Project is economically viable.

(11) Conclusion on Economic Feasibility

It can be concluded that the Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

6.4.14 Operation and Effect Indicators

(1) Operation Indicator

Gas meters should be almost free from malfunctions for continuous supply to the customers. Therefore, the operation indicator and its target value are recommended as below.

Indicator	Target	Remarks
Number of outages due to meter defects	0.1% of installed meters	Outages due to other reasons such as piping defects should not be counted.

(2) Effect Indicator

Introduction of a pre-paid metering system will improve the energy saving mind-set of domestic customers and will reduce the waste in their natural gas usage. Therefore, the effective indicator for the introduction of a pre-paid metering system will be the gas consumption volume of domestic customers. The method of measurement of gas consumption volume as an effect indicator is recommended as follows.

1) Select 1,000 customers from the initial pilot meter installations
2) After the installation of the pre-paid gas meters, the actual gas consumption will be measured prior to the activation of the pre-paid metering system for at least two months. (Customers will still pay according to the fixed rate in this period.)
3) After collecting the actual gas consumption data before the activation of the pre-paid metering system, pre-paid cards will be handed over to the customers and the pre-paid metering system will be activated. Then, the actual gas consumption data after the activation of the metering system will be collected and stored in the Data Base Centre.
4) The difference in the gas consumption volume between before and after the activation of the metering system will be periodically monitored as an effect indicator.
5) The target value is tentatively recommended as shown below.

Indicator	Base	Target
Average monthly consumption of a domestic customer (after 2 years operation)	99 m3/month*	72 m3/month**

* The base is tentatively set at 99m3 based on the information from Petrobangla annual report 2011 as well as the latest gas production volume, and it should be re-set based on the actual measurement of the pilot installations prior to the activation of the pre-paid gas metering system.

** The target value is also tentatively set at 72m3 based on the data from the 4,500 meter pilot project of TGTDCL, and it should be re-set based on the actual measurement of pilot installations as well as the latest gas price policy.

6.4.15 Environmental and Social Considerations

This project is very similar to the prepaid gas meter installation project for Dhaka (TGTDCL franchise area) as dealt with under Section 6.3.15. In fact, in Section 6.3.15 the environmental and social considerations for both projects are dealt with together comprehensively (including the environmental scoping shown in Table 6.3-16). In effect, all aspects including alternative considerations (and zero option) and environmental scoping are very similar for both projects (Dhaka and Chittagong).

In summary, the results of the scoping shown in Table 6.3-16 indicate that there will be no significant adverse effects consequent to the prepaid gas meter installation (for domestic customers) projects on any environmental elements (ranked D) other than for potential beneficial effects on the local economy (ranked B+). Consequently, both projects could be categorized as Category C thereby also justifying the decision by DoE for the non-requirement of any environmental process including project registration or ECC by the project proponents (TGTDCL and KGDCL).

As such, no further consideration on environmental or social aspects is regarded as necessary for either of these projects on prepaid gas meter installation for domestic consumers.

6.4.16 Associated Risks under the Project

Associated risks during the project implementation period are summarized below.

Basically, the Implementation Agency is responsible for these risks. In order to avoid these risks, the following actions will be required.

No.	Associated Risk	Responsibility	Measures
1.	**Preparatory Stage**		
1.1	Overall schedule delay due to project approval delay by GOB	KGDCL	1) Early approval of DPP 2) Early contract of SLA
1.2	Delay of Site (household) Selection	KGDCL	Detail site investigation and planning before Contractor's detail design stage

No.	Associated Risk	Responsibility	Measures
		Consultant	considering various installation cases
1.3	Resistance of domestic customers	KGDCL Consultant	Meeting with pilot area candidate customers to come to a mutual understanding for gas saving. The Public Awareness Campaign is prior to the installation of meters.
1.4	Time delay for new town installation	KGDCL Consultant	The schedule of the development plan and gas supply for new town areas may change, and it may affect the project implementation plan. So, meetings should be held with related authorities as well as customers during the preparation stage.
2.	**Implementation Stage**		
2.1	Lack of Contractor's Ability	KGDCL Consultant	1) Selection of qualified Consultant who prepares tender documents and evaluates them. 2) Careful check and review of tender documents submitted by the Contractor 3) Execution of company survey for the Contractor's ability as required 4) Contract indicating "contract-out condition" by reasons attributable to the Contractor in the termination clause. 5) Submission of client certificate or contract document for the contractor's project experiences
2.2	Delay of works and completion	KGDCL Consultant Contractor	5) Progress to be closely monitored in order to timely cope with problems (e.g. lack of understanding on contract, Misunderstanding of procurement schedule, inefficient work procedure, inadequate risk assessment and project management, etc.) 6) Confirmation of delivery period for the longest lead items 7) Contract indicating: i) Construction deadline ii) Delay Penalty for reasons attributable to the Contractor 8) Scheduling in consideration of possible causes of delay (e.g. Wet season)
2.3	Imperfect quality	TGTDCL Consultant	1) Submission of qualification certificates for piping and installation works and

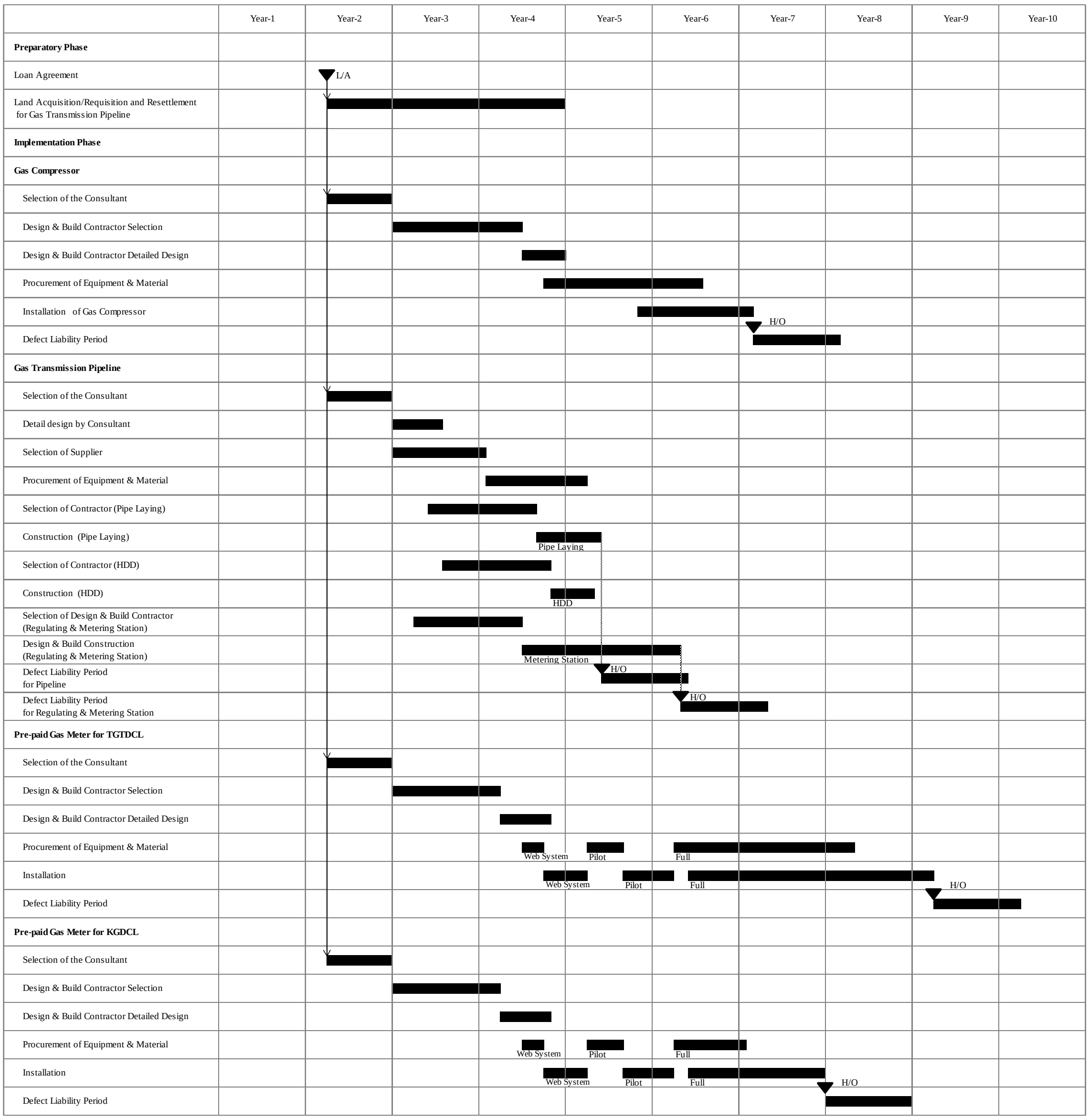
No.	Associated Risk	Responsibility	Measures
			non-destructive testing activities. 2) Sufficient design review of the Contractor's design documents 3) Check of quality control records prepared by the Contractor 4) Monitoring of all contractor's activities for taking quick countermeasures 5) Establishment of proper acceptance criteria for all contractor's activities 6) Penalizing the Contractor in case of non-fulfilment of equipment performance.
2.4	Cost overrun	KGDCL Consultant	1) Monitoring of all contractor's activities for taking quick countermeasures 2) Preparation of appropriate tender document for prevention of unexpected change orders 3) Progress to be closely monitored in order to timely cope with unexpected problems. 4) Securing of contingency
2.5	Conflict between house owner and customer	KGDCL Consultant	Some kind of agreement between the house owner and residents should be made for fair tariff collection in Case-B (just like a water supply bill is commonly collected from the house owner at a fixed rate). However, it is possible that such agreement cannot be made due to different opinions among the concerned people. So, guidance meetings and/or announcement of these new contract schemes shall be needed as public awareness campaigns support by the consultant
2.6	Installation of fewer gas meters	KGDCL Consultant	The estimated quantity of pre-paid meters in Case-B would include common kitchens of old apartments for low-income people that might include unauthorized burners and illegal branch piping connections that are not suitable for pre-paid meter installation. Therefore, it is possible that the total quantity of meters would be less than 60,000. So, further detail site investigations for Case-B site planning before the Contractor's detail design stage in consideration of unauthorized burners etc. shall be needed for its feasibility.

No.	Associated Risk	Responsibility	Measures
3.	**Operation & Maintenance**		
3.1	Gas leakage trouble due to lack of O&M skill (or poor installation etc.) that may cause trouble in the gas supply	KGDCL	1) Proper Operation & Maintenance based on O&M manual provided by the Contractor. 2) Appropriate budget allocation for O&M activities specified in O&M manual provided by the Contractor.
3.2	Incorrect operation	KGDCL	Ensure sufficient training for operators by the Contractor under the assistance of the consultant during project implementation stage.
3.3	Damage to pipe work due to poor maintenance	KGDCL	Regular patrols and inspections for precognition of possible pipe work damage due to poor maintenance
3.4	Damage to the pipeline by third party	Third party KGDCL	Regular patrols and inspections to find unauthorized pipe works.

Chapter 7 Entire Project Schedule & Cost

7.1 Entire Project Schedule

The entire Project Schedule is summarized as shown in the Figure 7.1-1.



Source: JICA Survey Team

Figure 7.1-1 Summary of the Project Schedule

7.2 Entire Project Cost

The entire project cost is summarized in Table 7.2-1.

Table 7.2-1 Summary of Project Cost

	Item	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local
			[Million JPY]			[Million BDT]			[Million USD]	
	Eligible Portion									
a	Construction & Installation (a1+a2+a3+a4)	18,613	13,834	4,778	14,541	10,808	3,733	187	139	48
a1	Gas Compressor	7,380	5,506	1,874	5,766	4,302	1,464	74	55	19
a2	Gas Transmission Pipeline	5,159	3,035	2,124	4,031	2,371	1,660	52	30	21
a3	Pre-paid Gas Meter (TGTDCL)	4,632	4,032	600	3,619	3,150	469	46	40	6
a4	Pre-paid Gas Meter (KGDCL)	1,441	1,261	180	1,126	985	141	14	13	2
b	Consulting Service(including Contingency) (b1+b2+b3+b4)	2,255	1,423	832	1,761	1,112	650	23	14	8
b1	Gas Compressor	844	614	230	659	480	179	8	6	2
b2	Gas Transmission Pipeline	615	386	230	481	301	179	6	4	2
b3	Pre-paid Gas Meter (TGTDCL)	464	242	222	363	189	174	5	2	2
b4	Pre-paid Gas Meter (KGDCL)	331	181	150	259	142	117	3	2	2
C	Contingency (c1+c2)	2,731	1,656	1,075	2,133	1,294	840	27	17	11
c1	Price Contingency on A (F: 1.3%L: 3.4%)(01+02+03+04)	1,714	919	796	1,339	718	622	17	9	8
01	Gas Compressor	706	368	338	552	287	264	7	4	3
02	Gas Transmission Pipeline	436	150	285	340	117	223	4	2	3
03	Pre-paid Gas Meter (TGTDCL)	449	313	136	351	245	106	5	3	1
04	Pre-paid Gas Meter (KGDCL)	123	87	36	96	68	28	1	1	
c2	Physical Contingency on A (5%) (01+02+03+04)	1,016	738	279	794	576	218	10	7	3
01	Gas Compressor	404	294	111	316	229	86	4	3	1
02	Gas Transmission Pipeline	280	159	120	219	124	94	3	2	1
03	Pre-paid Gas Meter (TGTDCL)	254	217	37	198	170	29	3	2	
04	Pre-paid Gas Meter (KGDCL)	78	67	11	61	53	8	1	1	
A	**Total of Eligible Portion (a+b+c)**	23,598	16,913	6,685	18,436	13,214	5,222	237	170	67
	Non Eligible Portion									
d	Administration Cost 5% (including Bank Charge 1%)(d1+d2+d3+d4)	1,301		1,301	1,016		1,016	13		13
d1	Gas Compressor	467		467	365		365	5		5
d2	Gas Transmission Pipeline	445		445	348		348	4		4
d3	Pre-paid Gas Meter (TGTDCL)	290		290	227		227	3		3
d4	Pre-paid Gas Meter (KGDCL)	99		99	77		77	1		1
e	House compensation (e1)	25		25	20		20			
e1	Gas Transmission Pipeline	25		25	20		20			
f	Land Acquisition & Requisition (f1)	2,393		2,393	1,870		1,870	24		24
f1	Gas Transmission Pipeline	2,393		2,393	1,870		1,870	24		24
g	Custom Duties、VAT and AIT (g1+g2)	9,993		9,993	7,807		7,807	100		100
g1	VAT : 15% & AIT: 10% (01+02+03+04)	6,507		6,507	5,083		5,083	65		65
01	Gas Compressor	2,334		2,334	1,823		1,823	23		23
02	Gas Transmission Pipeline	2,230		2,230	1,742		1,742	22		22
03	Pre-paid Gas Meter (TGTDCL)	1,450		1,450	1,133		1,133	15		15
04	Pre-paid Gas Meter (KGDCL)	493		493	385		385	5		5
g2	Custom Duties on Foreign Portion of A (01+02+03+04)	3,486		3,486	2,724		2,724	35		35
01	Gas Compressor 7.1%	401		401	313		313	4		4
02	Gas Transmission Pipeline 42.3%	1,232		1,232	962		962	12		12
03	Pre-paid Gas Meter (TGTDCL) 31.3%	1,417		1,417	1,107		1,107	14		14
04	Pre-paid Gas Meter (KGDCL) 31.3%	436		436	341		341	4		4
h	Interest During Construction (h1+h2+h3+h4)	8	8		6	6				
h1	Gas Compressor	3	3		2	2				
h2	Gas Transmission Pipeline	2	2		2	2				
h3	Pre-paid Gas Meter (TGTDCL)	2	2		2	2				
h4	Pre-paid Gas Meter (KGDCL)	1	1							
B	**Total of Non Eligible Portion (e+f+g+h)**	13,720	8	13,712	10,719	6	10,713	138	.08	138
	Grand Total (A+B)	37,318	16,921	20,397	29,155	13,220	15,935	374	170	205

Source: JICA Survey Team

7.3 Entire Economic and Financial Analyses

7.3.1 Project FIRR for the Entire Financial Analysis

To confirm the underlying financial viability or the true soundness of the Project, the FIRR of the entire Project was calculated. The revenue and costs for the entire project are summarized in the below table.

Table 7.3-1 Costs and Revenue of Entire Project for Financial Analysis

Costs:	• Construction cost, project management cost, dispute board fee, executing agency's administration cost, taxes, IDC and operation & maintenance
Revenue:	• Gas revenue (wellhead margins) from recovery volume of gas production/supply due to the installation of compressors • Gas revenue (transmission margins) from incremental volume of gas supply to western part of the country • Gas sales revenue from domestic customers and other sectors by reducing the waste in gas usage and interest from tariff collection in advance due to installation of pre-paid gas meters

Source: JICA Survey Team

The result of the calculation of the entire FIRR is as follows.

Entire FIRR: 9.35%

The result of the entire financial analysis including components of compressors, pipelines and pre-paid meters is summarized in Table 7.3-2.

Table 7.3-2 Project FIRR for Entire Financial Analysis

(Thousand USD)

Project Year	Project Life	Cash Inflow					Cash Outflow							Net Cash Flow for		
		Owned Capital	Foreign Loan	Domestic Loan	Operating Revenue	Total Revenue	Capital Costs	O&M Costs	Interest Foreign Loan	Interest Domestic Loan	Repay Foreign Loan	Repay Domestic Loan	Total Cost	Cash Balance	Project IRR	Cumulative Cash Balance
2		2,283	5,856	3,424	0	11,563	11,563						11,563	0	-11,563	0
3		4,146	12,852	6,220	0	23,217	23,217						23,217	0	-23,217	0
4		7,727	24,686	11,591	0	44,004	44,004						44,004	0	-44,004	0
5		14,180	38,814	21,269	6,292	80,555	74,263						74,263	6,292	-67,971	6,292
6	1	16,176	105,476	24,263	12,582	158,497	145,915	1,006					146,921	11,576	-134,339	17,868
7	2	6,126	28,878	9,189	24,302	68,495	44,193	1,545	3,383	1,979	5,639	3,298	60,036	8,458	-21,436	26,326
8	3	4,207	19,352	6,310	29,098	58,966	29,869	1,611	7,393	2,718	12,697	4,750	59,039	-73	-2,383	26,254
9	4	105	480	157	31,150	31,891	741	2,096	6,885	2,528	12,697	4,750	29,698	2,193	28,313	28,447
10	5	64	294	96	32,841	33,295	454	2,184	6,377	2,338	12,697	4,750	28,801	4,494	30,203	32,941
11	6				34,541	34,541		2,274	6,684	2,411	16,771	6,066	34,206	335	32,267	33,276
12	7				36,249	36,249		2,364	6,135	2,208	16,771	6,066	33,545	2,704	33,885	35,981
13	8				37,965	37,965		2,456	5,587	2,005	16,771	6,066	32,884	5,081	35,509	41,061
14	9				39,690	39,690		2,549	5,038	1,802	16,771	6,066	32,225	7,464	37,141	48,526
15	10				41,423	41,423		2,643	4,489	1,599	16,771	6,066	31,568	9,855	38,780	58,380
16	11				43,164	43,164		2,738	3,941	1,396	16,771	6,066	30,911	12,252	40,426	70,633
17	12				44,913	44,913		2,835	3,392	1,192	16,771	6,066	30,256	14,657	42,079	85,290
18	13				46,671	46,671		2,933	2,843	989	16,771	6,066	29,603	17,069	43,738	102,359
19	14				48,437	48,437		3,032	2,295	786	16,771	6,066	28,950	19,487	45,405	121,846
20	15				50,212	50,212		3,134	1,746	583	16,771	6,066	28,300	21,912	47,079	143,758
21	16				51,995	51,995		3,236	1,198	380	16,771	6,066	27,650	24,345	48,759	168,103
22	17				53,786	53,786		3,340	649	177	11,132	2,768	18,066	35,720	50,446	203,823
23	18				55,586	55,586		3,446	326	105	4,073	1,316	9,266	46,319	52,140	250,142
24	19				57,393	57,393		3,553	285	92	4,073	1,316	9,320	48,074	53,840	298,216
25	20				59,210	59,210		3,663	244	79	4,073	1,316	9,375	49,834	55,547	348,050
26	21				61,034	61,034		3,774	295	96	11,267	3,607	19,037	41,997	57,260	390,047
27	22				49,059	49,059		1,730	0	0	0	0	1,730	47,329	47,329	437,376
28	23				50,377	50,377		1,789	0	0	0	0	1,789	48,589	48,589	485,965
29	24				51,695	51,695		1,849	0	0	0	0	1,849	49,846	49,846	535,811
30	25				53,013	53,013		1,912	0	0	0	0	1,912	51,101	51,101	586,912
31	26				52,202	52,202		1,977	0	0	0	0	1,977	50,225	50,225	637,136
32	27				53,825	53,825		1,935	0	0	0	0	1,935	51,890	51,890	689,026
33	28				54,534	54,534		2,114	0	0	0	0	2,114	52,420	52,420	741,447
34	29				58,285	58,285		2,186	0	0	0	0	2,186	56,099	56,099	797,546
35	30				59,603	59,603		2,260	0	0	0	0	2,260	57,343	57,343	854,889
Total		55,013	236,686	82,519	1,381,130	1,755,348	374,218	74,164	69,186	25,462	262,831	94,597	900,459	**854,889**	932,747	
FIRR															**9.35%**	

Source: JICA Survey Team

7.3.2 Financial Analysis for the Entire Project

Weighted Average Cost of Capital for the Entire Project

WACC for the entire project, a natural gas efficiency project, is calculated by the weighted average of the WACCs of all 4 components to the total investment amount as follows.

WACC for the entire project = 6.45%

As a result of the above exercise, the weighted average of capital costs for the entire project is 6.45%. We conclude this section by confirming that the project is to be deemed viable when the project FIRR will be found above the WACC of 6.45%.

7.3.3 Conclusion on Financial Viability

The project FIRR for the entire project is at 9.35%, which exceeds 6.45%, the WACC. Therefore, the entire Project is regarded as financially viable and a sound investment.

7.3.4 Economic Analysis for the Entire Project

Benefits and cost for all the components were combined to carry out the economic analysis for the entire project, a natural gas efficiency project. The benefit and costs for the entire project are summarized in the below table. The results of the economic analysis are shown in the following section.

Table 7.3-3 Costs and Benefit of Pre-paid Gas Meters for Economic Analysis

Costs:	• Construction cost, project management cost, dispute board fee, executing agency's administration cost and operation & maintenance (excluding taxes and IDC)
Benefits:	• The recovery volume of gas production/supply due to the installation of compressors contributes to incremental supply toward the society, compared to "without project" scenario. Thus, the incremental revenue brought by gas supply due to the installation of compressors is regarded as a main economic benefit. • The construction of pipelines contributes to the increased volume of gas supply to the western part of this country. Such increased volume of gas supply is considered as a benefit toward the society. Thus, the incremental revenue brought by gas transmission due to construction of pipelines is regarded as a main economic benefit. • Cost saving in replacing import energy. Reduction of gas usage, consequently the saving of gas among domestic customers due to the introduction of pre-paid metering system will increase the gas supply to other sectors, and it will substitute expensive import energy.

Source: JICA Survey Team

7.3.5 EIRR for the Entire Project

Table 7.3-4 exhibits the calculation of the EIRR of the entire Project based on the economic benefits and costs discussed earlier. The entire EIRR is calculated at 21.18%, which clearly supports the economic viability of the Project, because the 21.18% of the entire EIRR is above the 12%, cut off rate of the evaluation criteria for economic analysis.

Table 7.3-4 EIRR of Entire Project

(Thousand USD)

Project Year	Project Life	Cash Inflow		Cash Outflow			Net Cash Flow for	
		Benefits	Total Benefit	Capital Costs	O&M Costs	Total Cost	Cash Balance	Cumulative Cash Balance
2		0	0	9,039		9,039	-9,039	-9,039
3		0	0	18,315		18,315	-18,315	-27,354
4		0	0	30,693		30,693	-30,693	-58,047
5		6,859	6,859	51,874		51,874	-45,015	-103,062
6	1	19,066	19,066	110,039	1,006	111,045	-91,978	-195,040
7	2	45,904	45,904	29,902	1,545	31,447	14,457	-180,583
8	3	58,688	58,688	19,979	1,611	21,590	37,098	-143,485
9	4	62,497	62,497	588	2,096	2,684	59,812	-83,673
10	5	63,725	63,725	363	2,184	2,547	61,178	-22,495
11	6	64,953	64,953		2,274	2,274	62,679	40,184
12	7	66,181	66,181		2,364	2,364	63,817	104,001
13	8	67,409	67,409		2,456	2,456	64,953	168,954
14	9	68,637	68,637		2,549	2,549	66,089	235,043
15	10	69,865	69,865		2,643	2,643	67,223	302,266
16	11	71,094	71,094		2,738	2,738	68,356	370,621
17	12	72,322	72,322		2,835	2,835	69,487	440,108
18	13	73,550	73,550		2,933	2,933	70,617	510,725
19	14	74,778	74,778		3,032	3,032	71,746	582,471
20	15	76,006	76,006		3,134	3,134	72,873	655,343
21	16	77,234	77,234		3,236	3,236	73,998	729,342
22	17	78,462	78,462		3,340	3,340	75,122	804,464
23	18	79,691	79,691		3,446	3,446	76,245	880,709
24	19	80,919	80,919		3,553	3,553	77,365	958,074
25	20	82,147	82,147		3,663	3,663	78,484	1,036,558
26	21	83,375	83,375		3,774	3,774	79,601	1,116,160
27	22	49,059	49,059		1,730	1,730	47,329	1,163,489
28	23	50,377	50,377		1,789	1,789	48,589	1,212,078
29	24	51,695	51,695		1,849	1,849	49,846	1,261,923
30	25	53,013	53,013		1,912	1,912	51,101	1,313,024
31	26	54,331	54,331		1,977	1,977	52,354	1,365,378
32	27	55,649	55,649		2,045	2,045	53,605	1,418,983
33	28	56,967	56,967		2,114	2,114	54,853	1,473,836
34	29	58,285	58,285		2,186	2,186	56,099	1,529,936
35	30	59,603	59,603		2,260	2,260	57,343	1,587,279
Total		1,932,345	1,932,345	270,792	74,274	345,066	**1,587,279**	
Entire EIRR							**21.18%**	

Source: JICA Survey Team

7.3.6 Conclusion on Economic Feasibility

It can be concluded that the entire Project is viable in economic terms, bringing sufficient benefit to the country to justify its implementation.

7.4 Terms and Conditions of Loan (In General)

This section elaborates on the Loan Agreement (L/A) between JICA and GOB as well as the Subsidiary Loan Agreement (SLA) between GOB and the executing agencies.

7.4.1 Loan Agreement between JICA and GOB

(1) Flow of the Procedure on L/A between JICA and GOB

It is considered that the flow of the procedure for the Loan Agreement (L/A) between JICA and GOB is as follows:

- Negotiation regarding loan terms and conditions is to be held between JICA and GOB.
- In this phase, the External Resource Division (ERD) under the umbrella of the Ministry of Finance (MOF) is to negotiate on behalf of GOB.
- JICA and GOB agree the loan terms and conditions, make L/A, and sign it.

(2) Disbursement Method and Procedure

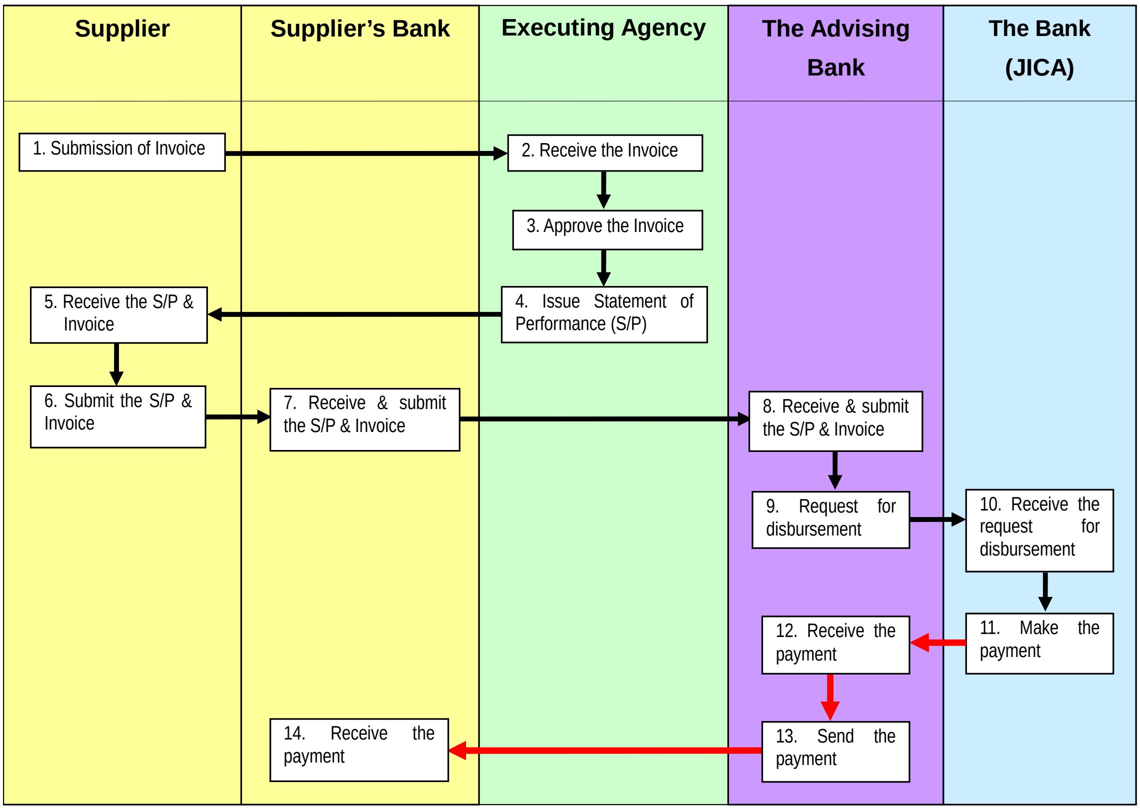
A disbursement method and procedure is to be determined in accordance with the terms and conditions of the L/A. There are various disbursement methods used by JICA.

1) Disbursement Method regarding JICA

The main disbursement methods of JICA are classified into 3 types; namely, commitment procedure, transfer procedure and reimbursement procedure.

a) Commitment Procedure

The commitment procedure is often called a Letter of Credit (L/C) method. In this procedure, the borrower is responsible for opening the L/C. This procedure would also be utilized for the projects implemented by ADB. The flow of the commitment procedure is given in the figure below.



*Red coloured arrows in the above figure show the flow of the actual disbursement.
Source: JICA Survey Team

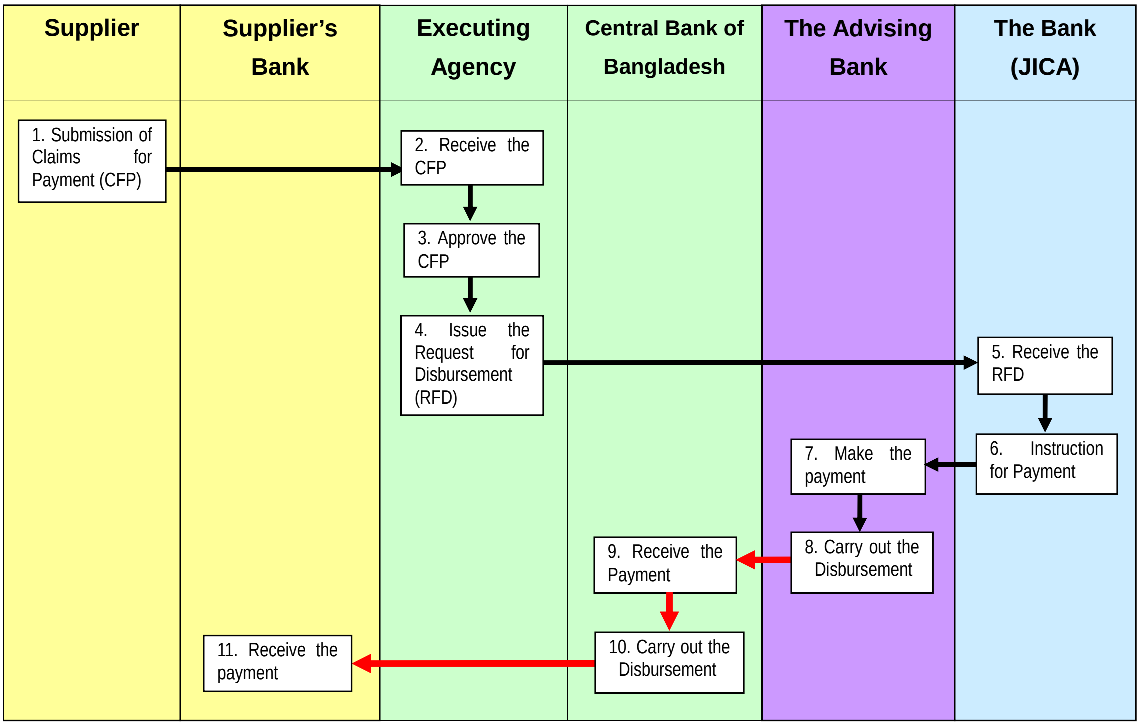
Figure 7.4-1 Flow of the Commitment Procedure

The disbursement is made to a supplier from JICA. The flow of disbursement is simple due to using the Letter of Credit (L/C). However, there is a possibility that the disbursement could fall into arrears in this procedure if discrepancies occurred in the L/C procedure between banks. It is difficult for JICA to confirm the actual flow of the disbursement procedure or to ensure prompt disbursement. The required documentation for the commitment procedure is as follows:

- L/C by issuing bank
- Invoice from supplier
- Statement of Performance (S/P) from an executing agency
- Request for Disbursement from advising bank

b) Transfer Procedure

The disbursement is made after completion of a Bank Arrangement between banks. It is not necessary to open a L/C in this procedure. In this procedure method, JICA is to carry out the disbursement to the Central Bank of Bangladesh after the executing agencies issue the Request for Disbursement to JICA. Subsequently, the Central Bank of Bangladesh makes the payment to the supplier, this is called a “direct payment procedure” in ADB. The flow of the transfer procedure is shown in the figure below.



Source: JICA Survey Team

Figure 7.4-2 Flow of the Transfer Procedure

The transfer procedure is less likely to incur a delay in payment of the transfer than the commitment procedure, because it is possible for JICA to manage the disbursement procedure. It is considered that it is better to apply this method. The required documentation for the transfer procedure is as follows:

- Claims for Payment (CFP) made by the supplier
- Request for Disbursement (RFD) made by the executing agencies
- Transfer Instruction made by JICA

c) Reimbursement Procedure

Executing agencies make a payment to the supplier in advance on behalf of JICA and afterward the executing agencies submit a claim for the same amount to JICA who then issues payment to the executing agency. In this disbursement method, the payment to the supplier from the executing agencies would be temporarily borne by the executing agencies so that it is not recommended to apply this disbursement method.

2) Disbursement Method regarding ADB

Most of the projects funded by ADB in the gas sector field in Bangladesh employ the “commitment procedure” method. In this method, payments are made to a supplier against a L/C and this is similar to the commitment procedure of JICA. There is another disbursement method of ADB, “direct payment procedure”, which is called the “transfer procedure” by JICA, as mentioned above.

In order to avoid the delay in payment by employing the commitment procedure thought L/C procedure, to implement the Project smoothly and for JICA to manage the flow of disbursement procedure easily, it is hoped that the transfer procedure of JICA is employed for the Project.

(3) Loan Conditions

Loan conditions on the L/A between JICA and GOB will be as follows:

- Repayment period: 40 years
- Grace period: 10 years
- Interest rate: 0.01% per annum

7.4.2 Subsidiary Loan Agreement between GOB and Executing Agencies

(1) SLA Conditions on the Project Funded by ADB

The loan conditions on the Subsidiary Loan Agreement (SLA) between GOB and the executing agencies are examined in this section. The terms and conditions of SLA for the Project funded by ADB were confirmed. Pursuant to the terms and conditions of the SLA, the repayment amount shall be in local currency equivalent determined at the official rate of exchange prevailing on the date of such repayment, which means that the foreign exchange and interest rate risks are to be borne by each executing agency during the prepayment period. The table below summarizes the typical terms and conditions on SLA of the Project funded by ADB.

Table 7.4-1 Subsidiary Loan Conditions funded by ADB

Subsidiary Loan Condition		Remarks
1) Repayment period	Around 15 years (Inc. grace period)	This has been in effect since 17th March, 2004.
2) Grace period	Around 3 years	Ditto
3) Interest rate	Around 5% per annum	Ditto
4) Currency	Bangladesh Taka	The local currency equivalent is determined by the official rate of exchange prevailing on the date of such repayment. The foreign exchange risks are to be borne by each executing agency.
5) Repayment to	The Ministry of Finance	-
6) Repayment from	Each executing agency	-

Source: TGTDCL and GTCL

(2) Recommended SLA Condition Funded by JICA

Recommended SLA conditions for each executing agency funded by JICA are as follows:

Table 7.4-2 Conditions of SLA for Executing Agencies

Executing Agency	Repayment period (year)	Grace period (year)	Interest rate (%)	Currency	Foreign currency risk
BGFCL	15	5	4	Taka	MOF
GTCL	15	5	4	Taka	MOF
TGDCL	20	8	1	Taka	MOF
KGDCL	20	8	1	Taka	MOF
Standard Terms and Conditions	*15*	*3*	*5*	*Foreign currency*	*Executing Agency*

Source: JICA Survey Team

In particular, the currency for repayment should be Bangladesh Taka and it is hoped that each executing agency does not bear foreign exchange risk, which means that such foreign exchange risk is to be borne by MOF in order not to deteriorate the financial situation of the executing agencies. The draft SLA for the Project, including terms and conditions made by JICA Survey Team, is shown in Appendix 20 to 23.

7.5 Steering Committee for the Project

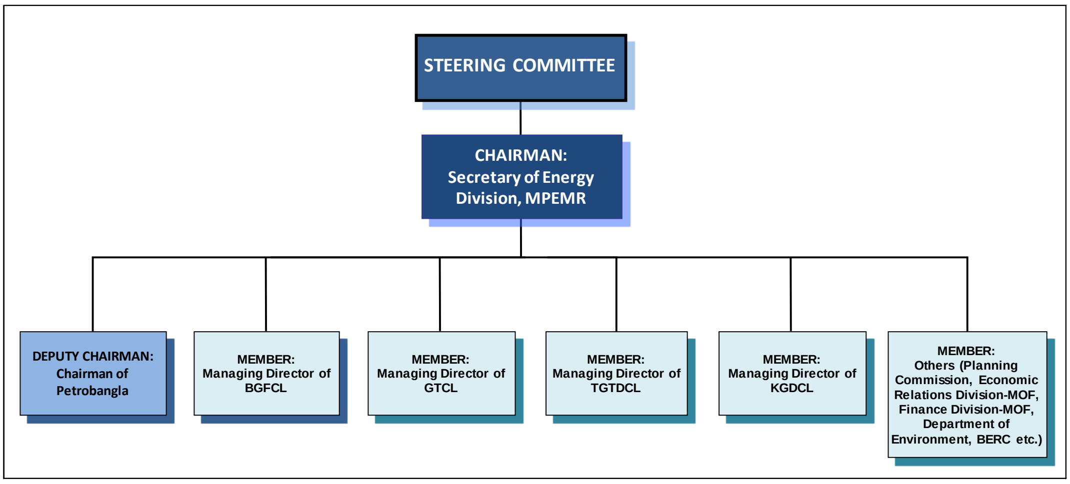
A Project Steering Committee (SC) will be established for the Project to oversee the overall project progress and effective coordination among the various stakeholders. The SC will also discuss the overall issues related to the Project such as gas tariff and mechanism of gas wheeling charges among upstream to downstream users to ensure the executing agencies' financial viability, and play a role to resolve the issues which require higher level interventions. The committee will be headed by the Secretary of Energy Division, MPEMR. Members and composition of SC are as bellow. The attendee from each organization might be substituted by the authorized representative. The first SC meeting will be held at the earliest possible time after the Loan Agreement as requested by BGFCL, GTCL, TGTDCL and KGDCL. Subsequent SC meetings will be held based on the request from each executing agency.

Table 7.5-1 Composition of Members of Steering Committee

No.	Position in Steering Committee	Regular Position
1	Chairman	Secretary, Energy Division, MPEMR
2	Deputy Chairman	Chairman, Petrobangla
3	Member	Managing Director, BGFCL
4	Member	Managing Director, GTCL
5	Member	Managing Director, TGTDCL
6	Member	Managing Director, KGDCL
7	Other members	To be invited on an ad hoc basis (Eg. Planning Commission, Economic Relations Division-MOF, Finance Division-MOF, Department of Environment, BERC) *depending on the issues)

Source: JICA Survey Team

In addition to the above, the recommended organization chart of the steering committee for the Project is described below.



Source: JICA Survey Team

Figure 7.5-1 Organisation Chart of Steering Committee for the Project

Chapter 8 Gas Transmission Pipeline Network Analysis

8.1 General

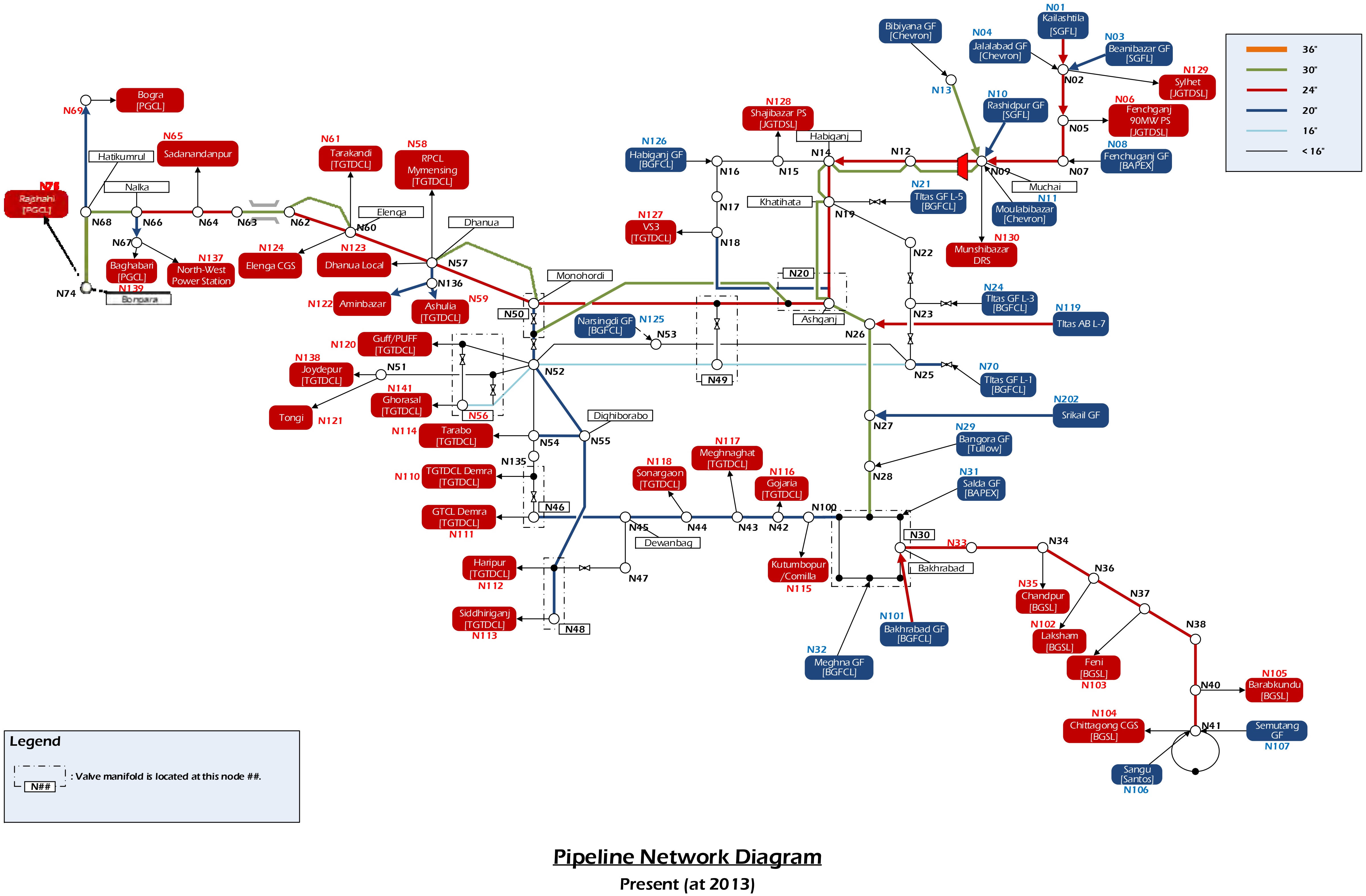
Natural gas is one of the indigenous energy resources in Bangladesh and is significantly contributing to the economic growth of the country. However, in recent years, supply of the natural gas has been insufficient for the domestic demand, which has rapidly been increasing with the growth of economy.

In this pipeline network analysis, flow simulation is carried out to verify capacity of gas transmission and distribution pipelines in Bangladesh on the basis of pipeline data such as gas supply and demand forecast, operating conditions of pipeline network, currently undergoing and planned projects by using the flow simulation software, “PIPESIM”. The pipeline capacity is analyzed for future pipeline facilities planned in 2015, 2020, 2025 and 2030.

8.2 Establishment of Simulation Model

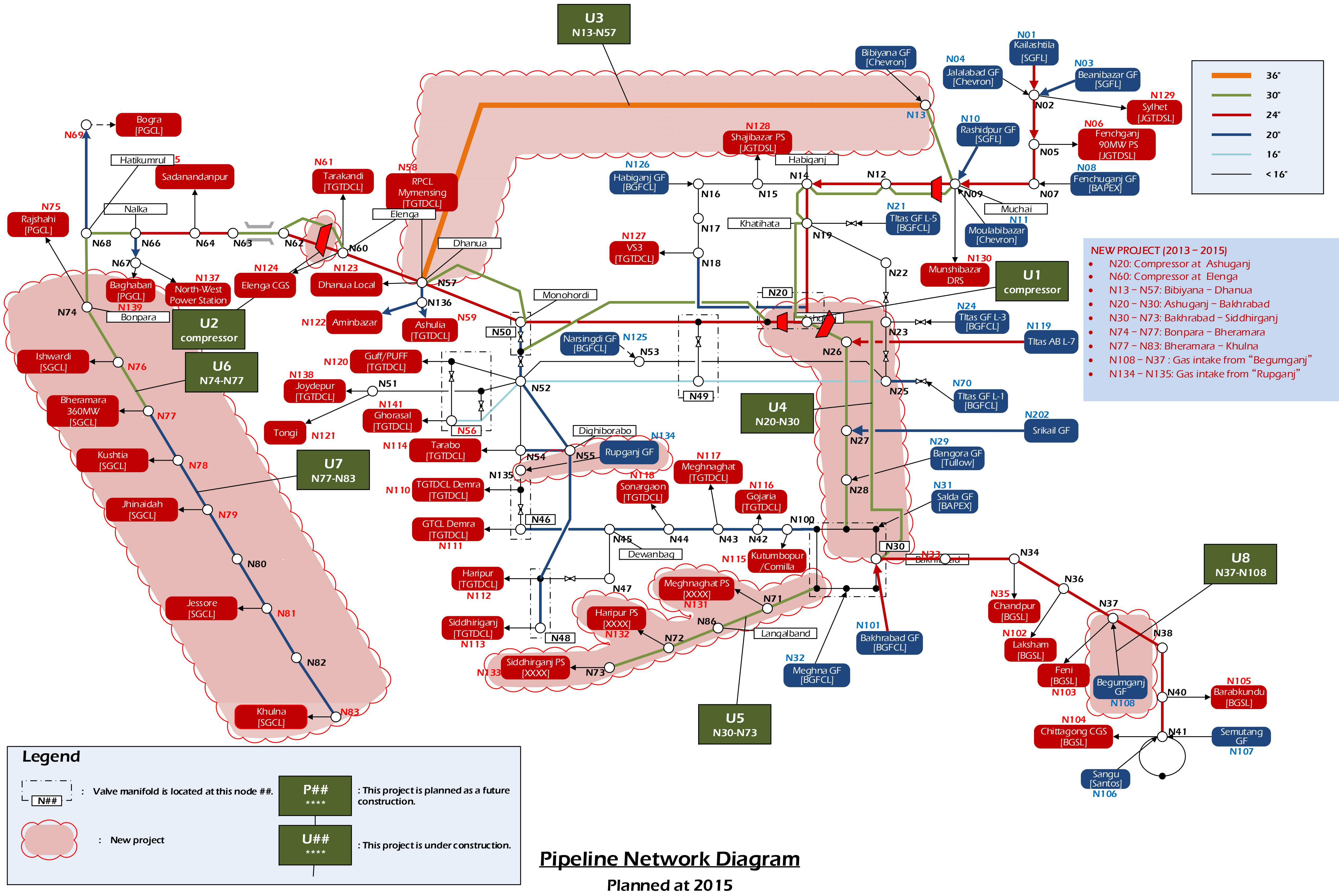
Prior to the simulation, the current pipeline network model, as of 2013, was developed in accordance with information collected through site survey and hearing from GTCL. And the pipeline network diagrams for 2015, 2020, 2025 and 2030 were prepared every five (5) years in consideration of future pipeline projects that are currently under construction or planned in the near future. As for 2025 and 2030, since no future plan is scheduled at this moment, the future pipeline network diagrams for the said period are unified into one (1) sheet of Figure 8.2-4.

Refer to Figure 8.2-1 to Figure 8.2-4.



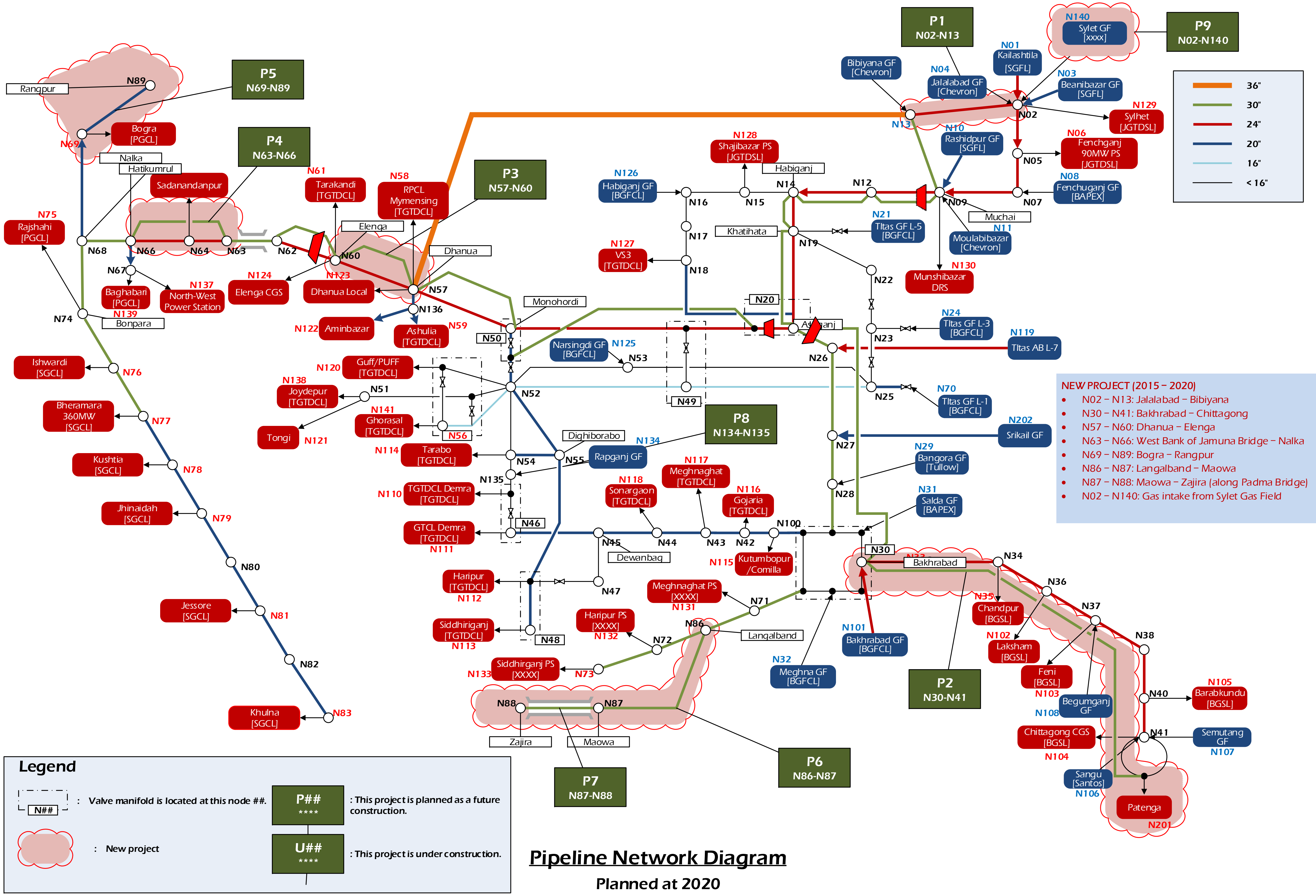
Source: JICA Survey Team

Figure 8.2-1 Pipeline Network Diagram in 2013



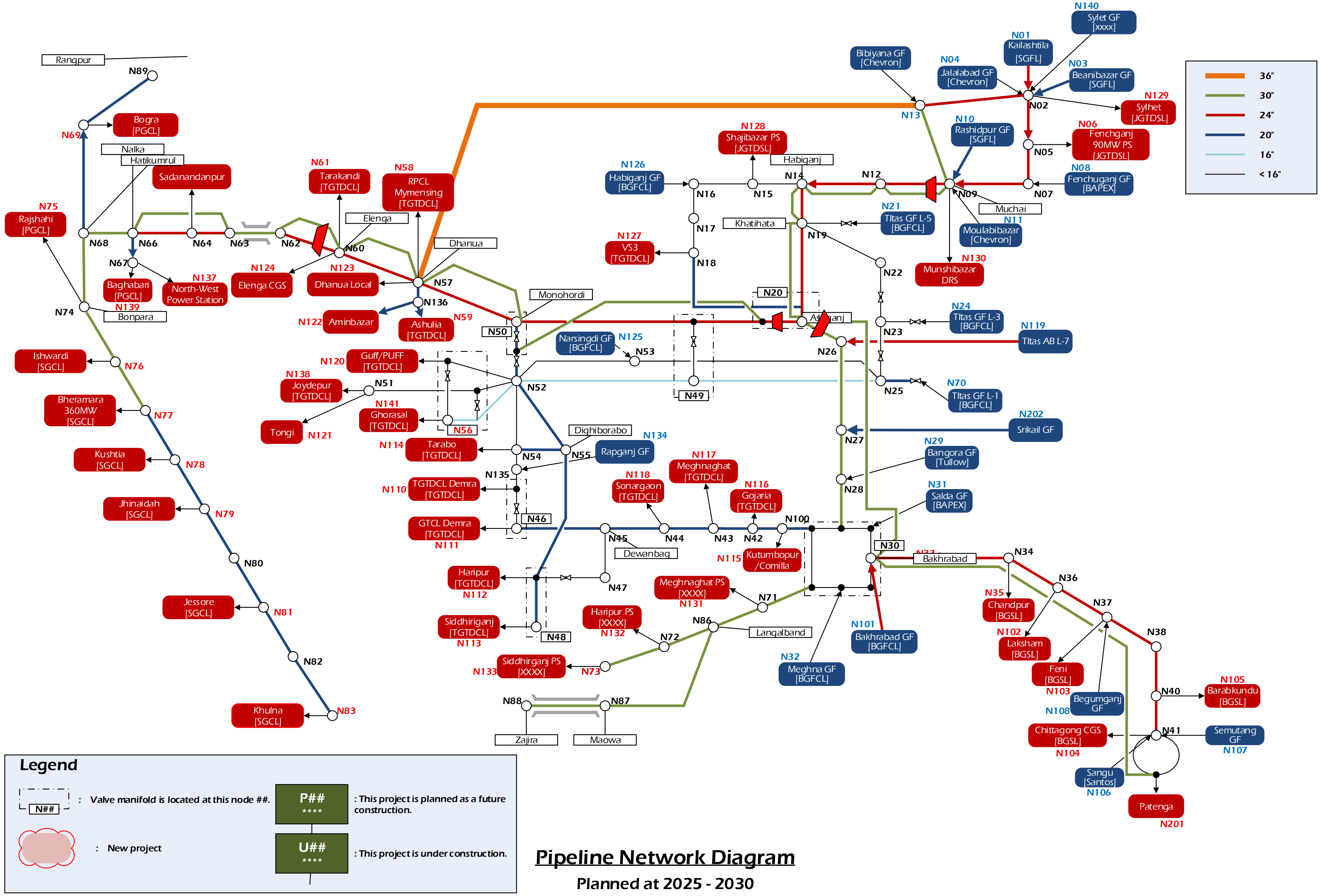
Source: JICA Survey Team

Figure 8.2-2 Pipeline Network Diagram in 2015



Source: JICA Survey Team

Figure 8.2-3 Pipeline Network Diagram in 2020



Source: JICA Survey Team

Figure 8.2-4 Pipeline Network Diagram in 2025 - 2030

8.3 Calibration of Existing Pipeline Network Model (as of 2013)

In order to establish a simulation model for existing pipeline network, current pipeline data was calibrated so as to balance operating conditions such as flow rate, operating pressure and temperature at all the points on the network, based on some operating conditions to be available at this moment. The pipeline data, operating conditions and its calibration results, are described in Appendix 1.

8.4 Verification of the Pipeline Capacity for Future Demand (as of 2015, 2020, 2025 and 2030)

Using the calibration results stated in Section 8.3, the network analysis was conducted for the future cases in 2015, 2020, 2025 and 2030. In this analysis, total gas supply volume forecasted in future was assumed to be equal to total gas demand in the country.

As the results of this study, considerable bottlenecks of the pipeline system were checked and an appropriate improvement plan was proposed as an example for the next engineering stage.

8.5 Simulation Result

The simulation results of the pipeline network analysis in 2015, 2020, 2025 and 2030 are summarized below:

8.5.1 2015 CASE

As the result of the gas pipeline network simulation for the year 2015, the following bottlenecks were revealed. Refer to Figure 8.2-2.

(1) Bottleneck 1

The existing 24” pipeline between Dhanua (N57) and Elenga (N60) does not have enough capacity to transport required amount of demand gas. Therefore, all the delivery points (e.g. N61, 69, 76, 77, 78, 79, 81, 83, 139) located downstream of Elenga cannot supply gas with proper pressure level to end-users.

The reasons and countermeasures against the bottleneck are as follows.

1) Reasons

Gas flow rate of the existing Dhanua–Elenga pipeline is expected to be huge in this year because all the gases from Bibiyana Gas Field (N13) by 36’’ pipeline, and Monohordi by

24’’ & 30’’ pipeline are gathered at Dhanua and are transferred toward Elenga. Accordingly, it is considered that increase of the flow rate leads to an enormous pressure drop in this pipeline section.

2) Countermeasures

Installation of additional Dhanua–Elenga pipelines (duplication of pipeline) or additional booster compressor in Dhanua

As for the above bottleneck, duplication of Dhanua–Elenga pipeline is planned by the year 2017. Accordingly, the additional booster compressor installation scenario for the pipeline section was applied to solve this bottleneck.

According to installation of the compressor, required suction pressure of 650 psig in Elenga compressor station can be achieved and also existing 24” Dhanua–Elenga pipeline can transport required amount of gas to Elenga. In this case, a discharge pressure of 1,138 psig is required for the compressor in Dhanua.

(2) Bottleneck 2

Existing 24” N-S Pipeline between N02 and Muchai (N09) does not have enough capacity to transport required amount of demand gas.

The reasons and countermeasures against the bottleneck are as follows.

1) Reasons

Gas flow rate in the pipeline section increases due to increase of gas production volume of each gas field that was assumed so as to correspond to gas demand forecasted in 2015. It is considered that this phenomenon leads to a large pressure drop in this pipeline section.

2) Countermeasures

Maintaining higher production pressure at each well located upstream of Muchai

(3) Bottleneck 3

As for the above “Bottleneck 1”, a further bottleneck was revealed by installation of the booster compressor in Dhanua.

After installation of the compressor, suction pressure in the Elenga compressor station can fully improve; nevertheless two (2) delivery points (Jessore(N81)) and Khulna(N83)), located downstream of Elenga, still cannot supply gas with proper pressure level to end-users.

The reasons and countermeasures against the bottleneck are as follows.

1) Reasons

Discharge pressure of 1,000 psig in Elenga compressor station is not enough to deliver the gas to the delivery points (N81, 83).

2) Countermeasures

Installation of booster compressor upstream of Jessore. Alternatively, discharge pressure (1,138 psig) estimated for the Dhanua booster compressor may be raised so as to cover arrival pressure required at Jessore (N81) and Khulna (N83).

8.5.2 2020 CASE

As the result of the gas pipeline network simulation for the year 2020, the following bottlenecks were revealed. Refer to Figure 8.2-3.

(1) Bottleneck 1

Total capacity of 1,200 MMSCFD in Muchai compressor station is smaller than simulated flow rate of 1,500 MMSCFD.

Moreover, total capacity of 1,500 MMSCFD in Ashuganj compressor station is smaller than simulated flow rate of 1,716 MMSCFD. Therefore, flow rate required at the each compressor station cannot be covered by the existing compressors.

The reasons and countermeasures against the bottleneck are as follows.

1) Reasons

Gas flow rate in all the pipeline located upstream of Muchai and Ashuganj compressor stations increases due to increase of gas production volume of each gas field that was assumed so as to correspond to gas demand forecasted in 2020. Accordingly, it is considered that increase of the flow rate exceeds rated capacity of the compressor stations.

2) Countermeasures

Installation of additional compressor in both Muchai and Ashuganj compressor station

(2) Bottleneck 2

Arrival pressure of 206.16 psig expected at Ashuganj compressor station is lower than rated suction pressure (600 psig) of the existing compressor. In Muchai and Elenga compressor stations, arrival pressure is a little bit smaller than rated suction pressure of the each existing compressor.

Accordingly, rated discharge pressure cannot be obtained downstream of the three (3) compressor stations.

The reasons and countermeasures against the bottleneck are as follows.

1) Reasons

Similar to “Bottleneck 1”, gas flow rate expected upstream of the three (3) compressor stations increases due to increase of gas production volume of each gas field that is forecasted in 2020. Accordingly, it is considered that this phenomenon leads to a large pressure drop in this pipeline section.

2) Countermeasures

Installation of booster compressor at upstream of Muchai

(3) Bottleneck 3

The following pipelines do not have enough capacity to transport required amount of demand gas.

- Pipeline between Dhanua (N57) and RPCL Mymensing (N58)
- Pipeline between N136 and Ashulia (N59)
- Pipeline between N136 and Aminbazar (N122)
- Pipeline between Jessore (N81) and Khulna (N83)
- Pipeline between N135 and TGTCDL Demra (N110)
- Pipeline between N48 and Haripur (N112)

<u>Therefore, none of the delivery points located on the above pipeline sections can supply gas with proper pressure level to end-users.</u> The reasons for and countermeasures against the bottleneck are as follows.

1) Reasons

Gas flow rate in the above pipelines increases due to increase of gas production volume of each gas field that was assumed so as to correspond to gas demand forecasted in 2020. Accordingly, it is considered that increment of the flow rate exceeds the capacity of the pipelines.

2) Countermeasures

Due to increment of gas supply volume, bottlenecks occur at several delivery points on the pipeline network. In this case, it is preferable to install booster compressor in order to simultaneously improve transmission capacity of all the pipelines. In case the booster compressor is additionally installed in Ashuganj compressor station, discharge pressure at the station should be increased from 1,000 psig to 1,074 psig.

As for the bottleneck between Jessore (N81) and Khulna (N83), if the booster compressor is additionally installed in Elenga compressor station, discharge pressure at the station should be increased from 1,000 psig to 1,021 psig.

(4) Others

All gas flow lines that transfer gas produced in each gas field must have enough capacity to send the gas into the transmission pipeline. Accordingly, it is necessary to increase production pressure at each gas field in order to maintain transmission pipeline pressure, even if the gas production rate increases for the future gas demand.

Although this issue is not a bottleneck at this moment, proper measures are to be taken so as to overcome the operating pressure of transmission pipeline.

8.5.3 2025 CASE

As the result of the gas pipeline network simulation for the year 2025, the following bottlenecks were revealed. Refer to Figure 8.2-4.

(1) Bottleneck 1

Total capacity of 1,200 MMSCFD in Muchai compressor station is a little bit smaller than simulated flow rate of 1,206 MMSCFD.
Therefore, the flow rate required at the compressor station cannot be covered by the existing compressors. The reasons and countermeasures against the bottleneck are as follows.

1) Reasons
Gas flow rate in all the pipeline located upstream of Muchai compressor station increases due to increment of gas production volume of each gas field that was assumed so as to correspond to gas demand forecasted in 2025. Accordingly, it is considered that increment of the flow rate exceeds rated capacity of the compressor station.

2) Countermeasures
Installation of additional compressor in Muchai compressor station

(2) Bottleneck 2

The following pipelines do not have enough capacity to transport required amount of demand gas.

- Pipeline between Dhanua (N57) and RPCL Mymensing (N58)
- Pipeline between N136 and Ashulia (N59)
- Pipeline between N136 and Aminbazar (N122)
- Pipeline between Jessore (N81) and Khulna (N83)

Therefore, none of the delivery points located on the above pipeline sections can supply gas with proper pressure level to end-users. The reasons and countermeasures against the bottleneck are as follows.

1) Reasons

Gas flow rate in the above pipelines increases due to increment of gas production volume of each gas field that was assumed so as to correspond to gas demand forecasted in 2025. Accordingly, it is considered that increment of the flow rate exceeds capacity of the pipelines.

2) Countermeasures

Due to increment of gas supply volume, bottlenecks occur at several delivery points on the pipeline network. In this case, it is preferable to install booster compressor in order to simultaneously improve transmission capacity of all the pipelines. In case the booster compressor is additionally installed in Ashuganj compressor station, the discharge pressure at the station should be increased from 1,000 psig to 1,098 psig.

As for the bottleneck between Jessore (N81) and Khulna (N83), if the booster compressor is additionally installed in Elenga compressor station, discharge pressure at the station should be increased from 1,000 psig to 1,004 psig.

(3) Bottleneck 3

The existing 24” and 30” pipelines between Dhanua (N57) and Elenga (N60) do not have enough capacity to transport the required amount of gas.

The reasons for and countermeasures against the bottleneck are as follows.

1) Reasons

Gas flow rate in the above pipelines increases due to an increase in the gas production volume of each gas field that was assumed to correspond to gas demand forecast for 2025. Accordingly, it is considered that the increase of the flow rate will exceed the capacity of the pipelines.

2) Countermeasures

Installation of an additional booster compressor upstream of Elenga compressor station

(4) Others

Similar to "Others" described in 2020 CASE, it is necessary to increase production pressure at each gas field in order to maintain transmission pipeline pressure, even if the gas production rate increases for future demand.

Although this issue is not a bottleneck at this moment, proper measures are to be taken so as to overcome the operating pressure of the transmission pipeline.

8.5.4 2030 CASE

As the result of the gas pipeline network simulation for the year 2025, following bottlenecks were revealed. Refer to Figure 8.2-4.

(1) Bottleneck 1

The following pipelines do not have enough capacity to transport required amount of demand gas.

- Pipeline between Dhanua (N57) and RPCL Mymensing (N58)
- Pipeline between N136 and Ashulia (N59)
- Pipeline between N136 and Aminbazar (N122)
- Pipeline between Jhinaidah (N79) and Khulna (N83)

Therefore, none of the delivery points located on the above pipeline sections cansupply gas with proper pressure level to end-users. The reasons and countermeasures against the bottleneck are as follows.

1) Reasons

Gas flow rate in the above pipelines increases due to increment of gas production volume of each gas field that was assumed so as to correspond to gas demand forecasted in 2030. Accordingly, it is considered that increment of the flow rate exceeds capacity of the pipelines.

2) Countermeasures

Due to increment of gas supply volume, bottlenecks occur at several delivery points on the pipeline network. In this case, it is preferable to install booster compressor in order to simultaneously improve transmission capacity of all the pipelines. In case the booster compressor is additionally installed in Ashuganj compressor station, discharge pressure at the station should be increased from 1,000 psig to 1,107 psig.

As for the bottleneck between Jhinaidah (N79) and Khulna (N83), if the booster compressor is additionally installed in Elenga compressor station, discharge pressure at the station should be increased from 1,000 psig to 1,066 psig.

(2) Others

Similar to "Others" described in 2020 CASE, it is necessary to increase production pressure at each gas field in order to maintain transmission pipeline pressure, even if the gas production rate increases for the future demand.

Although this issue is not a bottleneck at this moment, proper measures are to be taken so as to overcome the operating pressure of transmission pipeline.

8.5.5 Conclusions

This pipeline network analysis was conducted using a flow simulation model which was established based on several assumptions. Accordingly, it seems that some differences between the simulation results and actual phenomena might occur by lack of information and the assumptions. Therefore, it is indispensable that all the simulation results are reviewed carefully based on sufficient data and proper assumptions.

Items to be reviewed in the next engineering stage are as follows:

- *Supplement of lack of information*
  - *All pipeline data, such as pipe size, wall thickness, and length for the existing and future pipelines*
  - *Pipeline elevation on all pipeline route*
  - *Data and information for valves and fittings on the gas pipeline network*
- *Review of study assumptions*
  - *Current gas production volume in each gas field*
  - *Current gas delivery volume to each end-user*
  - *Gas supply and demand forecast*
  - *Assumptions of temperature conditions such as soil temperature, gas intake temperature of each gas filed*
  - *Assumptions of pipeline friction factor*

And the following issues are recommended for future provision:

1) For improvement on accuracy of the pipeline network simulation, it is preferable that operating conditions (pressure and flow rate) at several delivery points, such as gas

terminal, gas manifold station and pipeline blanch point on the pipeline network are reflected faithfully in the simulation model as much as possible. It is recommended that an optimum reinforcement plan of the pipeline network is developed comprehensively based on the simulation results with sufficient accuracy.

2) This study was conducted with several assumptions to establish the simulation model of pipeline network. All the assumptions shall be reviewed in the next engineering phase.
3) It is recommended that tight supply situation of gas should be improved before reinforcement of existing gas transmission facility.
4) Gas supply forecast will fall much below gas demand from around 2021. Therefore, it is recommended that further gas development plans sufficient to the future demand is established and completed by the year.

As the result of this flow simulation, some bottlenecks were found in the future pipeline facility in case of applying a delivery pressure above 350 psig as an evaluation criteria. However, according to GTCL information, some parts of the existing pipeline facility have been operated below 350 psig for long periods of time and gas has been delivered successfully for each end-user without any trouble.

Accordingly, if minimum delivery pressure lower than the 350 psig can be allowed between GTCL and each end-user, several bottlenecks stated in this simulation result may be solved easily. Therefore, critical delivery pressure at each end-user's facility should be confirmed in detail in order to develop the optimum facility expansion plan for the future.

Therefore, the minimum delivery pressure for each end-user should be also added to *"Items to be reviewed in the next engineering stage"* above mentioned.

Chapter 9 Possibility of Future Assistance

9.1 Potential Projects for the Next Phase of JICA Assistance to the Natural Gas Sector

9.1.1 Project Components Excluded from the Natural Gas Efficiency Project

The project components listed in the table below were candidate components for the "Natural Gas Efficiency Project", however, these components were excluded from the project due to the following reasons:

- Limited budget for the project
- Category for Environmental & Social Considerations according to JICA guideline
- Relatively lower priority and necessity compared to the selected components

Table 9.1-1 Project Components Requested but Excluded from the "Natural Efficiency Project"

Projects				Executing Agency
(1)	Development of Gas Production Fields			
	1)	Titas Gas Field (Location A)	(Well head gas compressors)	BGFCL
	2)	Titas Gas Field (Location E)	(Well head gas compressors)	BGFCL
	3)	Titas Gas Field (Location G)	(Well head gas compressors)	BGFCL
(2)	Construction of Gas Transmission Pipelines			
	1)	Jalalabad – Bibiyana	24 inch x 54 km (new)	GTCL
	2)	Bakhrabad – Chittagong	30 inch x 201 km (new)	GTCL
	3)	Langalband – Maowa	30 inch x 40 km (new)	GTCL
(3)	Construction of Gas Distribution Pipelines			
	1)	River crossing pipelines by HDD (12 sites)	12–16 inch (parallel)	TGTDCL
	2)	Rehabilitation of existing critical pipelines	6–12 inch x 103.5 km	TGTDCL
	3)	Reinforcement of Chittagong ring main	24 inch x 5.5 km (parallel)	KGDCL

During the 3rd survey in Bangladesh, the Survey Team discussed the necessity and priority of these projects for the next phase of JICA assistance to the natural gas sector, and the result was as follows.

(1) BGFCL

BGFCL stated that ADB is going to assist for the installation of these well head compressors at Titas Gas Fields, and currently there is no other planned project to be assisted by JICA in the near future.

(2) GTCL

GTCL stated that a new gas transmission pipeline between Bakhrabad and Chittagong (parallel to the existing pipeline) is required and needs JICA's assistance due to the following reasons:

- Existing pipeline is the lifeline of gas supply to Chittagong area that currently suffers from insufficient gas supply, however, this pipeline has been used for more than thirty years and it is superannuated.
- Even if the LNG terminal in Moheshkhali island is constructed to overcome the supply –demand gap in Chittagong area, Bangladesh may need more LNG import to cope with the expected natural gas depletion. Therefore, additional LNG terminals in Chittagong area might be constructed, and this new pipeline will possibly be used to supply natural gas to other areas of Bangladesh from such LNG receiving terminals in Chittagong area.

(3) TGTDCL

TGTDCL did not declare the need for assistance for their projects listed in Table 9.1-1.

(4) KGDCL

KGDCL stated that the construction of distribution pipelines, 24 inch x 5.5 km including HDD river crossing parallel to existing 16 inch pipeline, is required for the reinforcement of Chittagong ring main and it needs JICA's assistance due to the following reasons:

- Due to the energy crisis in Bangladesh, especially in Chittagong area, an LNG receiving terminal on Moheshkhali island will definitely be constructed even though its preparation is currently delayed.
- Once gas supply to Chittagong area is increased from the said LNG receiving terminal, this new pipeline will contribute to sustainable gas supply to KAFCO.

9.1.2 Project Newly Requested by Executing Agencies for JICA Assistance

During the 3rd survey in Bangladesh, the Survey Team asked each executing agency to provide information regarding new planned projects which will be suitable for the next phase of JICA assistance to the natural gas sector. GTCL and KGDCL proposed the following projects.

(1) GTCL

1) Replacement of the 300 MMSCFD Demra City Gate Station

   This CGS is very old and currently not functioning though it is an important hub of gas supply to Dhaka Metropolitan Area. Replacement is required to improve the efficiency gas supply to Dhaka.

2) Renovation, Expansion and re-location works for the 200 MMSCFD Ashulia City Gate Station

   Due to inappropriate soil investigation and pile foundation, this plant including the control building has been inclined and settled in some location. The plant is currently operated at risk, and renovation, expansion and re-location is urgently required.

(2) KGDCL

1) Preparation of GIS based digital map of the gas networks

   It will help for planning, construction and maintenance of networks

2) Replacement and construction of distribution pipeline

   Where necessary to mitigate low pressure and increase flow capacity

3) Replacement and construction of District Regulating Station (DRS) with real time metering

   Where necessary to mitigate low pressure, increase flow capacity and calculate zone wise system loss.

9.1.3 Recommendation for the Next Phase of JICA Assistance Projects

In order to formulate a project under JICA assistance it is necessary to undertake the basic survey works to study further details and feasibility of the project as mentioned in Section 9.1.1 and 9.1.2.

Bangladesh is facing difficulty in finding new or big reserves in the absence of any appropriate exploration programme. For further details, please refer to Appendix 24.

9.2 Possible Large-scale Projects for the Development of the Natural Gas Sector in Future

9.2.1 Potential Fields for Future Development

Potential areas/fields and possible large-scale projects for the development of the natural gas sector in the future are listed below.

1) Hydrocarbon exploration in under-explored areas
   a) Bogra-Lalmai low amplitude broad regional structure
   b) Madarganj-Sariakandi area (located in a part of Bogra-Lalmai structure)
   c) The Calcutta (Kolkata)-Mymensingh Hinge Zone of the Bengal basin
   d) Hydrocarbon exploration in shallow structures: Surma basin areas

2) Hydrocarbon exploration in difficult areas
   a) Areas covered by large rivers and swampy-marshy areas: Sunamganj-Kishorganj and its surrounding haor (swampy-marshy) areas
   b) Coastal, transitional and offshore areas

3) Hydrocarbon exploration in deep structures
   a) Gas fields nearest and surrounding the Surma basin kitchen area: Bibiyana, Jalalabad, Kailas Tila, Rashidpur, Habiganj and Titas
   b) Gas fields surrounding the kitchen area of Faridpur-Barisal area: Titas, Bakhrabad and Bangora

4) Exploration for unconventional hydrocarbon resources
   a) Shale gas: Outer shelf area of the Bengal basin
   b) Coal bed methane (CBM): North western part of Bangladesh
   c) Gas hydrate: Offshore areas

The details of these projects are described in Sections 9.2.2 through 9.2.5.

9.2.2 Hydrocarbon Exploration in Under-explored Areas

Under-explored areas in Bangladesh include, alluvial deltaic plain lands where there is no surface expression of any anticlinal structures and are so far considered to bear low potential for hydrocarbon and as a result not much seismic survey or exploratory drilling were done.

There are very little to no hydrocarbon exploration activities in the large north-western part of Bangladesh. So far only 4 wells have been drilled in the north-western part of the country and three of them showed the presence of both of oil and gas. There is also the possibility of finding low amplitude structural, stratigraphic pinch out and fault controlled stratigraphic traps. There are instances of Direct Hydrocarbon Indicators (DHI) in the seismic sections of the area.

There is a vast area in the south-western part of the country that also remains under-explored. Only a small portion of Chittagong and Chittagong hill tract areas are thinly covered by seismic survey. Figure 9.2-1 shows the areas having thin seismic coverage and few or any drill holes.

(1) Bogra-Lalmai low amplitude broad regional structure

Figure 9.2-2 shows the two-way time contour map of the Plio-Pleistocene Dupi Tila formation. It appears that Dupi Tila reflects the structural pattern of the deeper formations both in the Surma basin and the Bogra Shelf and part of the basin area. It is evident from the figure that there exists a low amplitude broad anticlinal structure stretching from Sariakandi in Bogra in the north west, through Tangail to Lalmai area in the south east. It may be noticed that there also exists a number of small low amplitude structures on both the flanks of this regional structure. Of these smaller structures, Kamta, Narsingdi field, Kapasia structure and the proposed Rupganj structures lie on top of this structure.

DHI like a bright spot and flat spot are also present in the Madarganj and Sariakandi areas, that lies in the north-west end of this structure. A careful look also reveals indication of many other anticlinal features on both sides as far as Sariakandi at its north western end and Srikail, Bangora, Lalmai field lie on its south-eastern end. Since Figure 9.2-2 was mainly based on very sparse 2D regional seismic data, a high resolution 2D seismic survey over the enetire Inner Bogra Shelf area will provide better definition of these and other low amplitude structural and stratigraphic traps etc., if any, over the region.

Bogra Shelf bears potential for hydrocarbon, and as the regional geology of the area warrants high resolution seismic data, a project may be undertaken as follows with foreign collaboration for further exploration using a high resolution 2D seismic survey and several exploratory wells in the area, which is considered necessary to adequately assess the hydrocarbon potential of the region.

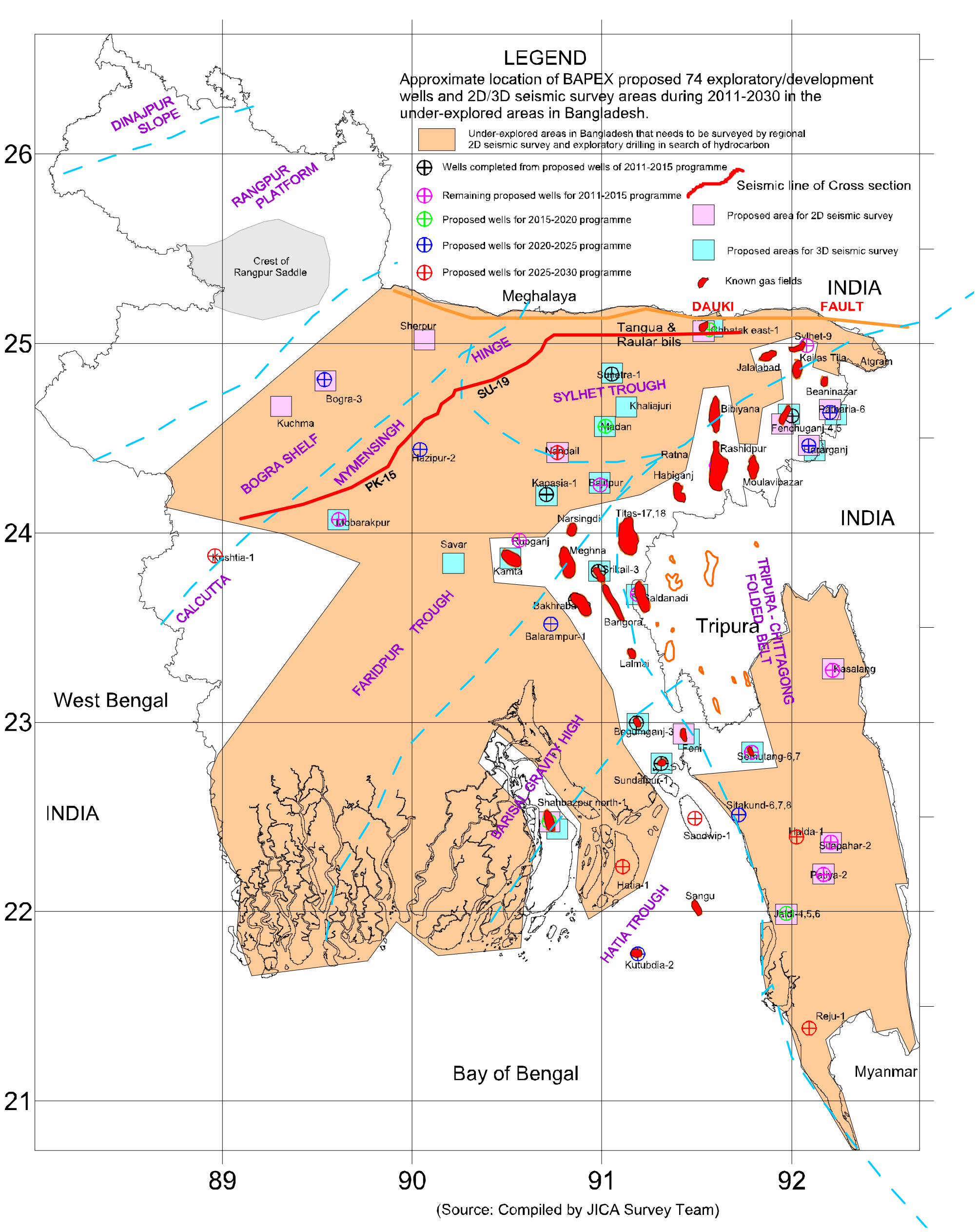


Figure 9.2-1 Map of Bangladesh showing low or no seismic or drilling coverage areas, even after including Bapex's 2011-2030 drilling and 2D/3D seismic programme.

(2) DHI in the Madarganj-Sariakandi Area

Madarganj and Sariakandi areas located over the crestal part of the regionally broad low amplitude Bogra-Lalmai structure are shown in Figure 9.2-2. The presence of seismic amplitude anomalies (bright spots) in the Oligocene-Miocene level of the section having direct detection features like flat spots are indicative of the presence of hydrocarbon in those structures. For further details, please refer to Appendix 24.

A project may be undertaken as follows with a few more seismic lines over these two structures followed by two test drill holes, one at Madarganj and the other at Saraiakandi, which are considered to be necessary to confirm the presence of hydrocarbon and to study their commercial viability.

(3) Possibility of stratigraphic traps along the Hinge Zone of the Bengal basin

Earlier 2D regional seismic data of greater Pabna and Mymensingh areas revealed the presence of large scale clinoforms all along the Shelf edge and basinward of the Calcutta (Kolkata)-Mymensingh Hinge Zone of the Bengal basin (Figure 9.2-3).

Earlier 1D basin modeling and petroleum system analysis in that area indicated that potential source rocks of the rift system include the Gondwana coal. Potential source rocks also include the shales and carbonaceous shales from the Miocene to Paleocene and Permo-Carboniferous age.

2D basin modeling done by ONGC, in the adjacent West Bengal area of the Bengal Shelf shows similar results. The study also concluded that:

1) Excellent source rocks are present in the Gondwana sequence.
2) Cretaceous and Tertiary sections possess fair to good source rock characteristics.

It is therefore, very important to carry out regional properly planned 2D seismic survey across and along the Hinge zone (Figure 9.2-3) to detect and assess the hydrocarbon potential in the possible stratigraphic traps of this region.

Presence of both clinoforms and the source rock along the Hinge zone area and concealed structure needs to be studied very carefully with 2D regional seismic surveys for better definition, since such stratigraphic and concealed structures, close to the kitchen area, bear great potential for trapping hydrocarbon. For further details, please refer to Appendix 24.

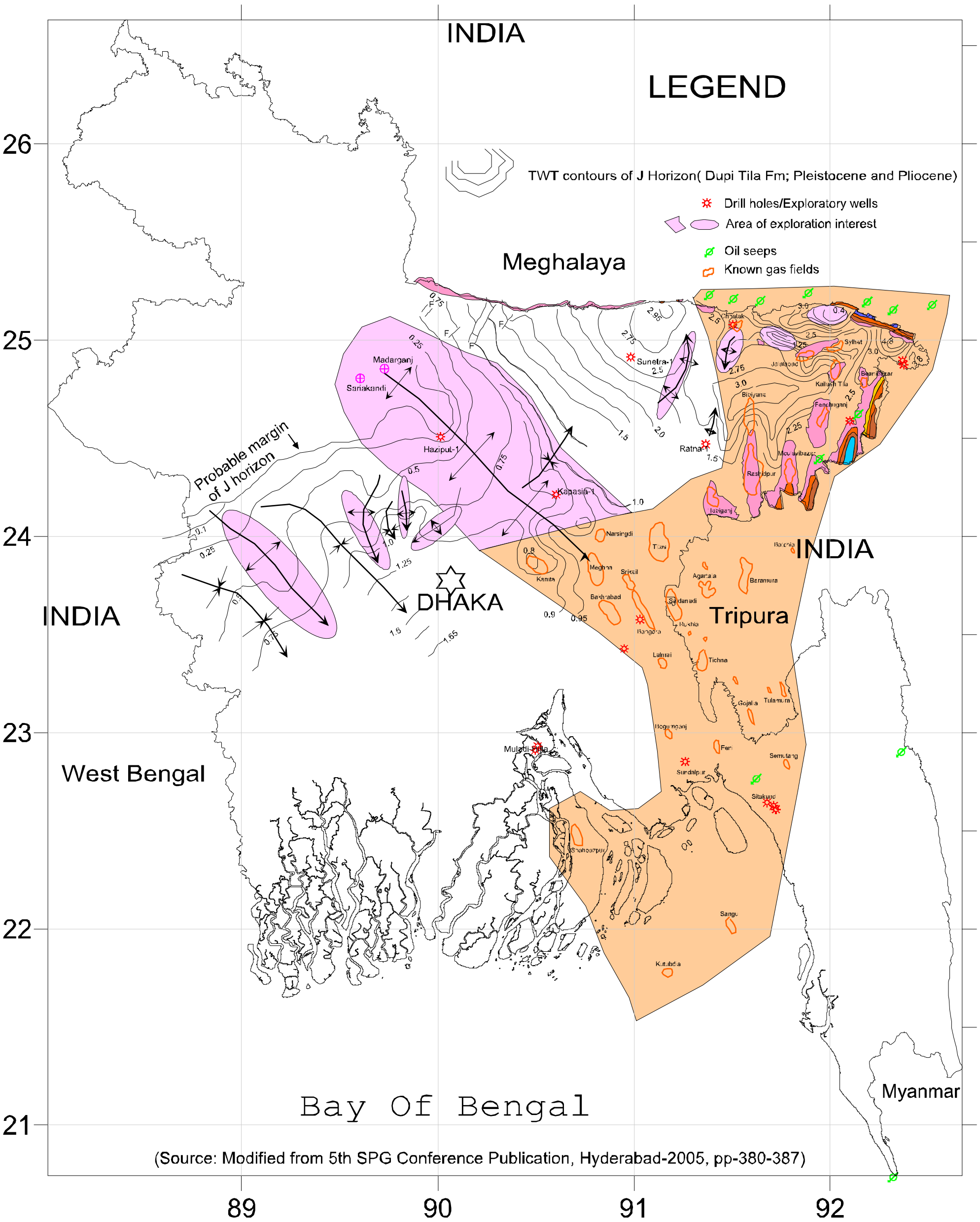


Figure 9.2-2 Map of Bangladesh showing distribution of two-way time contour map of Dupi Tila formation top in the Surma basin area.

(4) Hydrocarbon Exploration in Shallow Structures

It is a common experience in drilling wells for hydrocarbon to hit shallow gas zones (at depths of around 500 to 1,000 m) in the Surma basin areas. Several blowouts, which indicated reserves of several bcf of gas have been burnt out. Any technology to tap such shallow gas may become a viable energy source for local consumers, who often demand gas from the gas field grid pipelines. The first gas blowout in Bangladesh territory took place in Sylhet Gas field in 1955. Still today there is continuous gas seepage going on. The second gas blowout took place on June 14, 1997, at Magurchara, in the northeast Moulavibazar district. The blowout occurred when drilling reached a depth around 800m. It is estimated that the blowout destroyed around 245 million cubic feet of gas. At Tangra Tila two blowouts occurred in the Chhatak Gas field. In January 2005, the first one took place when drilling reached a depth of 550 m. According to the estimates of the explorers, the gas reserves below the first layer at 550 m are no less than 115 bcf and the gas loss has been initially forecast at Tk 1,150 crore ($185m). The second explosion of Tangratila took place in June 2005 at a depth of 435 m. It is estimated that the blowout might have burnt 260 bcf gross reserve.

It can be assumed that there are sand layers charged with gas in the range of multi billion cubic feet at depths ranging from 500 to 1,000 m in the Surma basin area. A project may be undertaken in collaboration with experienced foreign organizations to study and develop a suitable technology for safe method/technology to explore and tap them that could be beneficial to this country facing energy shortages. For further details, please refer to Appendix 24.

9.2.3 Hydrocarbon Exploration in Difficult Areas

"Difficult areas" falls in and around big rivers, swampy-marshy lands, hilly forest areas and deep forest areas, coastal and transitional areas where seismic survey and drilling are difficult to conduct.

(1) Areas covered by big rivers and swampy-marshy areas

Onshore hydrocarbon exploration activities are often constrained by difficult areas like big rivers such as Jamuna, Padma and Meghna. Areas covered by big rivers, lakes and hilly areas are shown in Figure 9.2-3. A significantly large surface area above the kitchen areas falls under big and wide rivers, marshy-swampy areas (Haor areas), where seismic coverage is poor to none. It is therefore important to obtain data from under these difficult areas. Figure 9.2-3 shows the big rivers of Bangladesh and the distribution of other difficult areas, for example, big water bodies like lakes, marshes, swamps, etc., that make geological and geophysical surveys like seismic surveys very difficult. There are also some hilly and forest areas in Sylhet and Chittagong areas that make access difficult for the surveyors. There are areas under big rivers and anticlines with thick forests that are very prospective for hydrocarbon and need to be surveyed.

Local experts and resources for exploration large river crossings, large lakes/water bodies and coastal or transitional areas, and for offshore marine survey/exploration have not been developed yet. Foreign cooperation, assistance in training and developing local manpower and acquiring necessary equipment will be very helpful for this. For further details, please refer to Appendix 24.

A joint venture project as shown below may be undertaken with experienced foreign organizations/companies to explore, develop and transfer knowledge and develop local expertise to carry out surveys in difficult areas.

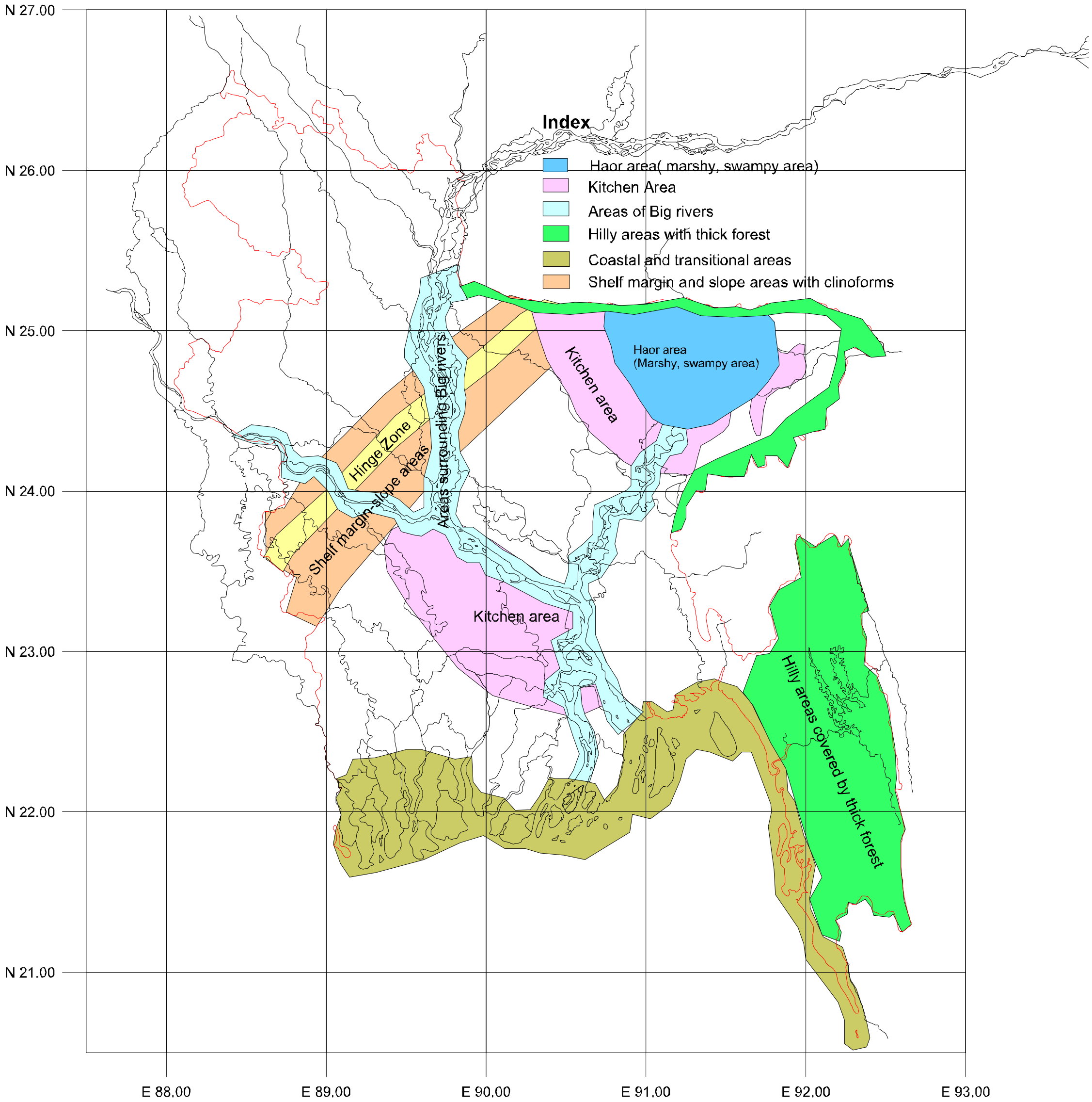
(2) Coastal, Transitional and Offshore Areas

There are large areas along the coastal region of Bangladesh having numerous rivers falling into the sea. It is often very difficult to reach and carry out exploration in those areas. Gas fields have been discovered both onshore close to coastal areas and in shallow water offshore areas. Therefore it is necessary to carry out exploration along the coastal and transitional areas. Coastal and transitional areas require a special type of technology, equipment and trained manpower for hydrocarbon exploration.

Bangladesh has only a few modest offshore gas fields, such as Sangu and Kutibidia, of which Sangu is already depleted. Comprehensive mapping and categorisation of offshore oil seeps is essential for efficient offshore oil and gas exploration. Seepage detection by SAR (Synthetic Aperture Radar) is a proven technique for mapping surface oil seeps which could provide the first indication of a petroleum system in these blocks. CGG Veritus did “Offshore Seeps Study” offshore Bangladesh in 2013 that cover offshore PSC blocks. Although offshore explorations so far have not discovered large hydrocarbon reserves, it is evident from the very recent NPA investigation with cutting edge technology that there is the presence of several oil seepages in the Bay of Bengal offshore Bangladesh, indicating the presence of hydrocarbon in the area. For further details, please refer to Appendix 24.

Local experts and resources for exploration in the coastal or transitional areas and for offshore marine survey/exploration have not been developed yet. Foreign cooperation, assistance in training and developing local manpower and acquiring necessary equipment will be very helpful for this. Any joint venture with experienced foreign organizations/companies would be helpful for the transfer of knowledge and to develop local expertise to carry out surveys in difficult areas.

Deep Exploration and Unconventional Hydrocarbon Resources.



Source: Compiled by JICA Survey Team from various published materials

Figure 9.2-3 Map showing difficult areas for seismic surveys due to big rivers, haor (marshy-swampy), hilly areas with forest, coastal and transitional areas.

9.2.4 Hydrocarbon Exploration in Deep Structures

All the gas fields so far discovered in Bangladesh are confined within the anticlinal structures and are distributed in multiple sand layers at different depths. These anticlinal folding patterns extend to a much deeper level that encompasses sediments of the Eocene to Pleistocene ages, whereas the current hydrocarbon exploration target depths are limited to within the Mid-Miocene sediments and shallower. There are possibilities for large-scale hydrocarbon reserves in deep structures in the Bengal Basin, but drilling deep wells is often very difficult due to the existence of abnormally high pressure zones, and generally not attempted by local experts.

Four wells in the Kailas Tila, Beanibazar, Fenchuganj and Bibiyana Gas Fields in the Surma Basin crossed 4,000 m and are rich in gas-condensate. It may be noticed that gas fields nearest and surrounding the Surma basin Kitchen area (Figure 9.2-2 and Figure 9.2-3) in the south of Sunamganj area, viz., Bibiyana, Jalalabad, Kailas Tila, Rashidpur, Habiganj, and Titas fields, have reserves on the order of multiple tcf. Also gas fields surrounding the kitchen area of the Faridpur-Barisal area, viz., Titas, Bakhrabad and Bangora also have gas reserves in tcf figures. Almost all the gas reservoirs are in the Miocene (Bokabil and Bhuban) formations. In addition, Oligocene Barail formations, which are the prime target for oil in neighbouring Assam area, occur at greater depths in most parts of Bangladesh. Moreover, a Barail formation was encountered in the Slope area in Hazipur-1 well with oil showing at the Lower Bhuban and Barail contact at a depth of 3,130m.

Therefore deep structures at depths, deeper than 4,000 m are to be targeted in future exploration to reach the Oligocene Barail formation. Such deep wells must cross the high pressure zone which occurs around 3,500-4,000 m. But further 2D seismic survey and G&G study will be needed before selecting suitable well locations. For further details, please refer to Appendix 24. A comprehensive large project, as shown below, may be undertaken in collaboration with experienced foreign seismic/drilling companies to drill to deeper horizons in those areas including 2D/3D seismic surveys, G&G study followed by 20-30 deep wells (4,000 m+ deep) at suitable locations in search of deeper oil and gas below the existing gas fields and in potential virgin areas.

9.2.5 Unconventional Hydrocarbon Resources

The presence of prolific natural gas, Gondwana coal onshore and a wide open ocean in the south leads to the possibility of finding unconventional resources like shale gas, CBM and gas hydrates in Bangladesh. No specific research on the prospect of CBM, shale gas or gas hydrates has been done in Bangladesh yet.

(1) Shale Gas

It is imperative to know the source rock of hydrocarbon generation for the exploration of shale gas. In the Bengal basin, it is understandable that the source rocks, responsible for the generation of natural gas being produced in Bangladesh, has not been established yet.

The potential source rocks in the neighbouring Assam–Arakan basin are mainly the late Eocene to early Oligocene Barail coal–shale and middle to late Eocene Kopili shale sequence. The Kopili rocks have source specific parameters similar to those of the Sylhet oils. The Kopili sediments also possess fair to good source rock characteristics and are marginally mature.

The Eocene Kopili shale occurs at great depths in the Surma basin and therefore cannot be tested for their source potential in Bangladesh territory. However in the Bogra Shelf and in the Platform areas, the occurrence of the Kopili shale is widespread as shown in Figure 9.2-4. The Kopili shale is being penetrated in Kuchma-X1, Bogra-1X, Singra-1X, and many wells in the Jamalganj, Joypurhat area. A drill hole for both exploration and research may be made in the outer shelf area to study its source potential in Bangladesh area. A project may be undertaken in collaboration with a foreign organization having relevant research facilities, experience and deep drilling capabilities to assess the shale gas prospect. For further details, please refer to Appendix 24.

(2) CBM

The most important parameters for CBM prospecting are the presence of a large volume of coal with high methane content and sufficient permeability within the seam to allow gas production. In the north western part of Bangladesh, there is an abundance of thick Gondowana bituminous coal in depths ranging from 200 to 2,000 m spreading over a very large area. A regional picture of probable distribution of the Lower Gondwana formations is shown in Figure 9.2-4. Until the present date there has been little study on the feasibility of CBM development in any of the 5 known coal fields, viz., Jamalganj, Barapukuria, Khalaspir, Phulbari and Dighipara, in the north western part of Bangladesh. Gondwana coal is also discovered in two wells in the Bogra shelf area.

An estimate of the total in-situ CBM resource (for all seams in all basins) was made (Muller, 2009), as shown in detail in Table 9.2-1. The estimated CBM gas concentration, in-situ resource and seam thickness in the Bangladeshi deposits is comparable with that at other active CBM projects elsewhere in the world. In comparison with the 0.9 Mt per year coal-feed to the 250 MW power plant at Barapukuria, 10 Gm^3 of gas at Jamalganj could power the same 250 MW plant for over 15 years (Muller, 2009).

Table 9.2-1 Estimated in-situ coal bed methane (CBM) resources in Bangladesh.

Coal field	Number of coal seams	Depth range of coal-seams (meters below surface)	In-situ coal resource (Mt)	High estimate in-situ CBM resource 12.68 m^3/ton (Gm^3)	Average estimate in-situ CBM resource 9.56 m^3/ton (Gm^3)	Low estimate in-situ CBM resource 6.51 m^3/ton (Gm^3)
Jamalganj	7	650 – 1158	2,513	31.86	24.11	16.36
Barapukuria	6	118 – 518	377	4.78	3.62	2.45
Phulbari	2	150 – 250	426	5.40	4.09	2.77
Khalaspir	8	257 – 483	828	10.50	7.94	5.39
Dighipara	1	328 - 422	600	7.61	5.76	3.91
TOTALS			**4,744**	**60.15**	**45.52**	**30.88**

Source: Muller (2009)

So far, practically, no activities have been observed relating to CBM exploration. It is learned that Petrobangla has taken up a small pilot project titled "Feasibility Study of Coal Bed Methane at Jamalganj Coal Field" and submitted it to EMRD for approval. The project proposal has recently received government approval. The approved project will be a feasibility study in Jamalganj coal field, including two drill holes and analysis of coal samples for their CBM potential. The budget will be around 3 million US$ equivalent. Depending on the results, another pilot project may be undertaken later.

It is understood that CBM has a huge potential in the north western part of Bangladesh. Therefore, a very large-scale and long-term comprehensive exploration/research and development programme as shown below, is necessary to evaluate and to avail such potential resources including 20 to 50 exploration drill holes (ranging from 500 to 3,000 m). Foreign organizations, having many years experience and great expertise, may be engaged to provide support in this respect. For further details, please refer to Appendix 24.

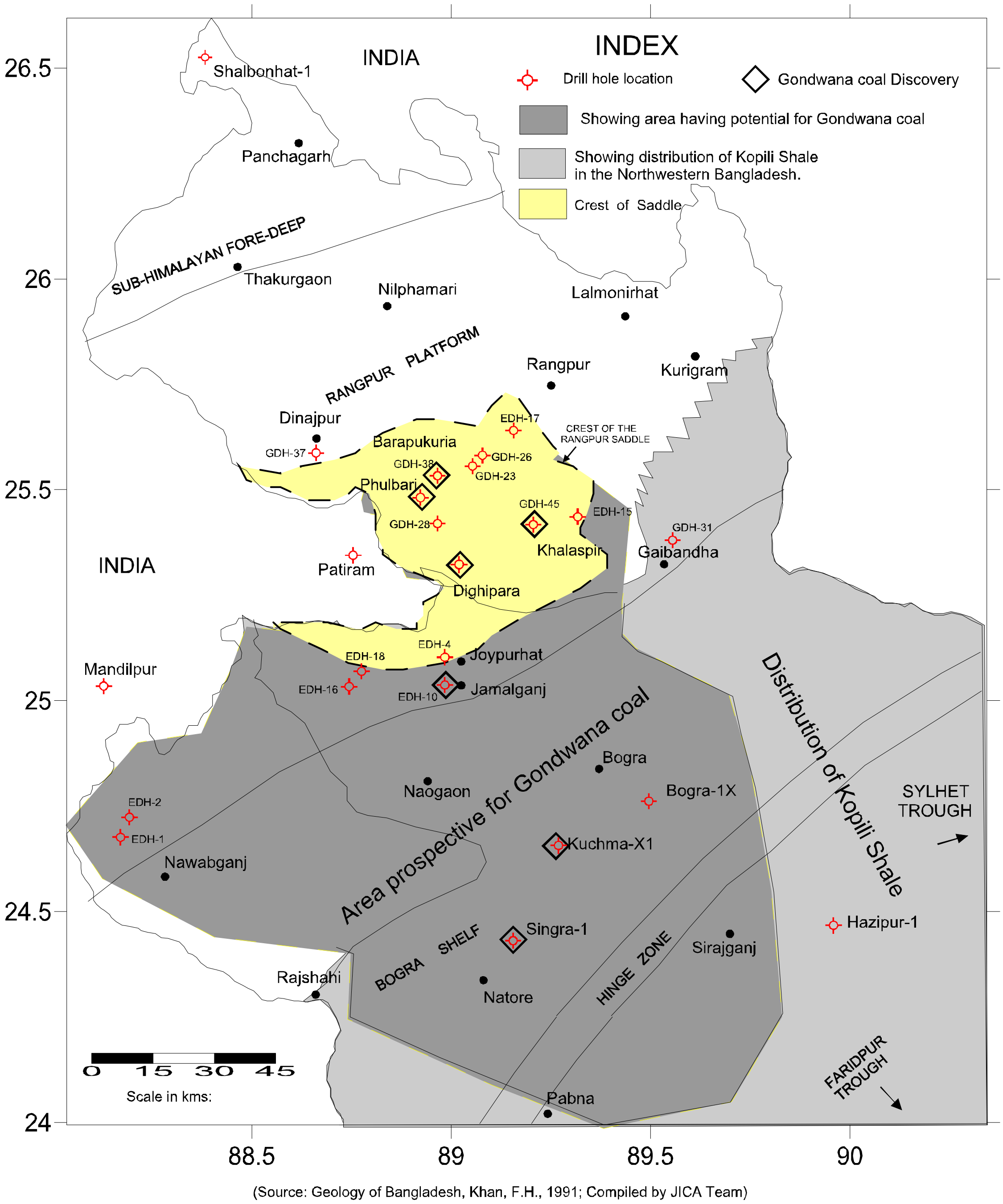


Figure 9.2-4 Probable outline of the areas having potential for Lower Gondwana and Kopili shale formations in the north western part of Bangladesh.

(3) Gas Hydrates

Potential of gas hydrates in the Bay of Bengal have not been studied yet. It a very important area from the future energy sources point of view. Some countries have experience and leading expertise in the area of gas hydrates. Engagement, assistance, and cooperation from the experienced countries may be sought for the assessment and future development of gas hydrates.

9.3 Technical Capacity Building

In order to achieve, maintain and manage the energy sector effectively and efficiently a requisite number of local experts needs to be developed by arranging local and foreign training and higher education in the related areas of expertise. Bangladesh does not have academic institutions capable of providing such state-of-the-art and cutting-edge technologies and lab facilities to address such limitations. Bangladesh also does not have z capability, equipment or facilities for shallow or deep marine survey and exploration activities. Assistance and cooperation from technically advanced countries having such experience and technology may be sought under a long term training project to meet such requirements and to locally develop expertise in areas such as the following:

- To develop expertise in exploration geoscience (G&G) and reservoir management areas.
- To develop expertise in basin studies and geochemical analysis
- To develop expertise in drilling in high-pressure zones
- To develop expertise in production and O&M
- To develop expertise in shallow or deep marine surveys including difficult areas
- To develop expertise in horizontal well drilling and completion

9.4 Conclusions and Recommendations

Based on the current status of Bapex's 2011-2030 exploration and development programme and other recent exploration and development activities in Bangladesh, it has been observed that there are several other high potential areas for hydrocarbon that remain outside the Bapex's exploration/development programme until 2030, and need immediate attention to explore those areas. In order to timely and appropriately address the ever increasing demand for natural gas in the country, it is necessary to implement several hydrocarbon exploration and development projects that have been recommended for the near future, which are summarized with the order of priority as follows and the project locations are shown in Figure 9.4-1. The order of priority was comprehensively determined based on project feasibility, necessity, project effects (e.g., activation of local industries), etc.

1) **Hydrocarbon exploration in under-explored areas:**

Project-1: 2D seismic survey and drilling programme in the Madarganj and Sariakandi areas around Jamuna river to confirm the presence of hydrocarbon.

Scope of the project:

1) 400 line-kilometer (LKM) 2D seismic data acquisition in the Madarganj and Sariakandi areas around Jamuna river
2) Two exploratory drill holes for confirmation of hydrocarbon
3) Training and manpower development for large river crossing technology
4) Estimated cost: US$ 30-35 million (seismic + 2 exploratory drillings, excluding cost for the development wells and construction of gas processing and transmission facilities)
5) Duration of the project: 2-3 years
6) Drilling of development wells and construction of gas processing and transmission facilities if hydrocarbon is discovered

Importance:

1) The results of the project can be obtained within a short period of time and at a low cost and therefore should be given priority over other projects
2) Presence of DHI in the area
3) Located in less developed areas
4) Near a urea fertilizer plant that uses natural gas
5) Near Jamuna Bridge, for easy transmission across the river
6) Will help to set up power plants and other industries in north western Bangladesh for faster economic development

2) **Hydrocarbon exploration in difficult areas:**

Project-2: 2D seismic survey to cover the haors (marshy-swampy areas) of Sunamganj-Kishorganj and surrounding areas and deep drilling for hydrocarbon exploration.

Scope of the project:

1) 800 LKM 2D seismic data acquisition in the Sunamganj-Kishorganj and its surrounding haor (swampy-marshy) areas.
2) Four exploratory deep drill holes (4,500 m+) for the confirmation of hydrocarbon.
3) Training and manpower development for survey in large haor areas.

4) Estimated cost: US$ 110-120 million (seismic + 4 well drillings, excluding cost of development wells and construction of gas processing and transmission facilities)
5) Duration of the project: 5-6 years
6) Drilling of development wells and construction of gas processing and transmission facilities, if hydrocarbon is discovered.

Importance:

1) Presence of several relatively large concealed structures makes it a very good target area for exploration
2) Located within the kitchen area, therefore, the likelihood of being charged with both oil and gas is very bright
3) Surrounding structures are all big gas fields, therefore, the possibility of finding a very big hydrocarbon reserve in not unlikely
4) Any discovery here will be a new one, and will increase the total hydrocarbon reserves of the country
5) If successful, the concept of concealed structure potential might also lead to new discoveries in other areas

3) **Hydrocarbon exploration in deep structures:**

Project-3: Deep drilling in the Bakhrabad gas field area to assess the hydrocarbon potential of the deeper horizons.

Scope of the project:

1) Reinterpretation of the existing seismic data and G&G study
2) Two exploratory deep drill holes (4,500 m+) for the confirmation of hydrocarbon
3) Training and manpower development for deep drilling having high pressure issues
4) Estimated cost: US$ 70-75 million (excluding cost of development wells and construction of gas processing and transmission facilities)
5) Duration of the project: 2-3 years
6) Drilling of development wells and construction of gas processing and transmission facilities, if hydrocarbon is discovered

Importance:

1) Possibility of finding of oil/gas in the deep structures of existing gas fields

2) Fields will have additional reserve and increase the life of the existing gas fields
3) Can use existing gas processing and transmission facilities
4) Not much additional time will be required

Similar deep exploration projects may be undertaken for the Sylhet, Kailas Tila, Beanibazar, Fenchuganj, Rashidpur, Habiganj, and Titas gas fields and in new areas where the prospects for deeper hydrocarbons are bright.

4) Exploration for unconventional hydrocarbon resources:

Project-4: High Resolution 2D seismic survey to identify all the Gondwana coal basins and drilling to confirm the presence of coal deposits and study their CBM potential over the Bogra Shelf and Rangpur Platform areas.

Scope of the project:

1) 1,500 LKM high resolution 2D seismic data acquisition over the Bogra Shelf and southern part of Rangpur Platform areas
2) 20-50 exploratory drill holes (ranging from 500 to 3,000 m+) for the confirmation of Gondwana coal
3) Laboratory analysis of coal for CBM potential
4) Training and manpower development for CBM development, operation and maintenence
5) Estimated cost: US$ 90-210 million (excluding cost of a CBM plant pilot project)
6) Duration of the project: 8-10 years
7) A CBM plant pilot project would be required later to assess its commercial viability

Importance:

1) New type of additional energy source
2) Possibility of large reserve

5) Hydrocarbon exploration in under-explored areas:

Project-5: 2D seismic survey over the Bogra-Lalmai low amplitude broad regional structure and exploratory deep drilling for hydrocarbon

Scope of the project:

1) 2,000 LKM 2D seismic data acquisition in the Bogra-Lalmai low amplitude broad regional structure and its surrounding areas

2) Four exploratory deep drill holes (4,500 m+) for the confirmation of hydrocarbon
3) Training and manpower development for surveys in large river crossing areas
4) Estimated cost: US$ 125-135 million (seismic + 4 well drillings, excluding development wells and construction of gas processing and transmission facilities
5) Duration of the project: 4-5 years
6) Drilling of development wells and construction of gas processing and transmission facilities would be required if hydrocarbon is discovered

Importance:

1) Large regional anticlinal structures with good possibility of hydrocarbon
2) Two kitchen areas at both flanks
3) Few gas fields already exist over the structures

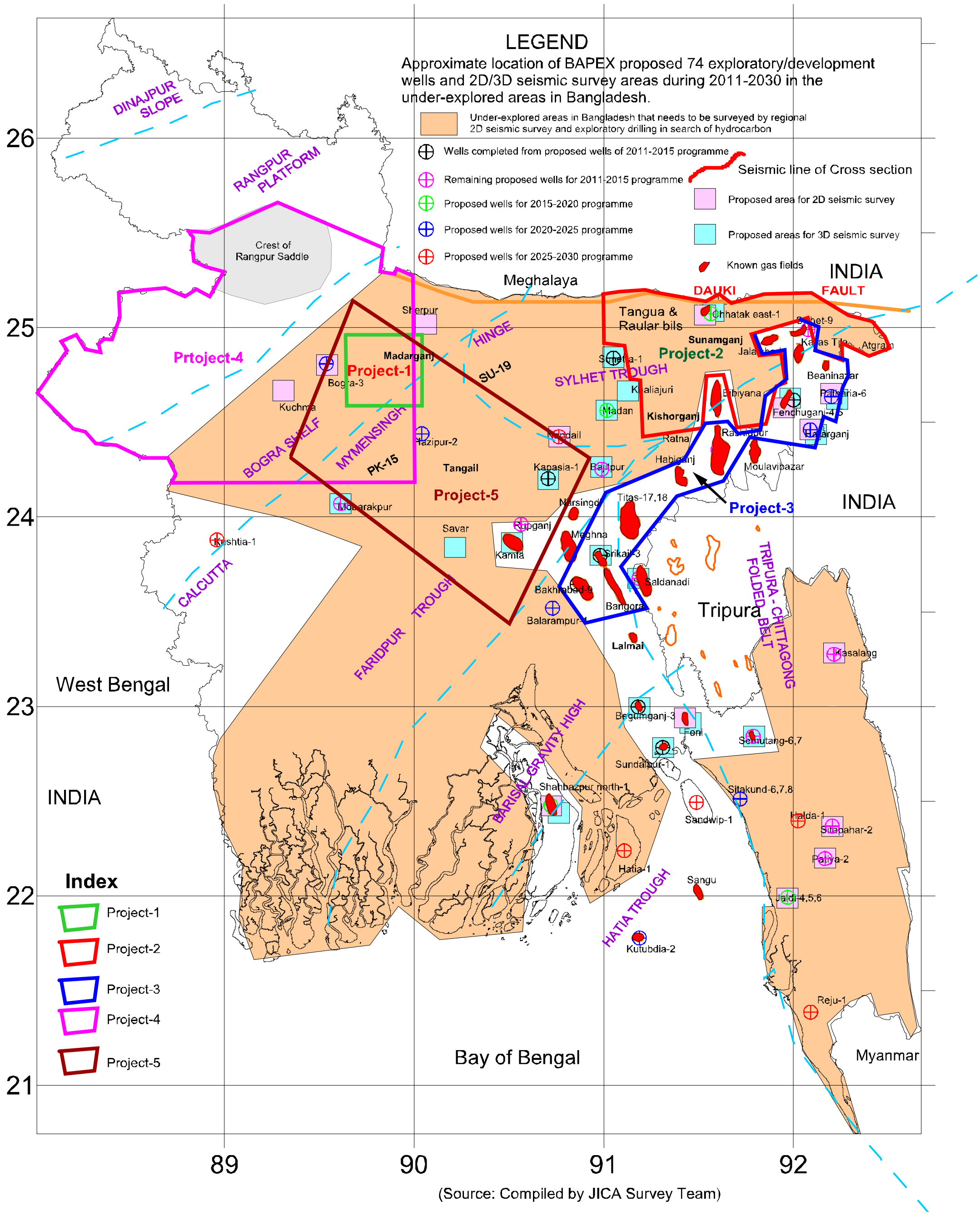


Figure 9.4-1 Map of the Proposed Project Locations

In addition, the following project is proposed independent of the above-mentioned projects.

- Technical capacity building:

  Project-6: Human Resource Development (HRD) project to train relevant personnel with state of the art and cutting-edge technologies and develop facilities to maintain and manage the energy sector effectively and efficiently

Scope of the project:

1) Area of expertise: As shown above (exploration geoscience, reservoir management, etc.)
2) Number of personnel: As required
3) Estimated cost: US$ 10-20 million
4) Duration: Long term

Chapter 10 Recommendations for Technical Cooperation

10.1 Technical Cooperation for Enhancement of the Pre-paid Meter System in Bangladesh

For promotion of the efficient use of natural gas in Bangladesh, the introduction of the pre-paid gas metering system should not be limited to this project, and the nationwide diffusion should be realized in the future.

As mentioned in this report, in this Project, pre-paid meters will be installed only where installation is relatively easy. However, there are many other difficult cases with problems to be solved for further diffusion in the future such as unauthorized connections and/or illegal piping works.

Furthermore, the pre-paid metering system is quite new technology in Bangladesh.

Therefore, a Technical Cooperation Scheme consisting of the following three steps is recommended for the nationwide diffusion of the pre-paid gas metering system:

<u>Step - 1: Preventive Diagnosis and Maintenance for Distribution Pipelines</u>

1) Investigate the actual conditions of the gas distribution pipe lines and also customer service lines to define the problems to be solved such as gas leakage and gas pressure drops.
2) Assist the gas distribution company to establish a preventive diagnosis method and to improve the maintenance of distribution pipelines required for nationwide diffusion of the pre-paid gas metering system.
3) Assist gas distribution companies to ensure the required staff assignment as well as budgetary allocations for the above activities.

<u>Step -2: Standardization of pre-paid meter installation and associated piping, and the best method for nationwide diffusion of the pre-paid gas metering system</u>

1) Investigate the actual conditions to define the problems to be solved for the installation of pre-paid gas meters in difficult cases, and also the problems in distribution pipelines and gas appliance condition. And propose the solutions for such problems. (e.g. countermeasures for the drop in gas distribution pressures, etc.)
2) Propose the standard for the installation of pre-paid meters with protection devices as well as piping arrangements both for existing customers and new residential buildings.

3) Investigate the actual current customer data to define the problems to be solved for better customer management, which is indispensable for the nationwide diffusion of the pre-paid gas metering system, and propose the solutions for such problems.
4) Examine the economic and financial feasibility for the continuous nationwide installation of pre-paid meters based on the actual data of natural gas consumption and also the cost required for the installation inclusive of difficult cases.
5) As a result of the above, propose the best approach for the nationwide diffusion of the pre-paid gas metering system.

Step - 3: Development of regulations/standards for pre-paid gas meters

1) Propose the regulations/standards required for the nationwide diffusion of the pre-paid gas metering system such as:
    - Safety regulations regarding gas meters
    - Inspection and maintenance standards for gas meters

Chapter 11 Workshop in Japan

11.1 Purpose of Workshop in Japan

In order for key personnel of the natural gas sector in Bangladesh to learn the latest technology in gas related facilities, a workshop in Japan is being held in this preparatory survey.

In this workshop, the following facilities related to the gas sector are being visited and explained.

- Compressor Factory
- Gas Supply System
    - LNG receiving terminal
    - Gas supply central control centre
- Gas meter factory

11.2 Outline of Workshop

(1) Duration of Workshop

The workshop was carried out during the period of 25th February to 4th March, 2014.

(2) Participants from Bangladesh

No.	Name	Position	Organisation
1	Mr. Mozammcl Hoque Khan	Secretary	EMRD
2	Syed Masum Ahmed Choudhury	Deputy Secretary (Development 2)	EMRD
3	Mohammad Nurul Absar	Managing Director	BGFCL
4	Md. Kamruzzaman	General Manager (Operation)	BGFCL
5	Md. Abul Kalam Azad	Project Director	GTCL
6	Mohammad Abdul Bari	Deputy General Manager	TGTDCL
7	Meer Abdul Matin	Managing Director	KGDCL
8	Mohammad Azizul Hoque	Deputy General Manager	KGDCL
Total		Eight (8) participants	

(3) Implementation Members

1) Host Organisations for Workshop

Host organisations for the workshop were JICA Tokyo and Kansai.

2) Implementation Organisation for Workshop

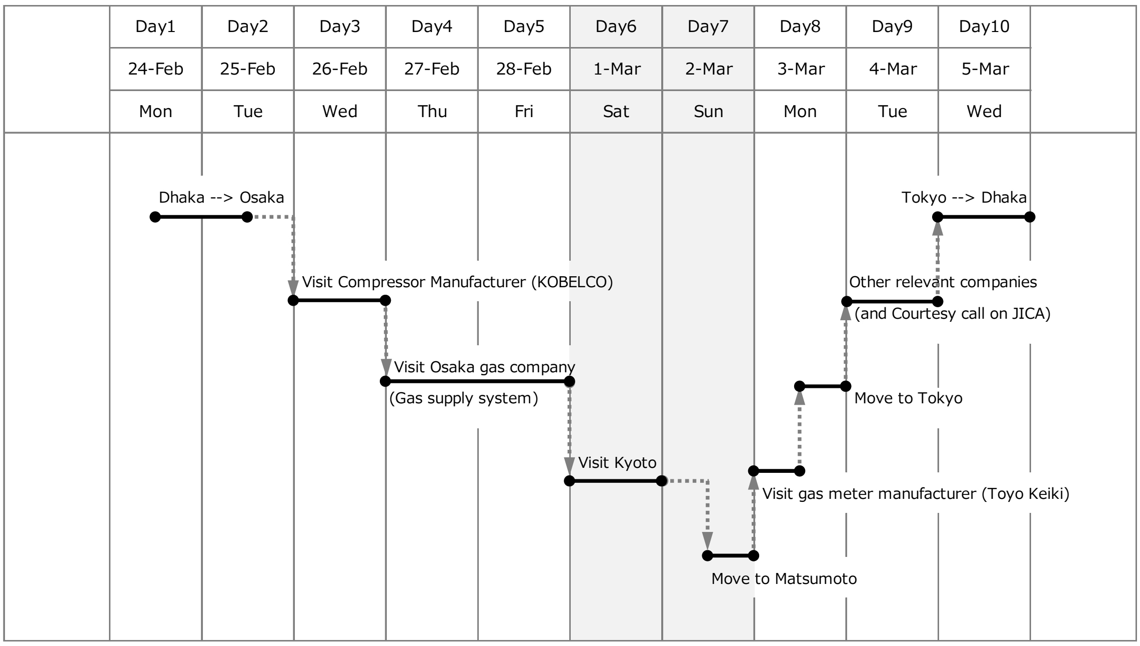
The workshop was carried out by Oriental Consultants Co., Ltd., the JICA Survey Team for the Natural Gas Efficiency Project. Members in charge of the workshop are as follows:

No.	Name	Position	Organisation
1	Kazutora KONO	Team Leader	Oriental Consultants Co., Ltd.
2	Takahiro MOJI	Economic and Financial Analyses / Organisational Frameworks / Project Coordination	Oriental Consultants Co., Ltd.

11.3 Workshop Schedule and Programme

The Workshop schedule in Japan was as shown below.

(1) Brief Workshop Schedule



(2) Workshop Programme

The programme of the workshop in Japan was as shown below.

	Date			Visits	Location
1	24, Feb	Mon	21:00 - 6:00	✈ Leaving Bangladesh (Dhaka -> HongKong (KA-0191)	
2	25, Feb	Tue	7:50 - 12:15	✈ Arriving at Osaka (HongKong -> Osaka (CX-0562)	
			14:10 - 15:00	Moving to Hotel by Bus (Kansai Airport-Crowne Plaza ANA Osaka)	
3	26, Feb	Wed	**10:30 -11:30**	**Programme Orientation for Workshop**	JICA Kansai
			14:00 - 16:30	**Visit KOBELCO Compressor Factory**	KOBELCO at Takasago City in Hyogo
4	27, Feb	Thurs	**10:30-12:30**	**Meeting for Gas Project**	Room701, Crowne Plaza ANA Osaka 7F
			14:30 - 16:00	**Visit Osaka Gas Co., Ltd. Senboku LNG Receiving Terminals**	Osaka Gas at Takaishi City in Osaka
			16:00 - 17:00	Moving to Hotel by Bus	
5	28, Feb	Fri	**9:00 - 10:30**	**Visit Osaka Castle**	Osaka Castle
			13:00 - 14:30	**Visit Osaka Gas Co., Ltd. Gas Spply Central Control Center**	Osaka Gas at Chuo Ward in Osaka City
			15:00 - 17:00	**Meeting for Gas Project**	Room701, Crowne Plaza ANA Osaka 7F
6	1, Mar	Sat	AM	Holiday	
			12:30 - 13:30	**Lecture on Japanese History and Culture**	Crowne Plaza ANA Osaka
			14:40 - 15:30	**Cultural Experience at Fukujuen**	
			16:00 - 17:00	**Visit Kinkakuji**	Kinkakuji
			17:00 - 18:00	Moving to Hotel by Bus	
7	2, Mar	Sun	AM	Holiday	
			12:50 - 13:10	Moving to Shin-Osaka Station	
			13:40 - 14:33	Shin-Osaka -> Nagoya (Hikari470)	
			15:00 - 17:53	Nagoya -> Nagano (Shinano17)	
			17:55 - 18:10	Moving to Hotel by Bus (JAL City Nagano)	
			19:20 - 19:30	Moving to Restaurant	
			19:30 - 21:00	**Dinner with Toyo Keiki**	
			21:00 - 21:10	Moving to Hotel by Bus	
8	3, Mar	Mon	**9:30 - 14:30**	**Explanation of the Toyo Keiki and Lecture on 1) Gas Meter made in Japan, 2) the Processing of Manufacturing Gas Meters and 3) Visit the Factory of Manufacturing Gas Meters**	Toyo Keiki HQ Factory at Matsumoto City in Nagano
			19:35 - 20:00	Moving to Hotel by Bus (Grand Palace Hotel Tokyo)	
9	4, Mar	Tue	**10:30 - 11:30**	**Lecture on Gas Industry in Japan**	Oriental Consultants HQ at Tokyo
			14:00 - 14:45	**Lecture by Toyo Engineering**	Oriental Consultants HQ at Tokyo
			14:45 -15:15	**Lecture by Toyo Gas Meter & Iwatani**	Oriental Consultants HQ at Tokyo
			15:25 - 15:45	**Lecture by Azbil Kimmon**	Oriental Consultants HQ at Tokyo
			16:00 - 17:30	**Seminar on Gas Situation in Bangladesh and the Project by JGI and Oriental Consultants**	Oriental Consultants HQ at Tokyo
			18:00 - 18:30	**Visit to JICA HQ**	JICA Tokyo
			19:00 - 21:00	**Dinner with JICA**	
			21:00 - 21:20	Moving to Hotel by Bus (Grand Palace Hotel Tokyo)	
10	5, Mar	Wed	10:35 - 15:00	✈ Leaving Tokyo（Tokyo -> HongKong (CX-0501)	
			17:00 - 19:55	✈ Arriving in Dhaka（HongKong -> Dhaka (KA-0192)	

(3) Contents of Workshop

Contents of the workshop are described as follows:

Study tour of compressor factory at KOBELCO in Takasago of Hyogo prefecture (26th February)

Study tour of LNG receiving terminal at Osaka Gas in Osaka (27th February)

Sturdy tour of gas supply central control centre at Osaka Gas in Osaka (28th February)

Study tour of gas meters at Toyo Keiki in Matsumoto of Nagano prefecture (3rd March)

Lecture on the gas industry in Japan by Japan Gas Association in Tokyo (4th March)

Group photo after finishing workshop at Oriental Consultants in Tokyo (4th March)