FEASIBILITY STUDY OF GAS SUPPLY TO RAJSHAHI

By

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CANDIDATE'S DECLARATION

It is hereby declared that this project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Signature of the Candidate

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RECOMMENDATION OF THE BOARD OF EXAMINERS

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TO MY BELOVED PARENTS

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ABSTRACT

The gas fields in Bangladesh discovered so far discovered are located in the Eastern Part of the country. As a result gas based power plants, fertilizer factories and industries have been set up only in the Eastern Part of the country. Non-availability of natural gas is the major obstacle to set up industries in the northern region, especially in the divisional city Rajshahi and its adjacent areas. As a result expected development has not been achieved in the northern part. Major objectives of this project are to study the feasibility of gas pipeline to divisional city Rajshahi which includes design , financial and economic aspects. The study reviews the present gas supply, demand, transmission scenario and also analyzes forecasted production, supply, demand and transmission plan. The study also identifies the limitations of gas supply to divisional city Rajshahi..

Financial parameters such as Net present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR) has been calculated on the basis of 20 years project life. The analysis is firstly done on the basis of present postage stamp method of wheeling charge. The result of financial analysis shows that NPV, BCR and IRR for base case are Tk. (656.692) million, 0.78 and 13% respectively. The same for pessimistic case are Taka (1690.746) million, 0.43 and 7.65% respectively. For optimistic case these values are Taka 294.611 million, 1.10 and 16% respectively. The result shows that by applying postage stamp method of wheeling charge the project is financially viable only for optimistic case. The result of economic analysis shows that the project is economically viable for base case and optimistic case and not viable for pessimistic case. On the other hand, if revenue is calculated on distance based wheeling charge then the project is financially viable for base case and optimistic case and economically viable for all cases.

Sensitivity analysis shows that the project viability largely depends on the power sector gas demand. With power sector minimum demand the project in not financially viable even with other sectors maximum demand. On the other hand with power sector maximum demand the project is financially viable even with other sectors minimum gas demand.

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API	American Petroleum Institute
AGMS	Ashuganj Gas Manifold Station
ASME	American Society of Mechanical Engineers
BAPEX	Bangladesh Petroleum Exploration Company Limited
BCIC	Bangladesh Chemical Industries Corporation
BCR	Benefit Cost Ratio.
BFA	Bakhrabad Franchise Area
BGFCL	Bangladesh Gas Field Company Limited
BGSL	Bakhrabad Gas System Limited
BMPP	Burge Mounted Power Plant
BPDB	Bangladesh Power Development Board
CC	Combined Cycle
CGS	City Gate Station
CNG	Compressed Natural Gas
CT	Combustion Turbine
DPP	Development Project Proposal
DPT	Dye Penetrant Test
ECNEC	Executive Committee for National Economic Council
EIA	Environmental Impact Assessment
ERW	Electrical Resistance Welding
FBE	Fusion Bonded Epoxy
GIIP	Gas Initial In Place
GTCL	Gas Transmission Company Limited
HCU	Hydro Carbon Unit
HDD	Horizontal Directional Drilling
IOC	International Oil Company
IRR	Internal Rate of Return
JGDTCL	Jalalabad Gas Transmission and Distribution Company Limited
JFA	Jalalabad Franchise Area

MMSCFD	Million Standard Cubic Feet per Day
MPT	Magnetic Particle Test
MW	Mega Watt
NDT	Non Destructive Test
NPD	Norwegian Petroleum Directorate
NPV	Net Present Value
PFA	Pachimanchal Franchise Area
PGCL	Pashchimanchal Gas Company Limited
PSC	Production Sharing Contract
ROW	Right of Way
RT	Radiographic Test
SAW	Submerged Arc Welding
SOW	Set On Weight
ST	Steam Turbine
SMYS	Specified Minimum Yield Strength
TCF	Trillion Cubic Feet
TFA	Titas Franchise Area
TGTDCL	Titas Gas Transmission and Distribution Company Limited
UT	Ultrasonic Test
3LPE	Three Layer Polyethylene

SYMBOLS & TERMS

Ci	=	Cost (investment, operating and other associated expenses
I	=	Time period which runs from year to year n
n	=	The compounding period
NPVa	=	Net present value at lower discount rate
NPV_b	=	Net present value at higher discount rate
Po	=	The value of investment at year zero
P_n	=	The value of P_o at some future year, N
PV	=	Present value
r	=	Interest rate
r_a	=	Lower discount rate
r_b	=	Higher discount rate
r^*	=	IRR to be calculated

CHAPTER 1

INTRODUCTION

Natural gas is a very important national asset for Bangladesh. Use of natural gas in industries, power plants and commercial units have resulted increased production in industrial and commercial sectors, thus contributed significantly to overall economic development of the country. The government of Bangladesh has given importance to socio-economic development by ensuring the optimum use of natural gas. After completion of the Jamuna Multipurpose Bridge, a good communication has been established between the capital city to the western zone particularly with Rajshahi, Bogra, Rangpur, Dinajpur etc. As a result a congenial atmosphere has been created to develop different types of industries in the north-west divisional city Rajshahi.

Natural gas network has already been extended across the Jamuna River to supply gas up to Sirajgonj and Bogra towns. This is why the desirability of getting gas is being increased for existing and proposed power plants, industrial and domestic customers of north-west divisional city Rajshahi. At present negative impact is imposing on environment and socio-economic condition of Rajshahi and its adjacent areas due to use of wood, kerosene, LPG, diesel, furnace oil etc. in industrial, commercial and household activities.

Government of Bangladesh has planned to install a 3x30 MW power plant in Rajshahi within December 2010. Therefore extension of gas infrastructure to the divisional city Rajshahi and its adjacent areas will act as a positive impact on national economy and future necessary development. Gas supply to Rajshahi will be possible only after completion of gas transmission pipeline from Sirajgonj to Rajshahi.

Industrialization, socio-economic development and pollution free environment of Rajshahi city will be achieved after completion of this gas transmission pipeline project. Socio-economic development of the people of the north-west region of Bangladesh will be possible later by providing gas to Natore, Chapainawabganj and Nagaon districts. The completion of this pipeline project will also create the

opportunity of further extension of gas transmission network and development of infrastructure in the north-west region of the country.

1.1. Objectives

The main objectives of this study are as follows:

- Design a pipeline for gas snpply to divisional city Rajshahi and its adjacent areas.
- Study the technical feasibility of the proposed pipeline project.
- Analyze financial and economic aspects of the proposed project.
- Identify the limitations for gas supply to divisional city Rajshahi and further distances.
- Recommendations to overcome the limitations.

1.2 Methodology

- Review of the present supply, demand, consumption, transmission scenario of natural gas in Bangladesh.
- Review of the forecasted production, demand, supply and consumption of natural gas in Bangladesh.
- Identify the supply sources, potential consumers, gas demand and possible gas transmission pipeline construction for divisional city Rajshahi and its adjacent areas.
- Designing a pipeline for transmission of natural gas to the above areas.
- Financial and economic analysis of the proposed pipeline project.

CHAPTER 2

NATURAL GAS SUPPLY- DEMAND IN BANGLADESH

Natural gas is recognized as an important indigenous hydrocarbon resource in Bangladesh. It is now the major fuel for power generation in Bangladesh. It is also the raw materials for production of urea fertilizer and fuel for many industries and commercial establishment. It is an important cooking fuel in metropolitan areas like Dhaka, Chittagong, Sylhet, Commilla, Mymensing, Tangail etc. replacing the usual fuel such as wood and kerosene.

2.1 Reserves of Natural Gas in Bangladesh

Gas initially in place (GIIP) is the total amount of gas found initially in a reservoir when the reservoir is discovered. Reserve is that portion of the GIIP that can be produced from the reservoir under the present technical and economic conditions. Reserve estimation is very important for the proper planning of the energy sector of the country. It is recognized that reserve estimation is a dynamic process and the reserve of a field needs to be updated with the exploration, production and development activities. Several studies have been made for Bangladesh gas reserve estimation. A joint team of Hydrocarbon Unit (HCU) of Petrobangla and Norwegian Petroleum Directorate (NPD) conducted the latest study to estimate the gas reserve of Bangladesh. This joint study was conducted by experts of Norwegian side and those of Petrobangla, BAPEX, BGFCL, and SGFL on HCU side. This study estimated the 2P (Proven+ Probable) GIIP of the discovered fields as 28.647 TCF and recoverable reserve as 20.660 TCF[15] . This study contended that using modern technologies and good reservoir management practices it is possible to achieve a recovery factor of 70-80% in different gas fields. Based on recent information, cumulative production up to 31 December 2006 is 6.812 TCF and remaining recoverable reserve is 13.848 TCF. GIIP and reserve of different gas fields are shown in the table 2.1.

Table 2.1: Summary of Bangladesh Gas Reserve in TCF

SL no.	Fields	Year of Discovery	GIIP (2P)	Recovery factor %	Recoverable Reserve (2P)	Cumulative Production Up to December 2006	Remaining Reserve as on 1st January 2007
	A. Producing						
1	Bakhrabad	1969	1.499	70	1.049	0.662	0.387
2	Bangora	2006	0.448	70	0.314	0.0256	0.288
3	Beanibazar	1981	0.0243	70	0.017	0.044	-0 027
4	Bibiyana	1998	3.145	76	2.390		2.390
5	Fenchuganj	1988	0.404	70	0.283	0.037	0.246
6	Feni	1981	0.185	70	0.130	0.039	0.091
7	Habigonj	1963	5.139	75	3.854	1.396	2.458
8	Jalalabad	1989	1.195	70	0.837	0.362	0.475
9	Kailashtilla	1962	2.72	70	1.904	0.381	1.523
10	Meghna	1990	0.171	70	0.120	0.035	0 085
11	Moulovibazar	1999	0.449	80	0.359	0.056	0.303
12	Narshindi	1990	0.307	70	0.215	0.068	0.147
13	Rashidpur	1960	2.002	70	1.401	0.398	1.003
14	Salda	1996	0.166	70	0.116	0.048	0.068
15	Sangu	1996	1.031	82	0.845	0.398	0.447
16	Sylhet / Haripur	1955	0.684	70	0.479	0.184	0.295
17	Titas	1962	7.325	70	5.128	2.635	2.493
	Sub Total A		**26.4463**		**19.441**		**12.672**
	B. Production suspended						
18	Chattak	1959	0.677	70	0.474	0.026	0.448
19	Kamta	1981	0.072	70	0.050	0.017	0.033
	Sub-total B		**0.749**		**0.524**	**6.786**	**0.481**
	C. Non producing						
20	Begumgonj	1977	0.047	70	0.033		
21	Kutubdia	1977	0.065	70	0.046		
22	Semutanj	1969	0.227	66	0.150		
23	Shabajpur	1995	0.665	70	0.466		
	Sub-total C		**1.004**		**0.695**		**0.695**
	Grand Total (A+B+C)		**28.647**		**20.660**	**6.812**	**13.848**

Source: Bangladesh gas reserve estimation by joint study of Hydro Carbon Unit (HCU) of Petrobangla and Norwegian Petroleum Directorate (NPD).

(Note: TCF= Trillion Cubic Feet)

None producing fields Chattak and Kamta were taken out of production due to excessive sand and water. Production of Bakhrabad field has also become uncertain for the same reasons. 4 out of 8 wells of Bakhrabad field are only producing at a reduced rate of 35 MMSCFD and pressure 550 psig to overcome this situation. A compressor has set up at Bakhrabad Gas Field to increase the gas pressure with a view to maximize the capacity utilization of Bakhrabad-Chittagonj and Bakhrabad -Demra pipeline.

2.2 Present Production

At present gas is produced by state own enterprise i.e. companies of Petrobangla and International Oil Companies (IOC). Eighteen gas fields are producing around 1634 MMSCF gas per day. The present production capacity of 18 gas fields is around 1800 MMSCFD[1] . About 56% of total production comes from the state own enterprises i.e. from companies of Petrobangla and remaining 44% from IOC's under Production Sharing Contract (PSC). The present gas production from different gas fields are shown in table 2.2.

Table 2.2: Present Gas Production

Sl no.	Producing Fields	Operator	No. of wells	Production Capacity (MMSCFD)	Present Production (MMSCFD)
1	Bakhrabad Gas Field	BGFCL	4	34	32
2	Beanibazar Gas Field	SGFL	2	18	15
3	Fenchuganj Gas Field	BAPEX	2	36	21
4	Habigonj Gas Field	BGFCL	9	246	246
5	Horipur Gas Field	SGFL	2	10	8
6	Kailashtilla (MSTE) Gas Field	SGFL	4	74	73
7	Kailashtilla (Sillaca) Gas Field	SGFL	1	23	25
8	Meghna Gas field	BGFCL	1	1	1
9	Narshindi Gas Field	BGFCL	2	35	35

Table 2.2: Present Gas Production (contd.)

Sl no.	Producing Fields	Operator	No. of wells	Production Capacity (MMSCFD)	Present Production (MMSCFD)
10	Rashidpur Gas Field	SGFL	6	68	62
11	Salda Gas Field	BAPEX	2	13	11
12	Titas Gas Field	BGFCL	15	435	385
Sub total from State own enterprise			50	993	912
13	Bangora Gas Field	Tullow	2	70	71
14	Bibiyana Gas Field	Chevron	5	300	294
15	Feni Gas Field	Niko	3	7	6
16	Jalalabad Gas Field	Chevron	4	230	154
16	Moulovibazar Gas Field	Chevron	4	100	101
17	Sangu Gas Field	Cairn Energy	6	100	96
Sub total from IOC			24	807	721
Total Production			**74**	**1800**	**1634**

Source. Daily report of GTCL as of May 27, 2007

(Note : MMSCFD= Million Standard Cubic Feet per Day

The present gas production from different companies are also shown in figure 2.1

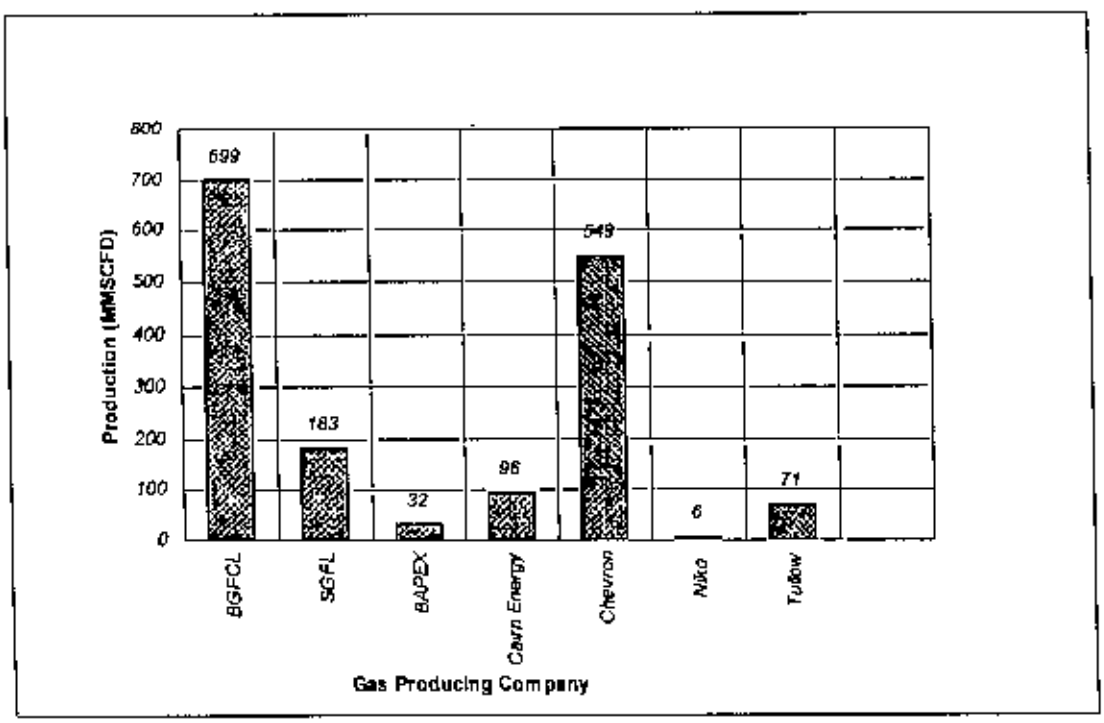


Figure 2.1: Company wise gas production in Bangladesh in 2006-2007

BGFCL is the largest gas production company in Bangladesh whose average daily production is about 699 MMSCFD. Chevron (an IOC) produces second largest amount of gas. Its daily production from three gas fields is about 549 MMSCFD. BAPEX is mainly the exploration company. To strengthen BAPEX financially government allowed to operate two gas fields, namely Salda and Fenchuganj. Average cumulative production of these two gas fields are 32 MMSCFD.

The present gas Production by companies as percentage in Bangladesh is shown in figure 2.2.

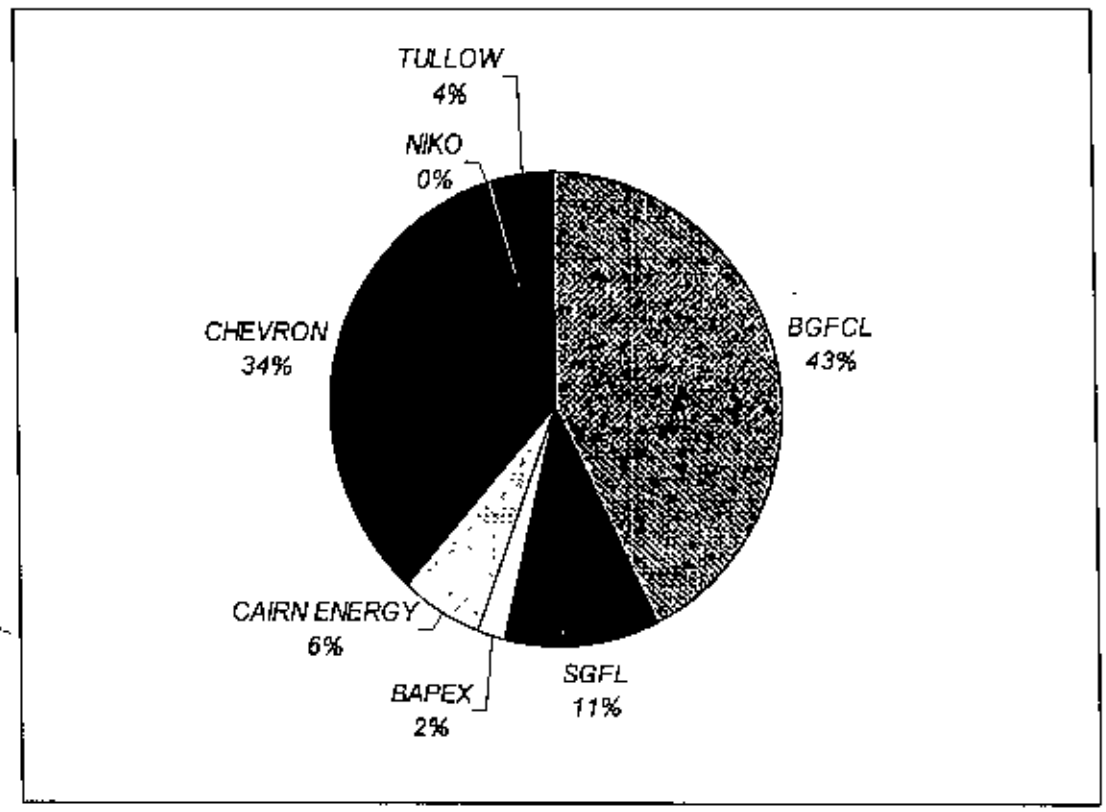


Figure 2.2: Gas Production by companies as percentage in Bangladesh (2006-2007)

BGFCL produces 43% of total productions. Chevron alone produces 34% of the total productions and cumulative production by IOC is 44% of total production. To meet the daily demand day by day we are becoming more dependent on IOC's production.

2.3 Present Consumption

The bulk of the gas consumption in power generation is about 45-50% , in the production of urea fertilizer is about 23-28% and the remaining 32-35% is being used

by various small industries, commercial customers and domestic users[18]. About 90% of total power generation and whole nitrogenous fertilizer production are at present gas based. Future growth of the economy in both indnstrial and agriculture sectors will increase the demand for natural gas.

Currently 4 companies of Petrobangla responsible for distribution and marketing of natural gas on the regional basis. These are:

a. Jalalabad Gas Transmission and Distribution Company Limited (JGTDCL): Jalalabad Gas franchise Area (JFA), Greater Sylhet.
b. Titas Gas Transmission and Distribution Company Limited (TGTDCL): Titas Gas franchise Area (TFA) , greater Dhaka, greater Mymensing and Brahman Baria.
c. Bakhrabad Gas System Limited (BGSL): Bakhrabad franchise Area (BFA), Greater Chittagong division excluding Brahmanbaria.
d. Pachimanchal Gas Company Limited (PGCL): Pachimanchal franchise Area (PFA), Rajshahi division.

Franchise area wise gas demand of the various categories of consumers area wise are provided in the table 2.3.

Table 2.3 Downstream Demand and Consumption of Natural Gas

Sl No.	Consumer	Capacity (MMSCFD)	Consumption (MMSCFD)	% of Total consumption
A. Titas Franchise Area (TFA)				
	Power			
1	Ashuganj Power Station (950 MW)	180	90.6	5.59
2	CDC Haripur PS (360 MW)	55	52.8	3.25
3	CDC Meghnaghat PS (450 MW)	90	70.6	4.35
4	Ghorasal Power Station (GPS)	241	124.6	7.68
5	Haripur PS (100 MW)	30	11.9	0.73
6	NEPC (110 MW)	28	15.5	0.96
7	REB (Madhabdy/ Ashulia-37/10 MW)	11	8.0	0.49

Table 2.3 Downstream Demand and Consumption of Natural Gas (contd.)

Sl No.	Consumer	Capacity (MMSCFD)	Consumption (MMSCFD)	% of Total consumption
8	RPCL PS (180 MW)	48	37.5	2.31
9	Siddirganj 210 MW PS	52	38.5	2.37
10	Siddirganj 50 MW PS	14	12.0	0.74
11	Tongi PS (110 MW)	20	19.6	1.21
	Independent Power producer (IPP)			
12	Alpha Power (10 MW)	2	1.5	0.09
13	AM Energy Ltd. (10 MW)	4	4.0	0.25
14	City Sugar Power (10 MW)	4	3.8	0.23
15	Meghna Energy (10 MW)	2	0.9	0.06
16	Partex Power (20 MW)	4	2.4	0.15
17	Rahim Energy (30 MW)	7	6.3	0.39
18	Shah Cement (10 MW)	2.5	1.8	0.11
19	Unic Power , unit-1&2 (40 MW)	7	5.5	0.34
	Fertilizer			
20	Ghorasal Urea Fertilizer Factory (GUFF)	45	38.0	2.34
21	Jamuna Fertilizer Co. Ltd. (JFCL)	50	40.9	2.52
22	Polash Urea Fertilizer Factory (PUFF)	18	13.7	0.84
23	Zia Fertilizer.Co. Ltd. (ZFCL)	50	47.0	2.90
24	Others (Industrial , Commercoal and Domestic)	600	572.0	35.26
	Sub Total	1565	1219.4	75.17
B. Bakhrabad Franchise Area (BFA)				
	Power			
1	Rawzan PS (210+210 MW)	90	84.0	5.18
2	Shikalbaha PS (60 MW)	20	0.0	0.00
	Fertilizer			0.00
3	Chittagonj Urea Fertilizer Factory Ltd. (CUFL)	50	52.5	3.24
4	Karnafuli Fertilizer Co. Ltd. (KAFCO)	65	35.0	2.16
5	Others (Industrial , Commercoal and Domestic)	120	104.8	6.46

Table 2.3 Downstream Demand and Consumption of Natural Gas (contd.)

Sl No.	Consumer	Capacity (MMSCFD)	Consumption (MMSCFD)	% of Total consumption
	Sub Total	345	276.3	17.03
C. Jalalabad Franchise Area (JFA)				
	Power			
1	Fenchuganj PS (90 MW)	18	16.6	1.02
2	Kumargaon PS (20 MW)	7	6.6	0.41
3	Shahjibazar PS (30 MW)	14	13.7	0.84
	Fertilizer			
4	Natural Gas Fertilizer Factory (NGFF)	18	16.7	1.03
5	Others (Industrial , Commercial and Domestic)	38	23.7	1.46
	Sub Total	95	77.3	4.77
D. Parchimanchal Franchise Area (PFA)				
	Power			
1	PDB Baghabari PS (100+71 MW)	50	23.0	1.42
2	Westmont PS (45+45 MW)	20	21.2	1.31
3	Others (Industrial , Commercoal and Domestic)	5	5.0	0.31
	Sub Total	75	49.2	3.03
	Grand Total	2080	1622.2	100.00

Source : Dailly gas report of GTCL as of 29.05.2007

(Note: MMSCFD= Million Standard Cubic Feet per Day)

Gas consumption in four different franchise areas of various categories of consumers are shown in figure 2.3.

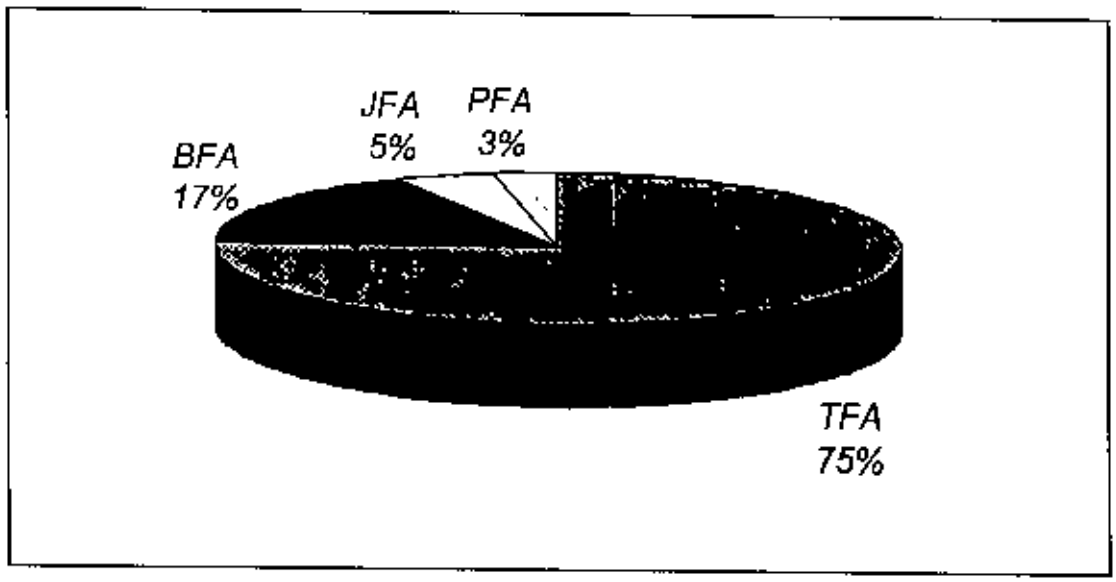


Fig 2.3 : Present Share of Gas Consumption by Different Franchise Areas

TGTDCL, the oldest gas marketing company in Bangladesh operates its business in greater Dhaka area. It consumes 75% of the total daily production. Most of the bulk consumers are in Titas Franchise Areas. On the other hand Pachimanchal Gas Company Limited formed in 2001, operating its business in Western Zone. It consumes only 3% of total daily production. If the entire North and South West zone are brought under gas network then demand and consumption in PFA will be increased significantly.

2.4 Gas Transmission

At present Gas Transmission Company Limited (GTCL) is responsible for operation and maintenance of the national gas and condensate grid line. Although, Titas Gas Transmission & Distribution Company Limited (TGTDCL) and Bakhrabad Gas System Limited (BGSL) are also operating and maintaining few old transmission pipelines.

2.4.1 Overview of transmission pipeline construction

The Gas Transmission Pipeline in Bangladesh after or before independence was mostly constructed targeting a particular bulk consumer or potential load center. Following the discovery of gas at Haripur at Sylhet 8" OD transmission pipeline was constructed from Haripur to Fenchuganj in the late fifties for supplying gas to Natural Gas Fertilizer Factory at Fenchugonj. Almost simultaneously a 4" OD transmission pipeline was constructed from Tangratilla to Chhatak for supplying gas from Chhatak Gas Field to Chhatak Cement Factory. After discovery of Titas Gas Field at Brahmanbaria the Titas-Narshingdi-Demra 14" OD gas transmission pipeline was constructed in 1967-68 for supplying gas to Dhaka City and Narayangonj area. Based on the gas available from the Titas Gas Field, important industrial centers were set-up at Ashugonj, Ghorashal, Narshingdi and Siddhergonj areas. The setting-up of Urea Fertilizer Factory at Ghorashal (UFFC), Palash Urea Fertilizer Factory (PUFF), Thermal Power Plants at Ashugonj, Ghorashal and Siddhergonj were based on gas available from the Titas Gas Field. Exploitation of gas from Habigonj Gas Field commenced with the supply of gas to Shahjibazar Power Plant. A transmission pipeline from the field was built upto Shamsharnagar to supply gas to tea gardens in and around Teliapara, Srimangal and Moulovibazar areas and also to various

consumers in Habigonj, Srimangal and Moulvibazar town. In 1980 a 12" OD gas transmission pipeline was constructed from Habigonj Gas Field to Ashugonj for supplying gas to Zia Fertilizer Factory in Ashugonj.

The most significant development in the gas sector after independence was the formation of Bakhrabad Gas Systems Limited (BGSL) which successfully implemented the following projects:

- Development of Bakhrabad Gas Field (in 1980-1982). Drilling of 4 (four) deviation wells and work over of BK-1 well.
- Installation of 60 MMCFD capacity Glycol De-hydration Plant.
- Construction of 175 KM long Bakhrabad-Chittagong Gas Transmission pipeline and 35 Km 24"/20"/16" Chittagong Ring Main pipeline (in 1982-1983)
- Lateral pipelines for supplying gas to Comilla, Chandpur, Feni, Maijdee and Kaptai.
- 24" OD 78 KM long Bakhrabad-Demra gas transmission pipeline.
- Installation of City Gate Stations at Foujderhat, Chittagong and Demra, Dhaka.
- Gas distribution network for Chittagong, Comilla, Chandpur, Feni, Maijdee and Kaptai i.e. in entire South Eastern Zone of Bangladesh.

The Development of Kailashtilla Gas Field in early eighties opened avenues for expansion of gas transmission network in the Sylhet area. A pipeline was built from Kailashtilla Gas Field to Chattak for meeting the demand of that area.

Two more important gas transmission networks were developed simultaneously under Second Development Project [4].

- 174 KM 24" OD North-South (N-S) Pipeline from Kailashtilla to Ashuganj with a parallel 6" OD condensate/NGL Pipeline (in 1991-1993).
- 124 KM 24" OD Brahmaputra Basin Pipeline from Ashugonj to Elenga for delivering gas to greater Mymensing areas, Jamuna Fertilizer Factory at

Tarakandi with a future provision for gas supply to the Western Zone of Bangladesh (in 1990-1991).

2.4.2 Present Gas Transmission

The gas transmission pipeline in Bangladesh have been planned and constructed at different stages primarily targeting a particular bulk consumer or potential load center. In the early development stage of gas sector, the grid concept was possibly not visualized. However, depending on specific requirement over the years, a national gas line grid has been developed and is linked to lateral and distribution networks for serving various gas consumers. Gas Transmission Company Limited (GTCL) was incorporated in 1993 in the unbundling process of gas sector restructuring for owning, operating and maintaining the high pressure gas transmission pipeline. The ownership of all such existing pipelines was to be handed over to GTCL in phases. However, at this stage the following companies are also operating some of the transmission pipelines in their respective franchise areas:

1. Titas Gas Transmission and Distribution Company Limited (TGTDCL)
2. Bakhrabad Gas Systems Limited (BGSL)
3. Jalalabad Gas Transmission and Distribution Company Limited (JGTDCL)

The transmission and distribution system is currently driven by utilizing field pressure, with no intermediate compressor station except one compressor to boost up the gas pressure of Bakhrabad Gas Field. Transmission pipelines constituting the national gas transmission grid is shown in table 2.4.

Table 2.4: Transmission Pipeline Constituting the National Gas Grid

Sl No.	Name of the pipeline	Dia (inch)	length (KM)	Operating pressure (psi)	Capacity (MMSCFD)	Operating Company
1	Ashuganj-Bakhrabad (A-B)	30	58	1000	375	GTCL
2	Ashuganj - Elenga (BB)	24	124	1000	300	GTCL
3	Ashuganj - Monohordi	30	37	1000	425	GTCL

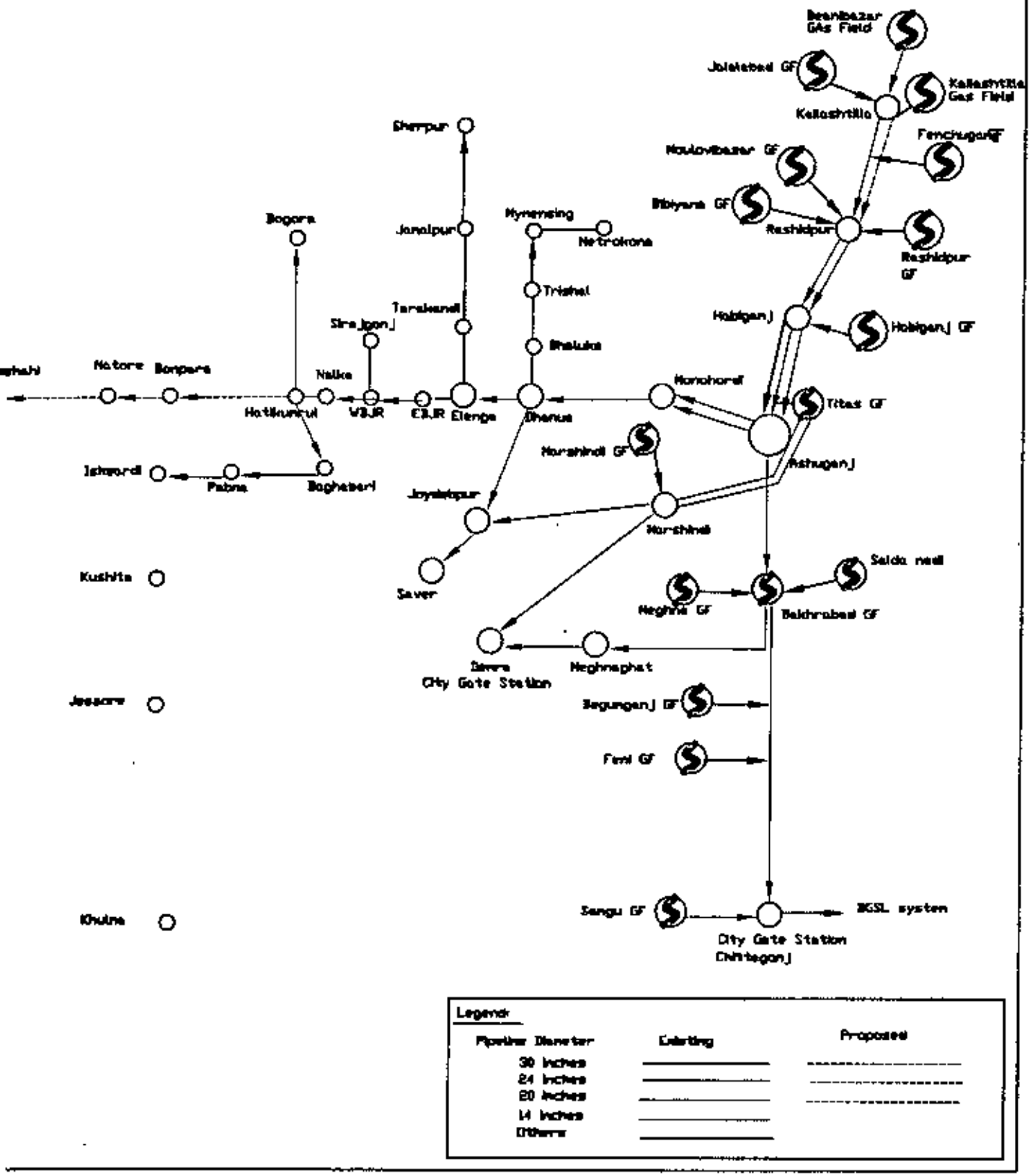
Table 2.4: Transmission Pipeline Constituting the National Gas Grid (contd.)

Sl No.	Name of the pipeline	Dia (inch)	length (KM)	Operating pressure (psi)	Capacity (MMSCFD)	Operating Company
4	Bakhrabad-Chittagonj	24	124	960	350	GTCL
5	Bakhrabad-Demra	20	69	1000	250	GTCL
6	Dhanua-Saver	20	60	1000	250	GTCL
7	Habiganj - Ashuganj	12	58	1000	85	TGTDCL
8	Habiganj Gas Field-Shajibazar Power Station	8	2	1000	50	JGTDSL
9	Haripur-NGFF	8	43	1000	60	JGTDSL
10	Jalalabad Gas Field - KTL II	14	15	1135	160	Chevron
11	KTL-II to KTL-I	14	3	1000	40	JGTDSL
12	KTL-Kuchai	6	52	1000	36	JGTDSL
13	Meghna-Bakhrabad	8	28	1000	45	BGSL
14	Monohordi-Narsindi-Siddirganj	20	65	1000	200	TGTDCL
15	Nalka-Bogra	20 & 30	55	1000	250	GTCL
16	North- South (N-S)	24	175	1000	400	GTCL
17	Rashodpur - Ashuganj	30	54	1000	425	GTCL
18	Salda-Bakhrabad	10	14	1000	65	BGSL
19	Sangu Gas Pipeline	20	48	1135	240	Shell - Cairn
20	Titas- Demra	14	82	1000	175	TGTDCL
21	Titas-Narshindi-Joydebpur	16/14	84	1000	220	TGTDCL
22	Western Zone Pipeline	30/ 24/ 20	73	1000	200	GTCL

(Note: MMSCFD= Million Standard Cubic Feet per day)

High pressure gas transmission network of Bangladesh is shown in line diagram 2.4

Figure 2.4: Gas Transmission Line Diagram:



If the transmission network in figure 2.4 is carefully analyzed it appears that Ashugonj is the focal point of the national gas grid. Gas from the Northern Gas Fields (Beanibazar, Jalalabad, Kailashtilla, Moulivibazar, Bibiyana, Rashidpur and Habigonj) are being transported through the North-South and Rashidpur-Ashuganj pipeline to Ashugonj Manifold Station of GTCL. From there it is further transmitted to Titas franchise area (TFA), Bakhrabad franchise area (BFA) and Pachimanchal franchise area (PFA) through Titas Valve Station-3 (VS-3) , Brahmaputra Basine (BB) pipeline and Ashuganj-Bakhrabad (A-B) pipeline. From Bakhrabad Gas Field Bakhrabad-Chittagong pipeline transports part of the required gas for Chittagong. The remaining gas for Chittagong is supplied from Salda, Meghna and Sangu Gas fields.

At present there is approximately 1400 Km (4" OD to 30" OD) high pressure gas transmission pipeline whose capacity is around 1650 MMSCFD which is marginally above the present average requirement[1.4]. Present transmission capacity and production capacity is hardly suitable for peak demand. North-South, Rashidpur-Ashuganj and Brahmaputra Basin pipelines are presently flowing over their capacity. To meet the projected gas demand and to facilitate gas supply to the North-Western and South-Western Zone of the country a loop line along BB pipeline needs to be constructed.

Gas pipeline network is the driving force of our economy. Starting with minor pipeline in Chhattak, the pipeline network today brought with it numerous complexities of operation. The future development of the country would depend largely on the dependable supply of energy, in other words a further development of the network especially in the Western Zone.

Gas fields so far discovered and developed are located in the Eastern Zones of the country. Consequently, the entire Eastern Zone of the country has been brought under high pressure gas transmission network connecting to the producing gas fields to the load centers. Marketing companies are providing gas for generation of power, production of fertilizer and as fuel to other industries, commercial and domestic consumers. In the recent past, the existing gas transmission grid has been extended to the Western Zone crossing Jamuna River up to Sirajgonj and Bogra. Diameter wise total existing pipe line is shown in figure 2.5.

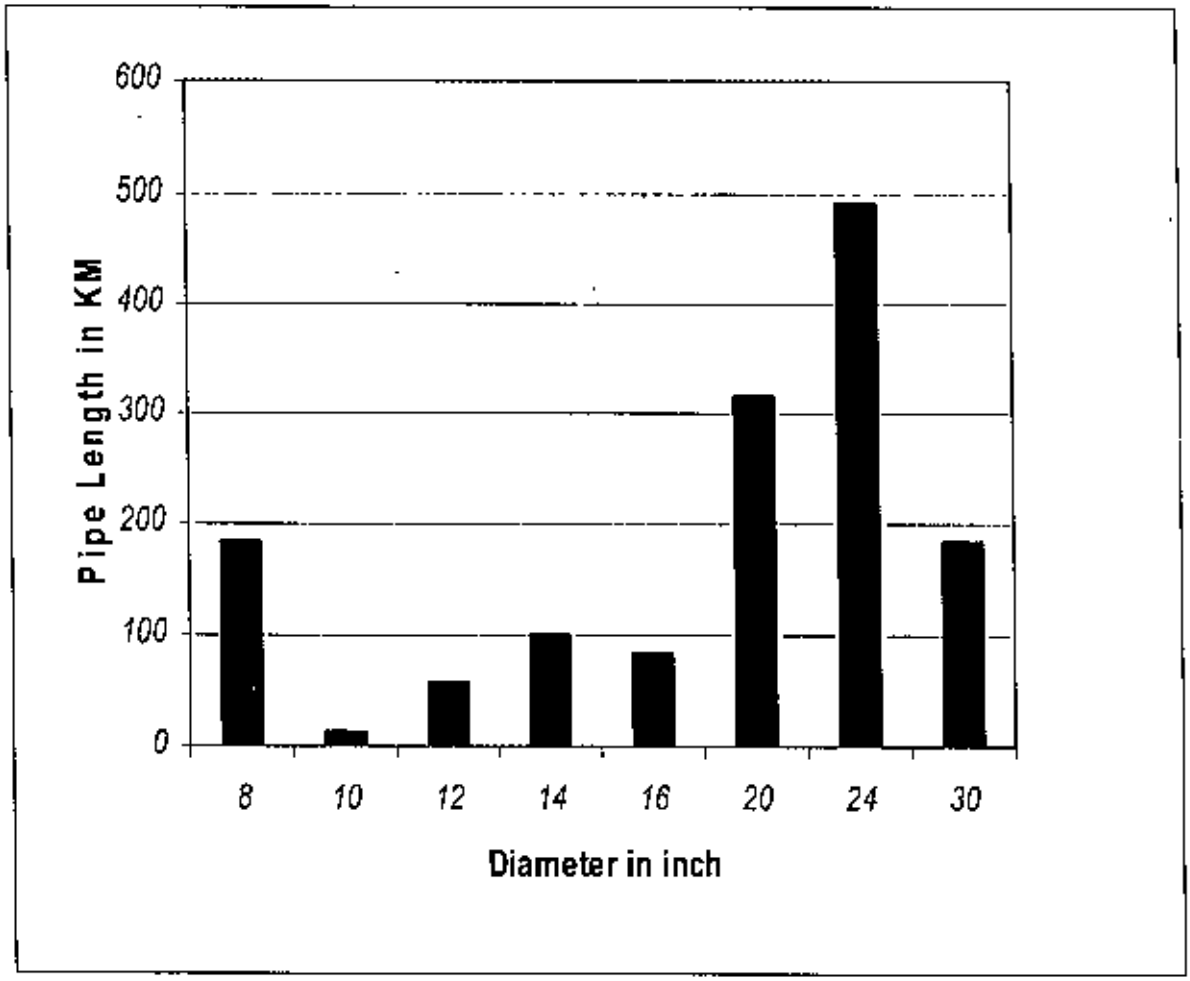


Figure 2.5: Diameter wise total transmission pipe length in 2006-2007

It shows that most of the transmission pipeline is above 20 inch diameter. Almost 1/3 of the total transmission pipeline is 24 inch in diameter. Careful analysis reveals that most of the lower diameter pipes are constructed to gas supply to a particular load center. Percentage share of pipeline by different companies are shown in figure 2.6.

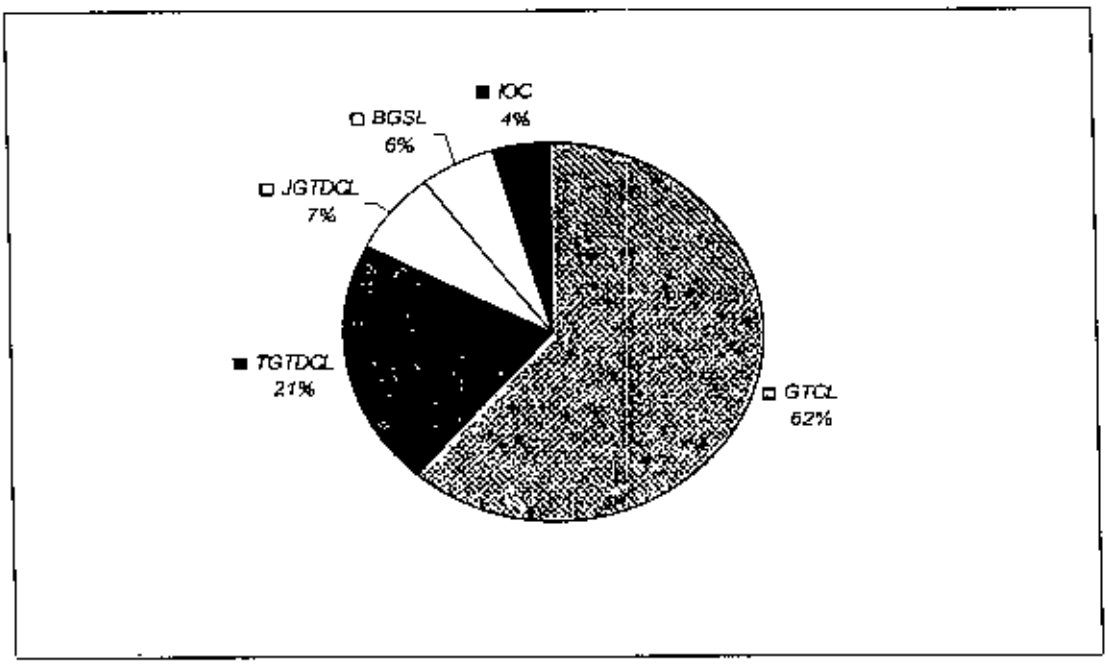


Figure 2.6: Share of total pipe length by different companies in 2006-2007

It shows that GTCL operate 62% of transmission pipe line which will be increased day by day as all the new pipeline will be built by GTCL.

Company wise total pipe length in 2006-2007 is shown in figure 2.7.

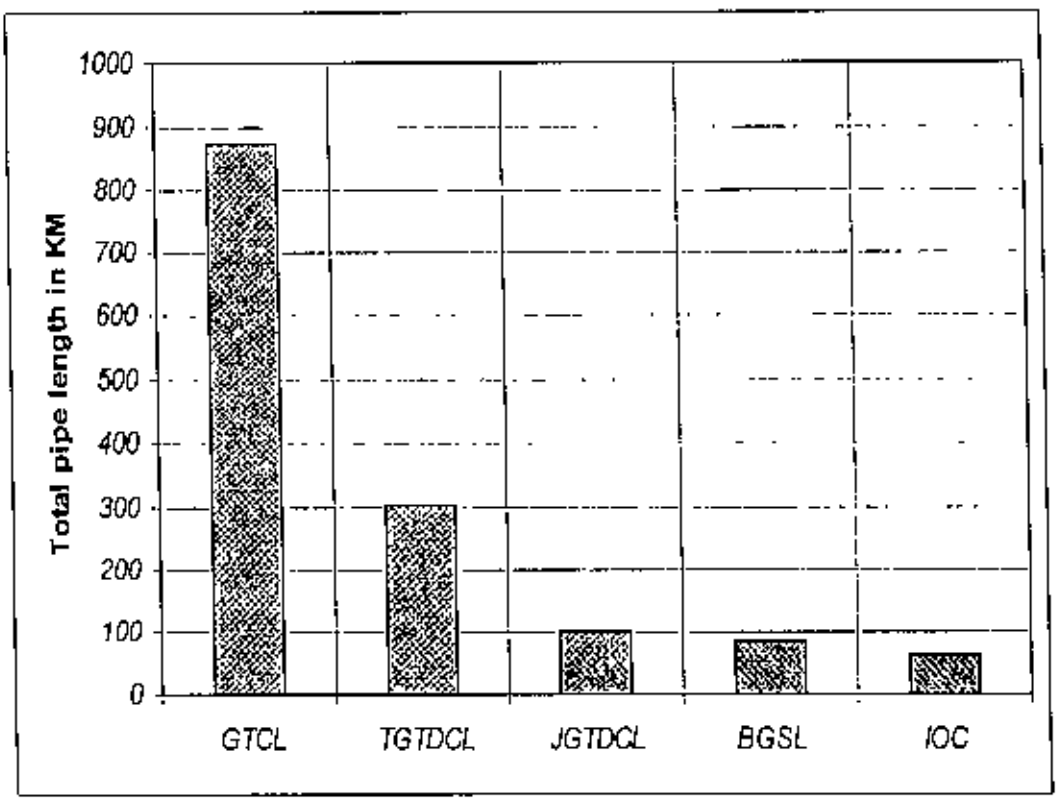


Figure 2.7: Company wise total pipe length in 2006-2007

2.5 Gas Production Forecast:

2P (Proven+ Probable) and Yet To Find (YTF) gas production forecast of different gas fields is shown in table 2.5.

Table 2.5: 2P and YTF Gas Production Forecast of Different Gas Fields[4]

Field	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Titas	414	335	342	350	350	400	477	500	500	500	500	500	500	450	350	300	300	200	150	50	2 7
Habiganj	265	270	270	270	300	350	400	495	500	500	500	500	500	500	400	325	275	200	150	100	2 6
Bakhrabad	26	34	35	45	45	45	45	75	75	75	75	75	75	75	75	75	60	40	25	15	0 4
Kamta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
Feni	35	35	35	35	30	30	250	20	0	0	0	0	0	0	0	0	0	0	0	0	0 2
Narshindi	20	15	15	25	25	25	25	25	25	25	25	25	25	25	25	25	20	15	10	8	0 2
Meghna	2 9	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	6	0 9	0	0	0.1
Salda Nadi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
Fenchuganj	45	45	45	45	45	45	45	45	45	45	45	45	45	45	35	30	30	25	25	0	0 3
Haripur	19	25	35	45	45	45	45	45	45	45	45	45	45	45	45	40	40	40	40	40	0 3
Chattak	10	25	30	45	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	0.4
Kailashtilla	53	130	150	150	250	250	250	250	250	250	250	250	250	250	250	200	200	200	200	200	1 5
Rashidpur	81	79	100	100	175	175	150	150	150	150	150	150	150	150	150	150	150	150	150	150	1 0
Beanibazar	21	21	21	19.5	19 5	19.5	18	18	17	17	15	10	10	10	9	9	9	8	8	8	0 1
Jalalabad	150	120	110	110	100	100	100	100	100	100	100	100	100	75	50	30	20	10	10	0	0 6
Sangu	153	160	160	150	140	120	110	100	87	70	55	46	39	26	16	10	0	0	0	0	0.5
Moulovibazar	65	60	60	60	60	60	60	60	60	60	60	60	60	50	40	30	27	17	5	0	0 3
Bibiyana	25	100	135	230	286	393	493	493	493	493	493	493	493	459	316	174	114	79	63	48	2 1
Kutubia	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	100	100	0 4
Shabazpur	0	0	0	0	0	0	0	0	0	30	60	60	60	60	60	60	60	60	60	60	0 2
Semutanj	0	0	0	0	0	0	0	0	15	20	20	20	20	20	20	20	20	20	20	20	0 1
YTF	0	0	0	0	0	0	0	0	123	219	384	585	786	1113	1600	1600	1600	1600	1600	1600	4 7
Prod MMSCFD	1385	1469	1558	1695	1951	2143	2553	2461	2620	2784	2962	3149	3343	3538	3626	3263	3101	2835	2686	2469	18 8
Total Prod TCF	0 5	0 5	0 6	0 6	0.7	0 8	0 9	0 9	1 0	1 0	1 1	1.1	1 2	1 3	1 3	1.2	1.1	1 0	1 0	0.9	18 8

2.6 Gas Demand Forecast

Different approaches have been adapted for forecasting gas demand for different sectors [2].

- Power sector gas demand forecast is based on power generation expansion plan up to 2024-2025. This results in a gas demand forecast on a power station by station basis.
- For fertilizer sector gas demand a plant by plant analysis is carried out.
- For the non-bulk sector (i.e. industrial/captive power, residential/commercial and transport/CNG) demand forecast is developed on a franchise area basis. The franchise areas used for non-bulk demand forecast are as follows:
    1. Titas Franchise area
    2. Baghrabad Franchise area
    3. Jalalabad Franchise area
    4. Pachimanchol Franchise area
    5. South/South West Franchise area

2.6.1 Power sector gas demand forecast

Existing power plants gas demand is shown in Table 2.6.

Table 2.6 : Existing Power Plant and Gas Demand in MMSCFD

Plant	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
A. TFA						
Ashuganj (728 mw)	180	180	180	180	180	180
CDC Horipur (360 MW)	55	55	55	55	55	55
CDC Meghnaghat (450MW)	90	90	90	90	90	90
Ghorasal (950 MW)	241	241	241	241	241	241
Horipur (100MW)	30	30	30	30	30	30
NEPC(110 MW)	28	28	28	28	28	28
REB (40 MW)	11	11	11	11	11	11
RPCL (180 MW)	48	48	48	48	48	48
Siddirganj (210 MW)	52	52	52	52	52	52
Siddirganj (50MW)	14	14	14	14	14	14
Tongi (110MW)	20	20	20	20	20	20
IPP						
Alpha Power (10 MW)	2	2	2	2	2	2

Table 2.6 : Existing Power Plant and Gas Demand in MMSCFD (contd.)

Plant	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012
Meghna Energy (10 MW)	2	2	2	2	2	2
Partex Power (20 MW)	4	4	4	4	4	4
Rahim Energy (10 MW)	7	7	7	7	7	7
Shah Cement (10 MW)	2.5	2 5	2.5	2.5	2.5	2.5
Unic Power -unit 1& 2 (40 MW)	7	7	7	7	7	7
Sub Total	**793.5**	**793.5**	**793.5**	**793.5**	**793.5**	**793.5**
B. BFA						
Rawzan (210 + 210 MW)	90	90	90	90	90	90
Shikalbaha (60 MW)	20	20	20	20	20	20
Sub total	**110**	**110**	**110**	**110**	**110**	**110**
C. JFA						
Fenchuganj (90 MW)	16	16	16	16	16	16
Kumargaon (20 MW)	7	7	7	7	7	7
Shahjibazar (30 MW)	14	14	14	14	14	14
Sub Total	**37**	**37**	**37**	**37**	**37**	**37**
D. PFA						
PDB –Baghabari (100+71 MW)	50	50	50	50	50	50
Westmont (45+45MW)	20	20	20	20	20	20
Sub Total	**70**	**70**	**70**	**70**	**70**	**70**
Total	**1010.5**	**1010.5**	**1010.5**	**1010.5**	**1010.5**	**1010.5**

Source: Wood Mackenzie , Preparation and development of gas sector master plan and strategy for Bangladesh-2005

Gas demand forecast for planned power plants is shown in Table 2.7.

Table 2.7. Gas Demand Forecast for Planned Power Plants in MMSCFD

Plant	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
Siddirganj (120MW)	20	20	20	20	20	20
Siddirganj Peaking PP (2x 120MW)	40	40	40	40	40	40
Chandpur(150 MW)	-	24	24	24	24	24
Horipur (150 MW)	-	24	24	24	24	24
Meghnaghat (450 MW)	-	-	72	72	72	72

Table 2.7. Gas Demand Forecast for Planned Power Plants in MMSCFD (contd.)

Plant	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
Khulna (100MW) Peaking PP	-	-	16	16	16	16
Bhola (150 MW)	-	-	24	24	24	24
Fenchuganj (90 MW) Phase 2	-	15	15	15	15	15
North Dhaka (450 MW)	-	-	-	72	72	72
Sirajgonj (450 MW)	-	-	-	-	72	72
Bheramara (450 MW)	-	-	-	-	72	72
Total	**60**	**123**	**235**	**307**	**451**	**451**

Source. Wood Mackenzie , Preparation and development of gas sector master plan and strategy for Bangladesh-2005

2.6.2. Fertilizer sector gas demand

The present fertilizer capacity in Bangladesh comprises six urea plants owned by Bangladesh Chemical Industries Corporation (BCIC) and export oriented plant the Karnaphuli Fertilizer Co. Ltd. (KAFCO) which is a state-private venture. The combined urea production capacity of the seven gas based fertilizer units is about 3.00 million tonnes per annum (mmtpa) and daily gas consumption is about 286 MMSCFD[2]. Gas demand for existing fertilizer factories are shown in table 2.8.

Table 2.8 Gas Demand for Existing Fertilizer Factory

Name of the Plant	Location	Commission	Capacity (mmtpa)	Average Gas consumption (MMSCFD)
Zia Fertilizer Co. Ltd. (ZFCL)	Ashuganj	1981	0 53	50
Jamuna Fertilizer Co. Ltd. (JFCL)	Tarakandi	1991	0.56	47
Urea Fertilizer Co. Ltd. (UFCL)	Ghorashal	1970	0.47	50
Polash Urea Fertilizer Co. Ltd. (PUFCL)	Polash	1985	0.47	15
Chittagong Urea Fertilizer Co. Ltd. (CFCL)	Chittagong	1987	0.47	50

Table 2.8 Gas Demand for Existing Fertilizer Factory (contd.)

Name of the Plant	Location	Commission	Capacity (mmtpa)	Average Gas consumption (MMSCFD)
Natural Gas Fertilizer Co. Ltd. (NGFCL)	Fenchuganj	1961	0.47	18
Karnaphuli Fertilizer Co. Ltd. (KAFCO)	Chittagong	1994	0.47	56
Total			2.99	286

Source: Wood Mackenzie, Preparation and development of gas sector master plan and strategy for Bangladesh-2005

Future gas demand for fertilizer sector:

The issue for Bangladesh is how to meet the demand for urea. It has the option to import urea from international market or manufacture it domestically. Analysis shows that installation of a green field urea plant would generate a negative NPV at current gas price for the fertilizer sector. If the gas price were to increase to more economic levels (USD 3.34/mmbtu) a higher negative NPV is generated. However economics alone may not be the deciding factor in the decision to import urea or manufacture it domestically. There are clearly some benefits associated with allowing this investment in a new fertilizer plant namely:

- It will give a positive signal regarding the investment climate in Bangladesh.
- It will generate new employment opportunities in the country.
- It will create increased domestic demand for gas. This will in turn provide a signal to upstream suppliers (especially IOCs) that any future gas discoveries could be sold in Bangladesh. In this way, it could be a positive step towards stimulating domestic exploration and production gas sector activity. Therefore we have assumed that the TAFA plant is commissioned by 2010-11, adding about 85 MMSCFD demand into the system.[2] Besides the TATA plant, we also assume the long awaited replacement of the NGFF by the Shahajalal Fertilizer factory takes place. While the proposed capacity of the Shahajalal Fertilizer plant is 1750 tpd, have assumed that to take advantage of economics of scale, a more economic configuration of 2500 tpd will be installed. Assume that the fertilizer factory would be commissioned by 2015-2016. Gas Demand forecast for fertilizer sector up to 2024-2025 is shown in Table 2.9.

Table 2.9 : Gas Demand Forecast for Fertilizer Sector Up to 2024-2025

Plant	2005-2006		2010-2011		2015-2016		2020-2021		2025-2026	
	Avg.	Peak	Avg.	Peak	Avg	Peak.	Avg	Peak	Avg	Peak
Zia Fertilizer Co Ltd. (ZFCL)	50	55	50	55	50	55	50	55	50	55
Jamuna Fertilizer Co. Ltd. (JFCL)	47	52	47	52	47	52	47	52	47	52
Urea Fertilizer Co. Ltd. (UFCL)	50	55	50	55	50	55	50	55	50	55
Polash Urea Fertilizer Co. Ltd. (PUFCL)	15	17	15	17	15	17	15	17	15	17
Chittagong Urea Fertilizer Co. Ltd. (CFCL)	50	55	50	55	50	55	50	55	50	55
Natural Gas Fertilizer Co. Ltd. (NGFCL)	18	20	18	20	0	0	0	0	0	0
Karnaphuli Fertilizer Co. Ltd. (KAFCO)	56	62	56	62	56	62	56	62	56	62
DAP , Chittagong			15	17	15	17	15	17	15	17
TATA ,Chittagong	--	-	85	94	85	94	85	94	85	94
Shahajalal	-	-	-	-	45	50	45	50	45	50
Total	**286**	**316**	**386**	**427**	**413**	**457**	**413**	**457**	**413**	**457**

-Source: Wood Mackenzie , Preparation and development of gas sector master plan and strategy for Bangladesh-2005

(Note: Average demand based on 90% capacity utilization and peak demand based on 100% plant capacity utilization [2].)

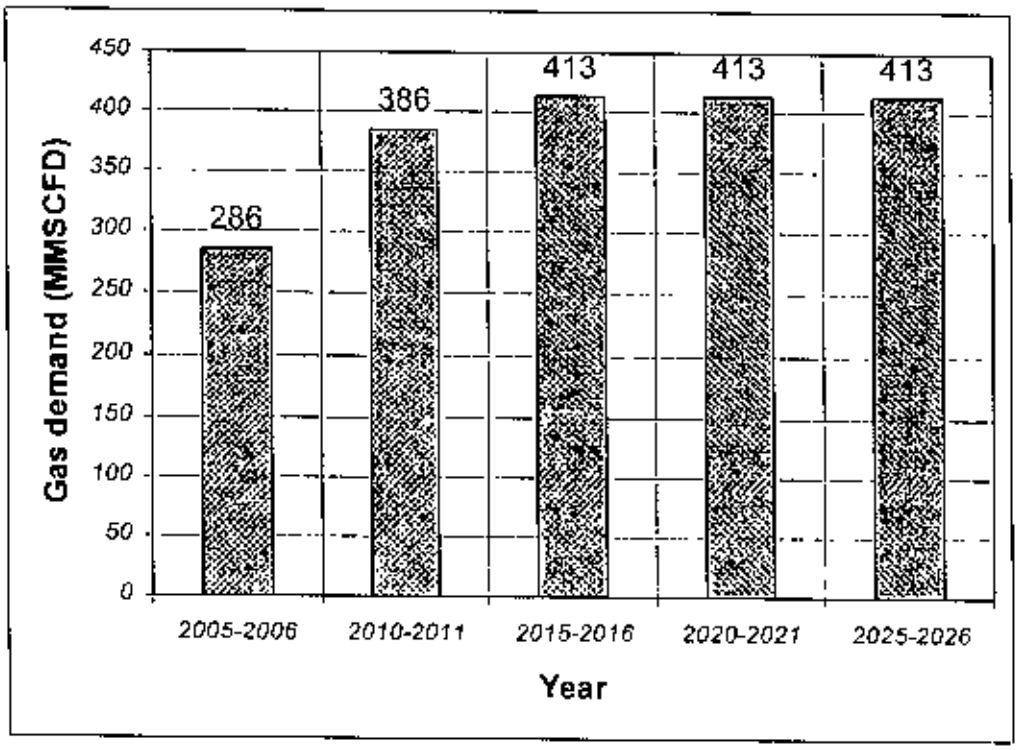


Figure 2.8: Gas demand for fertilizer up to 2025-2026

At present fertilizer sector gas demand is 286 MMSCFD. Figure 2.8 shows that it will be increased up to 386 MMSCFD by the year 2010 and 413 MMSCFD by the year 2015. After 2015 fertilizer sector gas demand will be constant.

CHAPTER 3

PROSPECT OF GAS UTILIZATION IN RAJSHAHI

Natural gas as a cheap. clean fuel transported by the pipeline will be used by existing and new power plants, fertilizer factories, industries, commercial and domestic consumers as a fuel replacement for diesel, wood, peat, agricultural residues.

3.1 Sources and Supply Situation to Rajshahi

Natural gas supply to divisional city Rajshahi and its adjacent area would be dependent on the supply from eastern area. On careful analysis of the national gas transmission network it appears that Ashuganj is the main hub of the national gas grid. Most of the gas from the northern gas fields (Beanibazar, Kailashtilla, Jalalabad, Moulovibazar, Bibiyana, Rashidpur, Habiganj and Titas) are transported through the Noth-South and Rashidpur-Ashuganj pipeline to Ashuganj Gas Manifold Station (AGMS) of GTCL. From AGMS it is further transported to Titas Franchise Area (TFA) and Pachimanchol Franchise Area (PFA) through Brahmaputra Basin pipeline, Bakhrabad Franchise Area (BFA) through Ashuganj-Bakhrabad pipeline. The Noth-South and Rashidpur-Ashuganj pipelines are ruming at full capacity. The current average gas transmission scenario through North-South and Rashidpur-Ashuganj pipeline to AGMS from north-eastern gas fields are given in Table 3.1.

Table 3.1: Gas Transmission Scenario of North-South and Rashidpur-Ashuganj Pipeline

Gas Field	Avg. Feed (MMSCFD)	Pressure (Psig)
Beanibazar	27	1079
Kailashtilla	73	1070
Jalalabad	166	1067
Fenchuganj	20	1042
Moulovibazar	101	1024
Bibyana	310	981
Rashidpur	62	982
Habiganj	180	990

Table 3.1:Gas Transmission Scenario of North-South and Rashidpur-Ashuganj Pipeline (contd.)

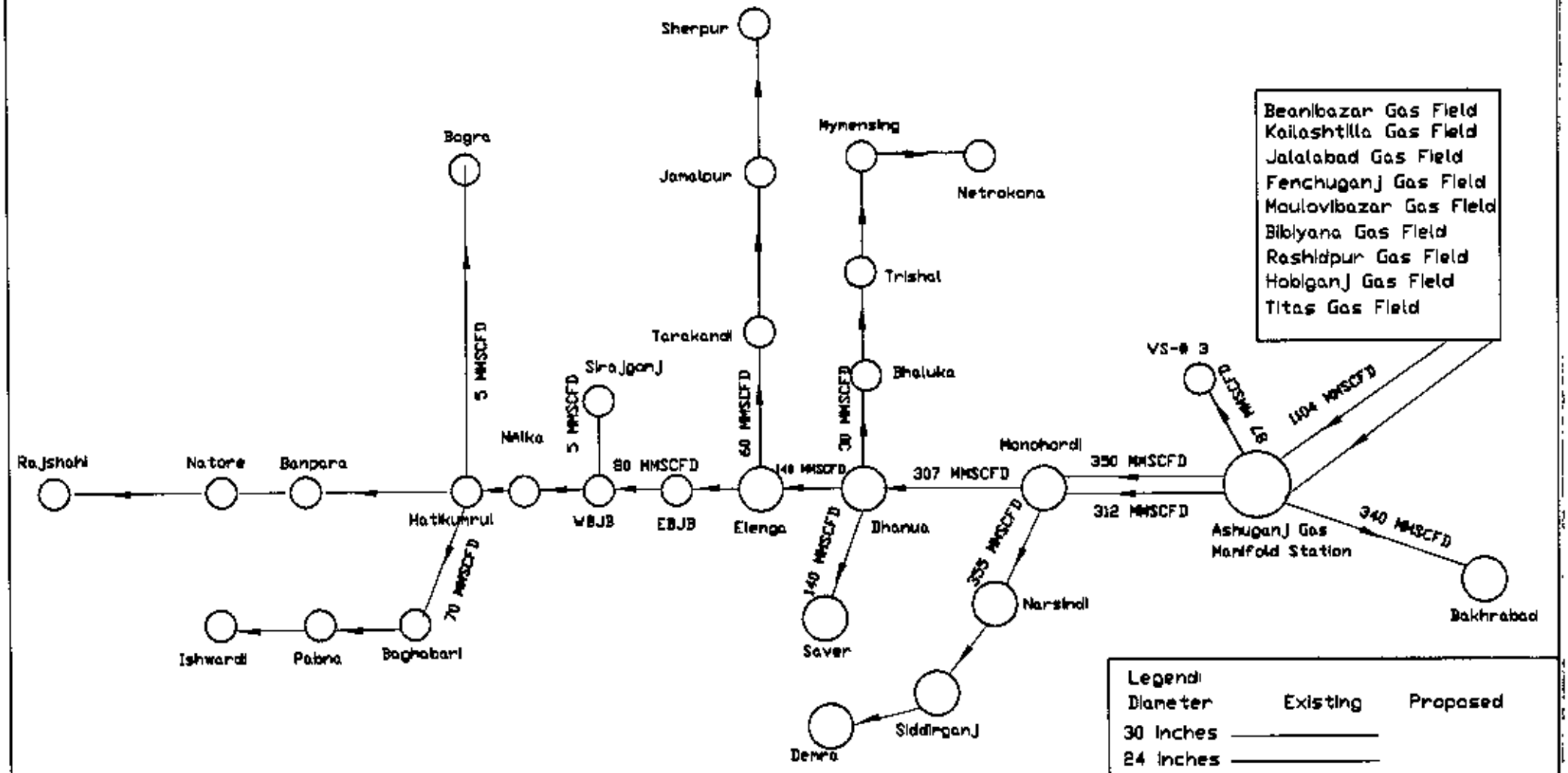
Gas Field	Avg. Feed (MMSCFD)	Pressure (Psig)
Titas	200	874
Total	1139	-
On the way JFA consumed	35	-
Total Feed To AGMS	1104	-

Gas from Ashuganj Gas Manifold Station can be evacuated through the following delivery lines.

Midline Valve Station # 3 at Ashuganj		- 87 MMSCFD
30" OD Ashuganj- Bakhrabad Pipeline		-340 MMSCFD
24" OD Brahmaputra Basin Pipeline		-310 MMSCFD
30" OD Ashuganj-Monohordi Pipeline		-350 MMSCFD
	Total	= 1089 MMSCFD

Brahmaputra Basin pipeline is the only transporter of gas to the western zone. Now it is operating at full capacity of 310 MMSCFD. It delivers gas to Narshindi Ghorashal, Siddirganj, Horipur and Demra through Monohordi- Narshindi-Siddirganj (20" OD x 65 Km) pipeline. It also supplies gas to various consumers in the Mymensing, Kishorganj, Netrokona, Savar, Tarakandi (JFCL), Jamalpur and Tangail areas. It transports gas to the western zone after meeting the gas demand along the pipeline route. Figure 3.2 shows the role of Brahmaputra Basin Pipeline The natural gas available to the western zone through Brahmaputra Basin pipeline is essentially the balance between its capacity and the gas demand in the eastern area. At present only 80-100 MMSCFD gas can be supplied to the western zone through Brahmaputra Basin pipeline. Therefore the capacity of the Brahmaputra Basin pipeline is a constraint for gas supply to the western zone. To satisfy the increasing demand of western zone a parallel pipeline from Monohordi to Elenga would be required. It requires additional investment to construct the pipeline. At present gas pressure at Elenga is about 600psig. To increase the capacity of downstream pipeline from Elenga it needs to boost up gas pressure from 600 psig to 1000psig at Elenga. Otherwise gas at desired pressure will not be available at Rajshahi in spite of pipeline

Figure 3.2 : Role of Brahmaputra Basin Pipeline



construction. If in future entire north and south west zone are brought under high pressure gas transmission network then existing gas pipeline over Jamuna Bridge (30"OD x 6 Km) will be another constraint for gas supply to western zone.

3.2 Potential Gas Consumer in Rajshahi Area

Western zone of Bangladesh is a potential area for gas market development. The possibility of expansion of gas network extending from Nalka to Rajshahi- Jessore-Khulna largely depends on identification of anchor load i.e. power plant and fertilizer factory in that area. Therefore, the study concentrates mainly on the assessment/ review of all existing, committed and new power plants, fertilizer factories and limited concentration on the commercial and domestic loads. Potential gas consumers in western zone depending on the nature and objective of gas use are classified as follows:

- Bulk customer
  - Power producing customer
  - Fertilizer producing customer
  - Captive power producing customer

- Non bulk customer
  - Industrial customer
  - Commercial customer
  - Seasonal customer
  - Domestic customer

3.2.1 Power Sector Gas Demand Forecast

Power plant is the main consumer of gas. Power producing customers are government i.e. Bangladesh Power Development Board (BPDB) and IPP (Independent power producer). Existing and planned power plants in western zone are given in table 3.2 and 3.3 respectively [7, 2].

Table 3.2 Existing Power Plants and Gas Demand in Western Zone Area

Sl. No.	Location	Operator	Plant Type	Year of commissioning	Type of Fuel	Installed capacity (MW)	Generating Capacity (MW)	Gas Demand (MMSCFD)
1	Baghabari	PDB	CT	1991	Gas	71	71	22
2		PDB	CT	2001	Gas	100	100	28
3		Westmont	CT	1999	Gas	2 x 45	90	20
4	Bogra	PDB	CT		HSD	7	6	-
5	Bheramara	PDB	CT	1976	HSD	3 x 20	54	-
6	Barisal	PDB	CT	1985	HSD	2 x 20	40	-
	Bhola	PDB	D	1988	HSD	2 x 3.2	6	-
7	khulna	PDB	CT	-	HSD	10	10	-
8		PDB	CT	-	SKO	10	10	-
9		PDB	CT	1980	SKO	2 x 28	56	-
10		PDB	ST	1973	HFO	60	55	-
11		PDB	ST	1984	HFO	110	95	-
12		Wartsilla	BMPP	1999	HFO	19 x 6	110	-
13	Rangpur	PDB	CT	1988	HSD	1 x 20	18	-
14	Sayedpur	PDB	CT	1981	HSD	1 x 20	18	-

Source: Daily report of BPDB .

Table 3.3: Planned Power Plants and Gas Demand in Western Zone

Location	Operator	Plant Type	Type of Fuel	Capacity (MW)	Planned year of Operation	Gas demand (MMSCFD)
Baghabari BMPP	PDB	CC	Gas	130	2008	26
Khulna	PDB	ST	Gas	197	2009	38
Sirajgonj	PDB	CC	Gas	450	2009	90
Bogra	PDB	CT	Gas	150	2009	30
Bhola	PDB	CC	Gas	150	2009	30
Khulna	PDB	CT	Gas	100	2009	20
Sirajgonj	PDB	CC	Gas	450	2012	90
Bheramara	PDB	CC	Gas	450	2012	90
Khulna	PDB	CC	Gas	450	2015	90
Rajshahi	PDB	CC	Gas	450	2016	90
Saidpur	PDB	CT	Gas	150	2018	30
Baghabari	PDB	Ct	Gas	150	2021	30
Barisal	PDB	CT	Gas	150	2021	30
Khulna new	PDB	CC	Gas	700	2023	140

Table 3.3: Planned Power Plants and Gas Demand in Western Zone (contd.)

Location	Operator	Plant Type	Type of Fuel	Capacity (MW)	Planned year of Operation	Gas demand (MMSCFD)
Khulna new	PDB	CT	Gas	700	2023	140
Khulna new	PDB	CC	Gas	700	2024	140
Baghabari	PDB	CT	Gas	150	2025	30
Rangpur	PDB	CT	Gas	150	2025	30
Bheramara	PDB	CT	Gas	150	2025	30
					Total Gas demand	1194

Source. Power sector master plan update, Nexant, component B.

3.2.2 Fertilizer sector gas demand forecast in western zone

Urea Fertilizer factories are the second major consumers of natural gas. Gas demand largely depends on setting up of fertilizer factory in the western zone for meeting the demand of vast agricultural land in the western zone of the country. It may be mentioned here that western zone of the country predominantly agro-based yet no urea fertilizer factory could be set up due to non availability of natural gas in the region.

Bangladesh Chemical Industries Corporation (BCIC) planned to install a 1700 Ton Per day capacity urea plant on the west bank of Jamuna Bridge i.e. at Sirajgonj It is expected that the operation will start from 2010. Besides, it is also proposed to construct a 1750 Ton Per Day capacity urea fertilizer industry at Bhola by 2011. Executive Committee for National Economic Council (ECNEC) has given approval for Borendro Fertilizer Limited at Bogra. Each of these plants may consume between 45-50 MMSCFD of natural gas [10]. Gas supply to Rajshahi will also create opportunities to set up a fertilizer factory at Rajshahi on the bank of the Padma river.

3.2.3 Industrial sector gas demand in western zone

There are various medium and small agro-based firms and factories in the western zone. These factories are rice polishing, tobacco, sugar, paper, bricks, dairy products, glass etc. Several others small factories are scattered in the region. According to the

Bangladesh Bureau of Statistics Rajshahi and Khulna division of western zone has 7,765 and 3,100 units of medium and large scale industries respectively.

The industrial development of this area is suffering due to high transportation cost, unsteady power supply, weak financing, inadequate infrastructure, lack of skilled manpower etc. Replacement of conventional fuel with natural gas should initiate development and consequently increase consumption of natural gas. Industries in western zone at Sirajgonj, Pabna, Rajshahi, Rangpur, Jessore, Khulna, export processing zone at Ishwardi and Mongla may be the major consumers of natural gas. Government of Bangladesh (GOB) has announced attractive package of incentives for setting up of industries at Uttara EPZ in Nilphamari.

Bangladesh Small and Cottage Industries Corporation is developing seventeen industrial estates in the north-western zone. Twenty districts are situated in the south-western zone of Bangladesh. Gas supply to this region would boost up the economic development of the region as it will encourage the establishment of new business and expand the activities of the existing ones.

3.3 20-Years Demand Forecast for Rajshahi

Gas demand in Rajshahi city and its adjacent areas largely depends on the timely completion of planned power plants, fertilizer factories and other industries. Bangladesh Power Development Board has planed to install 3x 30 MW power plants by the end of 2010 and 3x150 MW power plants by 2016 in Rajshahi.[11]. A recent study of power sector gas demand by Pachimanchal Gas Company Limited for Rajshahi area shows that PDB, Rajshahi has short term plan to install 2x30 MW power plants by December 2010, medium term plan to install 2x30 MW power plants and another 100 MW power plants will be installed by 2016. A recent study of gas demand for Rajshahi by GTCL shows that 20 MMSCFD gas demand by 2010 and 45 MMSCFD gas demand by 2023 [13].

3.3.1 Pessimistic condition

Considering power sector gas demand forecast by Power Development Board, Rajshahi and incase of industrial demand considering the demand of Bogora and Sirajgonj city. For pessimistic case it is expected that in non-bulk sector 12% annual increment of gas demand up to 5th year and then 8% after 5th year of operation. Cumulative Gas demand in Rajshahi city and its adjacent areas for pessimistic case is shown in table 3.4.

Table 3.4 Gas Demand of Rajshahi for Low Case

Year	Power		Fertilizer	Non bulk	Total gas Demand/ Day
	MW	MMSCFD	MMSCFD	(MMSCFD)	MMSCFD
0(2008)		0	0	0	0.0
1		0	0	0	0.0
2		0	0	0	0.0
3(2011)	60	10	0	5.0	15.0
4	60	10	0	5.6	15.6
5	60	10	0	6.3	16.3
6	60	10	0	7.0	17.0
7	60	10	0	7.9	17.9
8(2016)	160	10	0	8.8	18.8
9	160	26	0	9.5	35.5
10	160	26	0	10.3	36.3
11	160	26	0	11.1	37.1
12	160	26	0	12.0	38.0
13	160	26	0	12.9	38.9
14	160	26	0	14.0	40.0
15	160	26	0	15.1	41.1
16	160	26	0	16.3	42.3
17	160	26	0	17.6	43.6
18	160	26	0	19.0	45.0
19	160	26	0	20.5	46.5
20	160	26	0	22.2	48.2
21	160	26	0	24.0	50.0
22	160	26	0	25.9	51.9

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day)

Source: i) Power sector gas demand forecast is based on the proposed power plant data found from Bangladesh Power Development Board (BPDB), Rajshahi.

ii) Non bulk gas demand forecast is based on the recent gas demand of Sirajgonj and Bogora city..

3.3.2 Base condition

For base case or most likely condition it is expected that in non-bulk sector 15% annual increment of gas demand up to 5th year and then 10% after 5th year of operation. Cumulative Gas demand in Rajshahi city and its adjacent areas for base case is shown in table 3.5

Table 3.5 Gas Demand of Rajshahi for Base Condition

Year	Power		Fertilizer	Non bulk	Total gas Demand / Day
	MW	Gas Demand / day (MMSCFD)	Gas Demand	Gas Demand / day (MMSCFD)	MMSCFD
0(2008)		0	0	0	0 0
1		0	0	0	0 0
2		0	0	0	0 0
3 (2011)	90	14.4	0	5 0	19 4
4	90	14 4	0	5 8	20,2
5	90	14,4	0	6 6	21 0
6	90	14,4	0	7,6	22.0
7	90	14 4	0	8 7	23 1
8(2016)	240	38 4	0	10 1	48 5
9	240	38 4	0	11.1	49 5
10	240	38 4	0	12.2	50 6
11	240	38 4	0	13 4	51 8
12	240	38 4	0	14 7	53.1
13	240	38 4	0	16,2	54 6
14(2022)	390	62,4	0	17 8	80 2
15	390	62 4	0	19.6	82 0
16	390	62 4	0	21 6	84 0
17	390	62 4	0	23 7	86 1
18	390	62 4	0	26 1	88 5
19(2027)	540	86 4	0	28 7	115.1
20	540	86 4	0	31 6	118 0
21	540	86 4	0	34 7	121,1
22	540	86 4	0	38.2	124 6

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day:)

Source:

i) Power consumption forecast is based on the proposed power plant data found from Bangladesh Power Development Board (BPDB).

ii) Non bulk gas demand forecast is based on the recent gas demand of Sirajgonj and Bogora city..

3.3.3 Optimistic condition

For optimistic case it is expected that in non-bulk sector 20% annual increment of gas demand up to 5th year and then 10% after 5th year of operation. Cumulative Gas demand in Rajshahi city and its adjacent areas for optimistic case is shown in table 3.6.

Table 3.6 Gas Demand of Rajshahi for Optimistic Condition

Year	Power		Fertilizer	Non bulk	Total Gas Demand / Day
	MW	Gas demand / day (MMSCFD)	Gas Demand	Gas demand / day (MMSCFD)	MMSCFD
0(2008)		0	0	0	0.0
1		0	0	0	0 0
2		0	0	0	0 0
3 (2011)	90	14 4	0	5 0	19 4
4	90	14 4	0	6 0	20 4
5	90	14 4	0	7 2	21 6
6	90	14 4	0	8 6	23 0
7	90	14 4	0	10 4	24 8
8	540	86 4	0	12 4	98 8
9	540	86 4	0	13 7	100.1
10	540	86 4	0	15 1	101 5
11	540	86 4	0	16 6	103 0
12	540	86 4	0	18 2	104.6
13	540	86 4	0	20.0	106.4
14	540	86.4	0	22 0	108.4
15	540	86 4	0	24 2	110 6
16	540	86.4	0	26 7	113 1
17	540	86 4	0	29.3	115.7
18	540	86 4	0	32 3	118 7
19	540	86 4	0	35.5	121 9
20	540	86 4	0	39.0	125 4
21	540	86 4	0	43 0	129.4
22	540	86 4	0	47 2	133 6

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day)

Source:

i) Power consumption forecast is based on the proposed power plant data found from Bangladesh Power Development Board (BPDB)

ii) Non bulk gas demand forecast is based on the recent gas demand of Sirajgonj and Bogora city.,

Demand curve with time for low case, base case and most optimistic case are shown in the figure 3.3

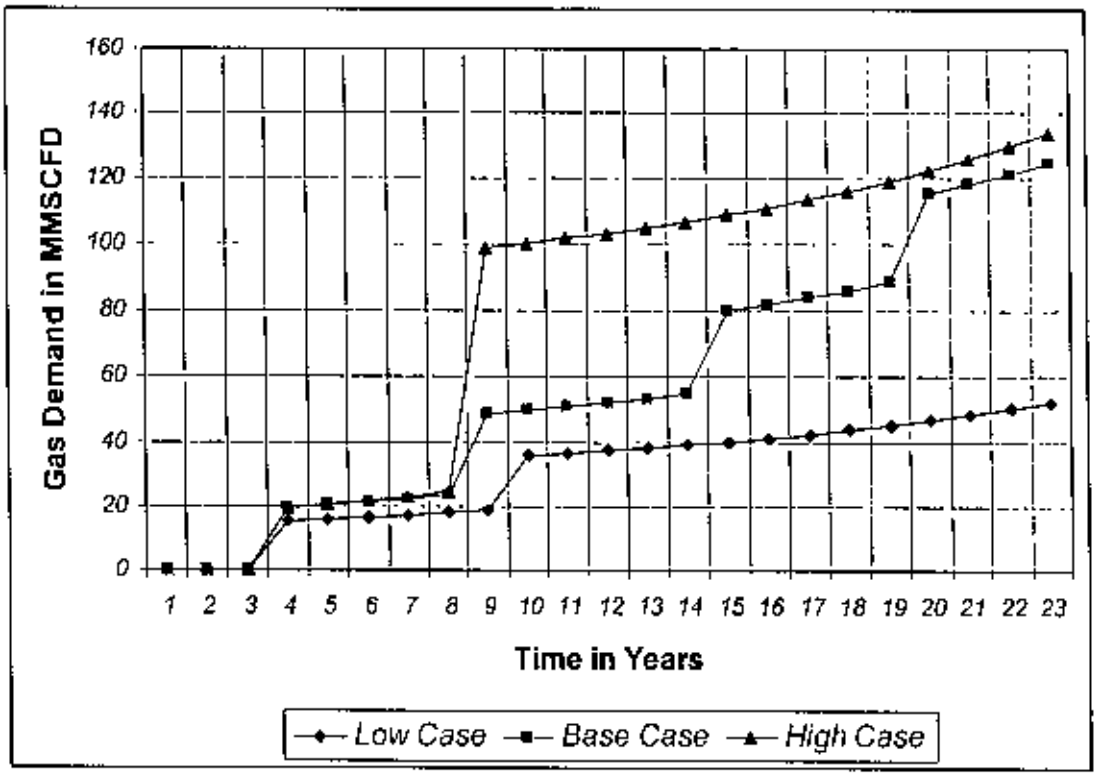


Figure 3.3: Gas Demand of Rajshahi for Pessimistic, Most Likely and Optimistic Condition

CHAPTER 4

PROPOSED PIPELINE DESIGN AND CONSTRUCTION

In earlier days, pipeline design was done considering the present load and 15% to 30% increment of load. But now a days the use of natural gas increased significantly. As a result the concept of pipeline design has also changed. Presently pipeline design is being done considering the present load as well as the assumed gas load of that particular area for the next 20 years which is also the effective life of the pipeline.

4.1 General Guidelines for Pipeline Design

- Total pipe length should be as minimum as possible
- Parallel to the existing utility corridors (highway, high tension electric transmission line)
- Avoid areas of high population density.
- Minimize highways, railways, rivers, canals, ponds, hills and mountains crossing to reduce the project cost.
- Cross highways, railways, rivers, canals, ponds at or close to 90 degree angle.
- Avoid areas of swamps and wetlands, rocky areas, unstable soil, historical places, environmentally sensitive areas e.g. mosque, graveyard, temple etc.
- Minimize crossover of existing facilities.
- Provide adequate construction area.

4.2 Brief Description of Proposed Pipeline

A pipeline route of 105 KM from Sirajgonj to Rajshahi has been selected for the proposed pipeline. It passes through the Sirajgonj, Natore and Rajshahi districts. Hatikumrul, an important place of Sirajgonj which would be the starting point of the pipeline. Hatikumrul is situated about 20 Kilometer west of Western Bank of Jamuna Multipurpose Bridge and besides the national highway. There will be a regulating & metering station at Hatikumrul. From Hatikumrul pipeline route follows Dhaka-Natore-Rajshahi highway up to Bonpara which is about 40 KM from the starting point. On the way it needs to cross the Atrai river by Horizontal Directional Drilling

(HDD) method. One valve station needs to be constructed on each side of Atrai river. There will be an offtake station at Bonpara for future provision of gas supply to Natore district and adjacent areas. Near Bonpara the pipeline crosses the Dhaka-Natore-Rajshahi highway and then goes to Rajshahi. On the midway from Bonpara to Rajshahi pipeline crosses the Baral River. Horizontal Directional Drilling (HDD) method will be used to cross the Baral river. One valve station will be constructed on each side of the Baral river. A City Gate Station (CGS) will be set up at Rajshahi. Purpose of City Gate Station is to regulate the gas flow and pressure.

4.3 Major Activities of the Proposed Pipeline

The cost of major activities of the proposed pipeline is based on actual cost of the relevant activities of Nalka-Bogra Project and Dhaka Clean Fuel Project.

4.3.1 Route survey

A pipeline route of about 105 KM has been selected for the proposed pipeline. This is a preliminary pipeline route. Extensive survey needs to finalize the pipeline route. A specialized contractor needs to engage for this purpose. Estimated cost for route survey is Tk.1.0 million.

4.3.2 Soil and sub soil investigation

Prior to pipeline construction soil and sub soil investigation is needed. One subsurface investigation is needed on average every 5 KM pipeline route. Therefore approximately 20 subsurface investigations are needed. Estimated cost for the subsurface investigation is Tk. 2.0 millions.

4.3.3 Land acquisition

Acquisition is the permanent possession of land. Eight meter wide strip along the pipeline route is acquisitioned. Pipeline is laid along the acquisition land. Eighty four hectors land is required to acquisition along the pipeline route for 105 kilometer long pipeline. Average cost of land acquisition is Tk. 1.7 millions per hector.

For one regulating and metering station at Hatikumrul two hectors land is required, another two hectors land is required for one City Gate Station at Rajshahi and five

intermediate valve stations each required 0.125 hector land. Therefore, a total (2+2+0.125*5) hectors = 4.625 hectors land is required for valve, metering & manifold and City Gate Station (CGS). Usually this land is at or close to the urban area. Therefore cost of land acquisition of this land is always higher than the cross-country land. Average costs of this land are Tk. 7.5 millions / hector.

4.3.4. Land requisition

Requisition is the temporary possession of land for the construction period only. Fifteen meter wide strip at the other end of acquisition land and along the pipeline route is requisitioned. After completion of pipeline construction requisition land is handed over to the original land owner. Requisition land is used to provide working space for construction crew and equipments. 157.5 hectors land is required to requisition for 105 KM long pipeline Average costs of this land are Tk 0.177 million/hector/year. In this case we assume two years construction period.

4.3.5. Land development cost

For one regulation & metering station at Hatikamrul, one City Gate Station (CGS) at Rajshahi and five intermediate valve stations a total of 4.625 hectors land is required to developed. Assume, average height of land development is 4 meters.

Therefore, Total earth filling required

= 4.625 hector X 4 meter

= 4.625 * 2.47105 * (4840x9)/10.7639 * 4 m^3

= 1,85,000 m^3

Unit cost of land development is Tk 189.00/ m^3 as per Public Works Department (PWD) standard.

4.3.6 Pipeline construction

Pipeline construction including preparation of Right Of Way (ROW), hauling of pipes, stringing the line pipe along the ROW, welding of pipes, Nondestructive

Testing (NDT) of weld joints as per API standard; joint coating, trenching, holiday inspection, repair of all coating and lowering of pipes, construction and placing of Set-On-Weight (SOW), back filling, fabrication and installation of pig launcher, pig receiver, construction and placement of marker post, pigging, hydro test, mobilization & demobilization. Rate of pipeline construction is TK 3.5 million/KM. This rate is on the basis of actual cost of pipeline construction for Nalka-Bogra Gas Transmission Pipeline Project.

4.3.7. River crossing

Horizontal Directional Drilling (HDD) method is used to cross the two major rivers on the way to pipeline route. These are Atrai river and Baral river. HDD crossing length of each river is about 500 meter. Total estimated cost for each river crossing is Tk. 108 813 millions . This estimation is on the basis of actual cost of Korotora river crossing on the way of Nalka-Bogra pipeline project at Sirajgonj.

4.3.8. Set on weight (SOW)

Fabrication, construction, transportation and placing of concrete block/Set-On-Weight (SOW) complete in all respect on 20 inch OD pipe by placing rock shield. Total estimated cost for SOW is Tk. 7.304 millions.

4.4 Pipeline Design

The method of determining the required size of pipe for a given pipeline will depend on a number of interacting technical and economic criteria. Initial sizing should be based on a simple steady-state concept. A number of formulas have been developed for relating pressure drop to gas flow rate, for example Weymouth, Panhandle, Spit glass equation which should be used for this purpose. But for high pressure and long distance pipeline Panhandle equation is the most suitable one.

Modified Panhandle equation for pipeline sizing is as follows:

$$Q_{mmscfd} = 0.00128084 ((P_1^2-P_2^2) / L)^{0.51} * d^{2.53} \quad \text{----------(4.1)}$$

Where,

Q_{mmscfd} = Flow in MMSCFD

P_1 = Upstream Pressure in psia

P_2 = Downstream Pressure in psia

L= Length of pipeline in miles

d= Inside diameter of pipe in inch

To calculate pipe wall thickness, following formula is used.

t= DP/ 2YFLJT ----------(4.2)

where,

t = Pipe wall thickness in mm

P = Design pressure in psig

D = Outside diameter of pipe in inch

Y = Minimum yield strength in psig

F= Design factor

L= Location factor, it depends on the route of the pipeline

T= Temperature derating factor

4.4.1 Minimum yield strength (Y)

The properties of steel used in the construction of pipeline are divided into two API specifications. 5L for normal quality steel and 5LX for high strength steels. These specifications are now accepted throughout the world. Table 5.1 gives the strength properties of most widely used steels.

Table 4.1: Strength of Line Pipe Steel

Specification	Grade	SMYS (psi)
5L	A	30,000
5L	B	35,000
5LX	X 42	42,000
5LX	X 46	46,000
5LX	X 52	52,000
5LX	X 56	56,000
5LX	X 60	60,000
5LX	X 65	65,000
5LX	X 70	70,000
5LX	X 75	75,000

(Note: SMYS= Specified Minimum Yield Strength)

4.4.2 Design factor (F) and class location factor (L)

American Society of Mechanical Engineers (ASME) suggests design factor of 0.8. Location factor are designated in ASME B31.8 code for high pressure gas transmission and distribution piping are given in table 4.2.

Table 4.2: Location factor (L) for different class location

Areas	Class Location	ASME	CSA
Desert	1	0.72	0.80
Village	2	0.60	0.72
City	3	0.50	0.56
Metropolitan	4	0.40	0.44

(ASME =American Society of Mechanical Engineers; CSA= Canadian Standard Association)

The effect of the location factor is to increase pipe wall thickness for a given size and grade of pipe as the construction area becomes more populated and the failure of a pipeline would be more serious.

4.4.3 Joint factor (J)

The joint factor varies with the type of joint used in manufacturing the pipe. For different manufacturing process joint factor are given in table 4.3.

Table 4.3: Value of joint factor (J)

Weld type	ASME B31.8
Seamless	1
ERW	1
SAW	1
Butt Welded	0.6
Spiral seam welded	0.8

(Note: ERW=Electrical Resistance Welding ; SAW= Submerged Arc Welding)

4.4.4 Temperature derating factor (T)

The temperature derating factor for steel pipe varies from 1.0 for operating temperature up to 250°F and 0.87 for an operating temperature of 450°F or above. Temperature derating factor for different temperature ranges are given in table 4.4

Table 4.4: Temperature derating factor (T)

Temperature (° F)	Value as per ASME B31.8
Upto 250	1.00
251-300	0.97
301-400	0.93
401-450	0.91
451 and above	0.87

4.4.5 Design Calculations

Data:

Gas demand for optimistic scenario = 133 MMSCFD

For Pipeline design assume, 15% additional load than optimistic demand

=133 MMSCFD * 1.15 = 153 MMSCFD

Therefore pipeline should be designed for Q_{mmscfd} =153 MMSCFD

Upstream pressure, P_1 = 600 psig =(600+14.73) psia = 614.73 psia

Assume Down stream Pressure, P_2 = 350 psig =(350+14.73) psia = 364.73 psia

L= 105 KM = 105 * 0.621 miles = 65.24 miles

Using equation (4.1) we get, d= 19.3 inch

From equation (4.2) we get,

t= DP/ 2YFLJT

where,

t = Pipe wall thickness

P = design pressure in psig = 1135 psig

D = outside dia of pipe in inch =20 inch

Y = minimum yield strength in psig = 60,000 psig (Assume API 5LX 60 Grade Steel Pipe)

F= design factor= 0.8,

Joint Factor, J=1

L= location factor, it depends on the route of the pipeline. For cross-country pipeline this factor equal to 0.6 .

T= Temperature derating factor =1 for temperature upto 250°F.

Therefore using equation (4.2) we get, t= 10.01 mm

Assume, corrosion allowance for steel pipe = 2mm.

Hence Pipe Wall Thickness= 10.01m +2 mm= 12.01mm

Compare this calculated pipe wall thickness to API 5L Line pipe Chart we get wall thickness from API chart = 12.7 mm.

The value of design parameters we got from the above calculations are shown in table 4.5.

Table 4.5: Calculated value of pipeline design parameters

Name of design Parameters	Value
Outside Pipe Dia (D)	20 inch
Pipe Wall Thickness (t)	12.7 mm

Hence in order to supply gas to Rajshahi and its adjacent areas a pipeline of 20 inch OD, 12.7mm WT, 105 KM length is to be considered and pipe steel grade is API 5LX 60.

4.5 Pre Construction Activities:

Prior to the actual construction process the following pre construction activities should be performed.

- Preparation of Development Project Proposal(DPP)
- Environmental Impact Assessment (EIA)
- Land acquisition and requisition
- Tender document preparation
- Tendering/ Bidding
- Contract award
- Procurement

4.5.1 Land acquisition and requisition

Normally 8 meter wide strip along the proposed pipeline route is to be acquisition and a 15 meter wide strip on one side of the acquisition is to be requisition. Acquisition is permanent possession of land and requisition is completely a temporary affair, only for the construction period. For valve and scrapper station separate block lands of required size have to be acquisition. For river crossing separate block lands of required size have to be requisition. The company submit the proposal with requisite number of drawings (mouza map) showing acquisition and requisition strip in two distinct colors (red for acquisition and green for requisition) to respective Deputy Commissioner (DC) office. The process of acquisition and requisition in Bangladesh is done through DC office of the respective district. The whole process continues in accordance with ordinance, Acts, Rules & Regulations issued by the Government from time to time.

4.6 Construction Activities

Major steps for pipeline construction are as follows.

4.6.1 Clearing and grading the right of way (ROW)

ROW is cleared of barriers and graded for movement of construction equipment, materials and ultimately construction of pipeline.

4.6.2 Stringing

Stringing is aligning the pipe along the ROW ready for welding. Trailor, side boom etc are used for stringing the pipe. Figure 4.1 shows the stringing the pipe along the ROW.

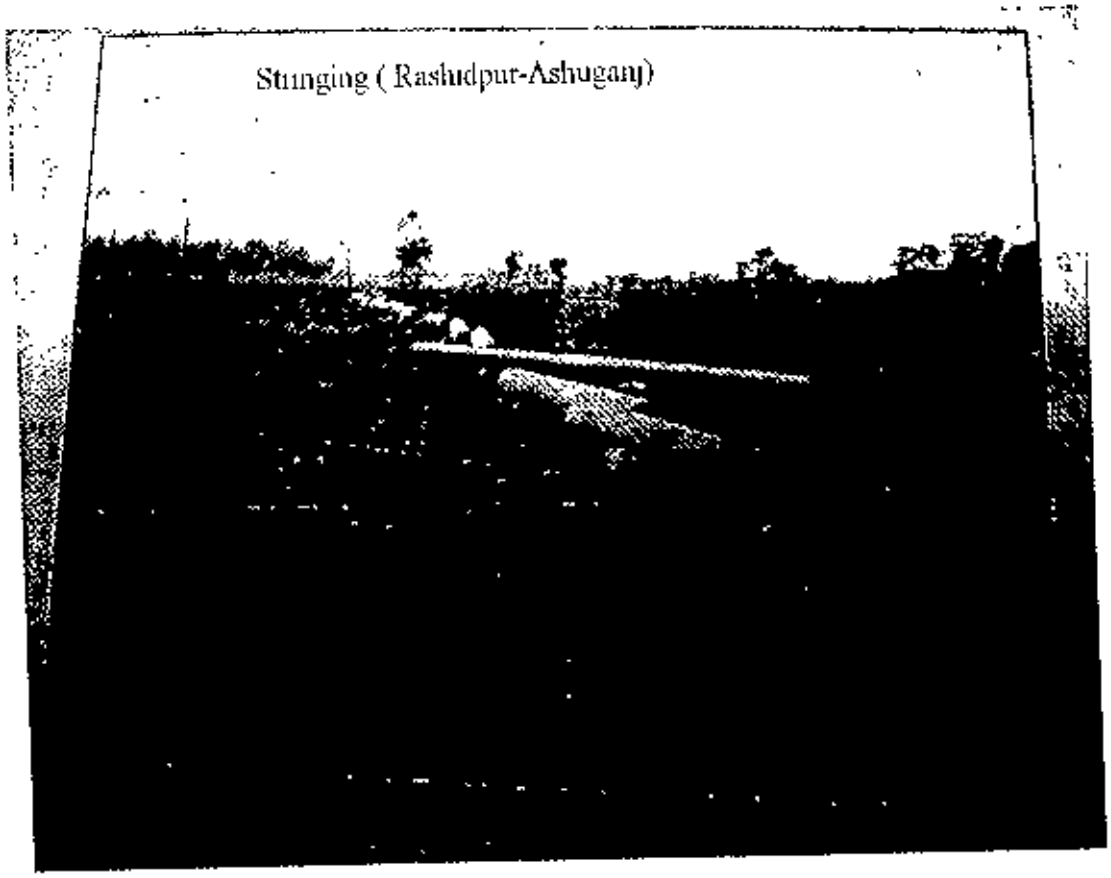


Figure 4.1: Stringing the pipe along the ROW

4.6.3 Lining-up for welding

When lining-up for welding, pipes should be placed on timber skid suitably cautioned on top and with sufficient clearance under the pipe to facilitate welding. If a length previously welded pipeline is lifted or moved care should be taken so that damage to the pipe and coating is avoided.

4.6.4. Welding

Pipe and fitting should be prepared, welded, and inspected in accordance with a suitable standard.

- Welders test

  -Welders test is an examination for the welders before going to the production weld. Selection criteria for the welders test are visual inspection and NDT report in accordance with a suitable standard. Mostly follows API 1104 Standard.

4.6.5 Non Destructive Testing

The following NDT methods are commonly used for inspection of welding joints

- Radiographic test
- Ultrasonic test
- Dye penetrant test
- Magnetic particle test
- Eddy current Test

100% of welded joints should be inspected using radiographic test in accordance with a suitable specification whereas Ultrasonic Test (UT), Dye Penetrant Test (PT), Magnetic particle Test (MT) has limited use in welding joint of gas pipeline.

Common welding defects are as follows:

- Porosity
- Cluster Porosity
- Slag inclusions
- Lack of fusion
- Lack of penetration
- Internal concavity
- Burn through
- Arc strike
- Crack

4.6.6 Night Caps

The open end of welded sections of pipeline should be closed by the use of suitable night caps, to prevent the ingress of foreign bodies into the welded pipe section.

4.6.7 Roads and railway crossings

Crossing should be constructed by open cut, thrust boring or tunneling methods. Open cut road crossing should be carried out in a manner which minimizes the disruption to normal traffic flow. Particular attention should be given for warning signs and lights during the construction of road crossing. For thrust boring drill a hole under the

roadway without disturbing the road / rail surface. A casing pipe is placed through the hole and then the pipeline is placed inside the casing. Spacer is used to center the pipeline within the casing pipe.

4.6.8 Water crossing

Crossing should be constructed by open cut, boring, tunneling or directional drilling method. Where water crossings are installed by open cut method the pipeline should be laid at a cover allowing for future bed movement, dredging operation etc. Temporary flume pipes or other methods should be considered to ensure that there is no disruption to water flow during construction. Consideration should be given to the application of a weight coating such as concrete weight coating to maintain negative buoyancy of the pipe during construction and when in service. Attention should be given to maintain the integrity of flood of tidal barriers during construction and also when in service.

4.6.9 Pipe coating

All except a portion of about 6 inch of each end of each pipe is often coated in the factory before delivery to the site. There are three types of coating generally used in the transmission pipeline. These are:

- Three Layer Polyethylene Coating (3LPE coating)
- Fusion Bonded Epoxy (FBE) Coating
- Polyethylene Coating

- **3LPE coating**

Apply adhesive on sand blast clean pipe surface and then apply epoxy paint of 40-100 micron over the adhesive. Finally apply polyethylene coating over the epoxy paint with 10-20 % overlap. Mostly used in the high pressure transmission pipeline. Figure 4.2 shows 3LPE coated pipe in GTCL store yard.

- **FBE coating**

Apply adhesive and epoxy paint over the cleaned pipe surface. Pipe with this type of coating mostly used in rivers, roads & railways crossing.

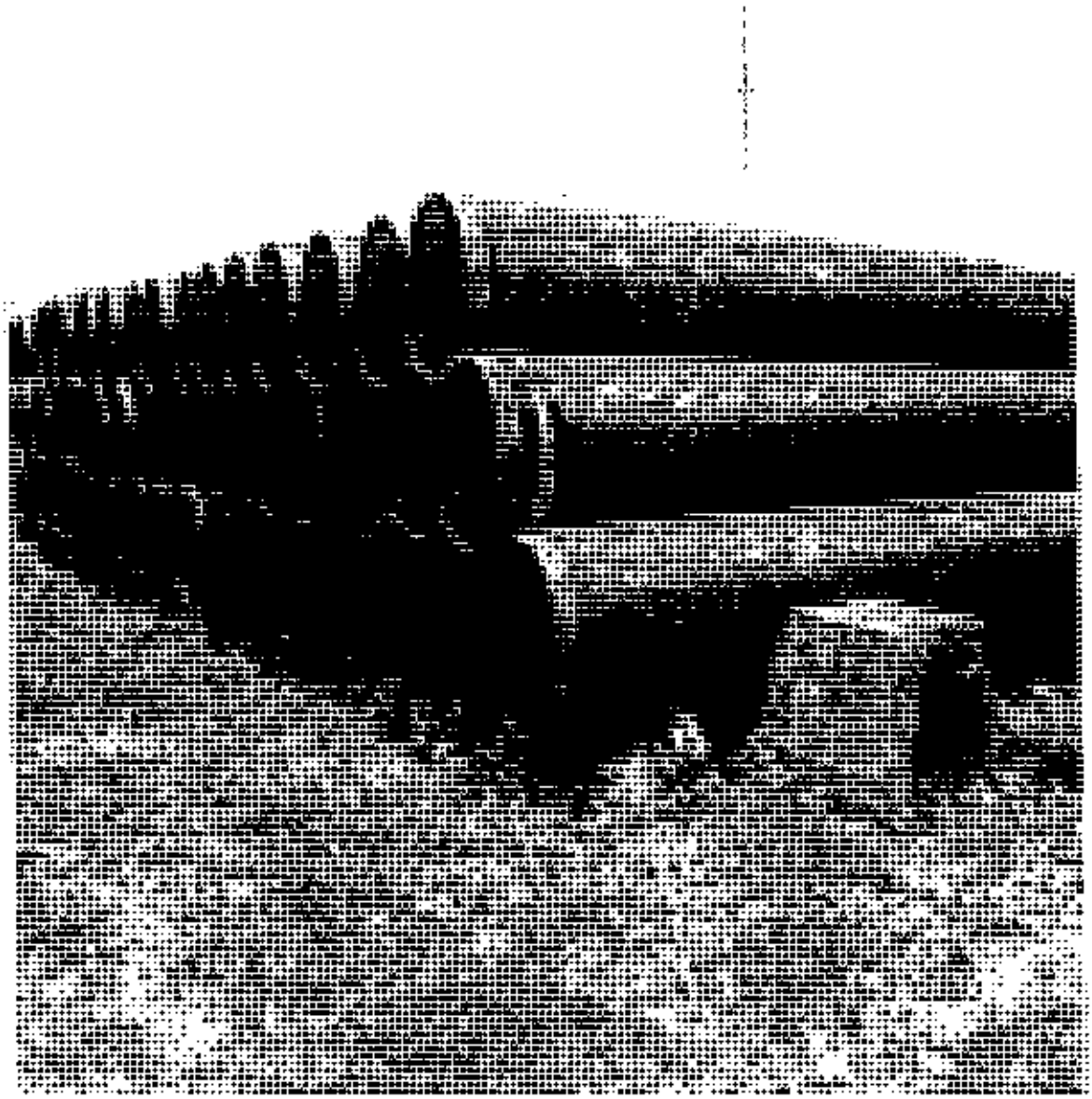


Figure 4.2: Three LPE Coated Pipe

4.6.10 Set On Weight (SOW)

Set on Weight is placed on 3 LPE coated pipe in marshy area. It provides negative buoyancy force on pipe surface. Figure 4.4 shows a typical set on weight.

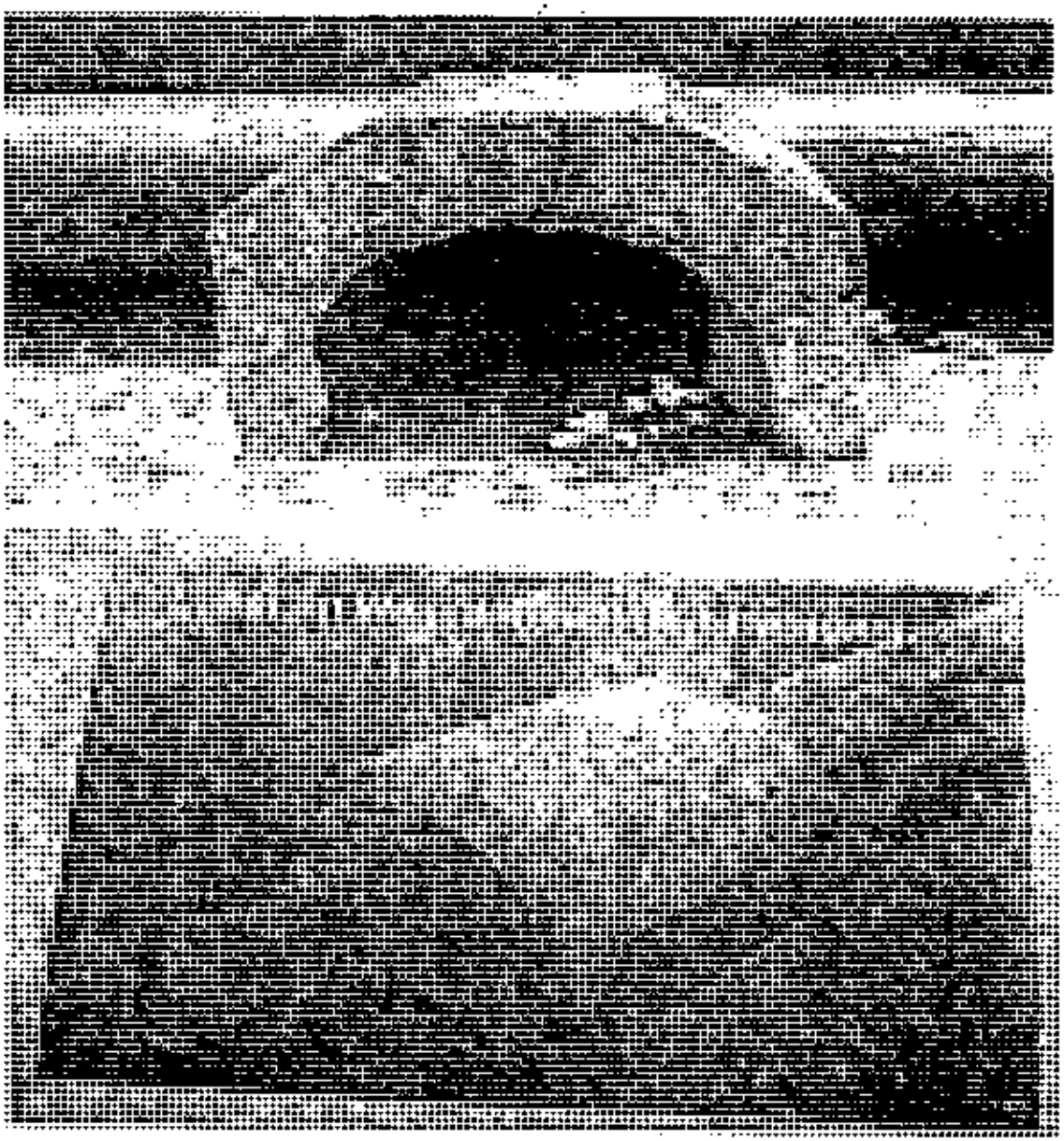


Figure 4.4: A typical Set On Weight (SOW)

4.6.11 Joint coating

The uncoated external portion of the pipeline joints should be protected to a standard at least equivalent to and compatible with the line pipe coating. Heat shrink sleeve is used for joint coating.

4.6.12 Trench excavation

Pipeline should normally be laid to contour with adequate cover typically not less than 1.2 meter from the ground level to minimize damage by third party interference.

The trench width should exceed the pipe diameter by a margin which will permit proper backfilling and compaction. For larger diameter pipes, consideration should be given to increase the width of the trench. Trenching is usually done by excavator.

4.6.13. Inspection of coating and wrapping

Immediately before the pipe is lowered, coating of the whole pipe section should be examined carefully by means of a holiday detector. Setting an appropriate voltage on holiday machine, running the machine over the pipe coating and any defect found will result an audible sound. In addition to holiday detection the pipe should be inspected for damage such as dents, grooves, notches, arc burns etc. If such damages are found should he rectified by proper method.

4.6.14. Lowering the pipe into the trench

When the pipe is lowered into the trench all equipment in contact with the pipe coating should be sufficiently padded to prevent damage to the coating. Roller cradles or wide belt slings should be used and the pipe should be lifted and lowered into the trench by means of suitable machinery, for example side boom, excavator etc. Throughout this operation care should be taken to avoid damage to the protective coating. Also need to be ensured that overstressing of the pipeline does not occur during the lifting and lowering operation.

4.6.15 Backfilling

After the pipeline is lowered into the trench, the excavated soil should be replaced such that the original soil sequence is preserved. The backfill should he properly compacted using mechanical means if necessary.

4.6.16 Marker post

The position of the pipeline should be indicated at suitable intervals by means of marker posts. These should be at field bends, at all crossings, at changes in direction and where practicable and should indicate the location of the pipeline.

4.6.17 Pigging

Pigging is performed to ensure that the pipeline is free from internal obstruction Brush/cup pig is used to clean the inner pipe surface. Gauge pig is used to check the pipe ovality. At the stage before testing and again at the stage before commissioning, a suitable gauging pig should be run through the pipeline to prove the bore. Diameter of the gauge plate should be 95% of the minimum bore of the pipeline or fittings. Figure 4.3 shows foam pig in GTCL store yard.

Figure 4.3: Foam pig

4.6.18 Hydrostatic test

Hydrostatic test is performed after mechanical completion of the pipeline. For hydro test water is poured into the pipeline section. Then pressurized the pipeline by injecting small amount of water through hand pump. As water in incompressible small amount of water injection raised the pressure significantly. As per API standard minimum hydro test pressure should be 1.5 times of design pressure Typical design pressure for high pressure gas transmission pipeline in Bangladesh is 1135 psi. Hence hydro test pressure is 1.5x 1135 psi = 1703 psi. After pressurization at 1703 psi hold it for 24 hours. Pressure and Temperature should be recorded on a chart paper for 24

hours hold period. If no significant pressure drops during 24 hours hold period then depressurize the pipeline at atmospheric pressure and it is said successful completion of hydro test.

- Before commencing pressurization need to obtain necessary permission from the competent authority. As per gas safety rules department of explosive is the competent authority in Bangladesh.
- Prior notification of testing should be given in writing to persons in the vicinity of the pipeline.
- Prior notification of testing should be given to local police and other authorities who may be affected.
- Warning notice stating "Warning- Pipeline under Test" and "No Parking" type sign should be placed at appropriate locations for the duration of the test.
- Patrols should be provided to watch special points of hazard during the test, in particular road, rail and water crossing and points of public access.
- Standby emergency crew should be available to deal any unwanted situation.

4.6.19. Commissioning

Commissioning is the flowing of natural gas through the newly constructed pipeline for first time. Pipeline, valves, fittings, metering etc. are checked and rectified if necessary during commissioning.

- Prior to the commissioning the pipeline should be dry up
- Methods available for drying up are:
  -Using dry air (compressor) push a series of foam pigs through the pipeline collecting water until the required dryness is achieved.
- The pipeline should be purged of air before the admission of the gas to be transmitted.
- Use inert gas to purge of air.
- After drying up a pipeline can be commissioned straight to gas.

CHAPTER 5

FINANCIAL ANALYSIS OF THE PROJECT

To judge a project from financial point of view, we need information about the following:

- Investment cost
- Operating recurring cost and
- Benefit from the investment.

Finally, output of the evaluation is Net Present Value (NPV), Benefit Cost ratio (BCR) and Internal Rate of Return (IRR).

5.1 Calculation of Costs and Benefits

To make a standard output of the study as per objectivity a project of 3 (three) years length is considered. The project schedule is shown in figure 5.1. Project evaluation process performs on three inputs, these are: investment cost, operating recurring cost and benefit from the project.

5.1.1 Investment cost

- Pre-construction expenditure

  These are based on the value of required quantity of land acquisition and requisition for the construction of pipeline. Land development, road survey, soil investigation, design , drawing, environmental impact assessment (EIA) etc.

- Cost of civil construction works

  These include probable expenditure for construction of pipeline and other pipeline facilities including river crossing by Horizontal Directional Drilling (HDD) method, functional and residential building, boundary wall, internal road, surface drain, retaining wall, fencing, water supply facilities at Hatikumrul and Rajshahi City Gate Station (CGS) and installation of Supervisory Control and Data Acquisition (SCADA) system.

- Machinery, equipment's and materials cost.

  These include probable cost of pipes, cost of SCADA equipments and spares, pre shipment inspection cost, transport cost, CD VAT, cost of office equipment and fixtures.

- Transport /Vehicles Cost

  These cost are calculated on basic requirements for construction period and for during operational period.

- Manpower

  Detailed description with standard salary structure for the project period manpower is shown in appendix A

- Cost of pipeline construction

  These costs include construction of pipeline and other pipeline related facilities; construction of cathodic protection system; installation of manifold, metering & regulating station ; construction of CGS , cost of construction of set-on-weight; cost of design, installation, testing & commissioning of SCADA system; CD-VAT for imported materials; cost of fuel and maintenance of vehicle, office rent etc. Detail break-up of total investment cost is shown in table 5.1 . Year wise break-up of investment cost is shown in appendix B

5.1.2 Operating recurring cost

All costs related to final running of gas transmission pipeline including raw materials, supplies and spares, duties & taxes, fuel & power, manpower, maintenance & repair etc. are termed as operating recurring cost. Operating cost is calculated on yearly basis. In this study initially a period of 20 years is considered for the proposed life of transmission pipeline. Detailed description of operating recurring costs for 20 years period is explained in appendix C.

Table 5.1 : Detail Break-up of Investment cost (105 KM, 20 inch OD)

SL No.	Description	In million Taka		
		LC	FC	Total
i.	**Pre-construction works**			
	a. Route Survey			
	105 km Route survey by local contractor	1.000	0.000	1.000
	b. Soil and sub surface investigation (20 Locations)	2.000	0.000	2.000
	c. Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) and Resettlement Plan (RP)	1.000	0.000	1.000
	d. Resettlement Compensation (105 Establishment)	10.500	0.000	10.500
	e. Land acquisition			
	For pipeline construction 84 hectors of land is required @Tk 1.7 million / hector	142.800	0.000	142.800
	4.625 hectors land is required for valve, manifold & metering and City Gate Station (CGS) @ Tk.7.5 million / hector	34.688	0.000	34.688
	(f) Land Requisition			
	157.5 Hector of land is required for 2 years period @ Tk. 0.177 million /hector/yr. = 55.755 million	55.755	0.000	55 755
	(g) Land Development Cost			
	1,85,000 m^3 of land development for valve station (05 nos.) , 1 no. Manifold and regulating station at Hatikumrul and 1no. CGS at Rajshahi @ Tk. 189.00 /m^3	34.965	0.000	34.965
	Sub Total	282.708		282.708
ii.	**Construction works**			
	(a) Construction of pipeline and other pipeline related facilities			
	(i) 20 inch dia 105 km pipeline construction @ Tk. 3.5 millions/ km	367.500	0.000	367.500
	(b) 2 Nos river crossing by HDD method each of 500 m length on Turn-key basis	21.000	196.626	217.626

Table 5.1 : Detail Break-up of Investment cost (105 KM, 20 inch OD)

SL No.	Description	In million Taka		
		LC	FC	Total
	(c) Installation of 01 no. manifold and regulating station at Hatikumrul , 01 no. CGS at Rajshahi and 05 intermediate valve stations.	24.000	0.000	24.000
	(d) Fabrication , construction and transportation and placing of concrete block (Set-on –weight) (as per design and drawing) complete in all respect on 304.8 mm OD line pipe by placing rock shield.	7.304	0.000	7.304
	(e) Construction of CP system	6.000	0.000	6.000
	(f)Functional Building 439 Sq.m Office building at Rajshahi	5.486	0.000	5.486
	(g) Residential Building 939 sq m Residential and dormitory building at Rajshahi	12.766	0.000	12.766
	(h) Other construction works i) Boundary wall, Marker post , water facilities (Multi purpose use) etc.	8.716	0.000	8.716
	ii) Civil construction for SCADA system	10.700	0.000	10.700
	Sub Total	463.472	196.626	660.098
iii.	**Machinery , Equipments and Materials**			
	(a) (i) Imported materials and Equipment for line pipe	0.000	1417.500	1417.500
	(ii) Imported materials and Equipment for SCADA system	0.000	100.000	100.000
	(b) Pre-shipment inspection (1% of materials cost)	0.000	15.175	15.175
	(c) . (i) CD-Vat (45% of linepipe material costs)	0.000	637.875	637.875
	(ii) CD-Vat (20 % of SCADA material costs)	0.000	20.000	20.000
	(d) Landing charge , port dues , transportation cost to site (7% of material costs	0.000	99.225	99.225

Table 5.1 : Detail Break-up of Investment cost (105 KM, 20 inch OD)

SL No.	Description	In million Taka		
		LC	FC	Total
	(e) Locally procured equipment (office equipment)	1.200	0.000	1.200
	Sub Total	1.200	2289.775	2290.975
iv.	**Transport/ Vehicles**			
	Jeep: 05 nos (2000-3000 CC)	18.000	0.000	18.000
	Double cabinPick-up (1500-2500 CC) : 01 no	1.500	0.000	1.500
	Sub Total	19.500	0.000	19.500
v.	**(a) Manpower**			
	Officer : 12 Nos	11.727	0.000	11.727
	Staff: 12 Nos.	2.999	0.000	2.999
	(b) Human resource development	1.375	0.000	1.375
	Sub Total	16.101	0.000	16.101
vi.	**Other costs :**			
	(a) Turn-key design, installation . Testing & commissioning of SCADA system	0.000	15.700	15.700
vii.	**Total Base Cost**	**782.981**	**2502.101**	**3285.082**
	(a) Interest during construction (5%)	39.149	125.105	164.254
	(b) Contingency (Physical + price) 1%	7.830	25.021	32.851
viii.	**Total**	**829.960**	**2652.227**	**3482.187**

Note: 1. Land acquisition and requisition cost have been calculated on the basis of actual cost of Nalka-Bogra project and the quantity of land has been fixed as bare minimum base on the Natural Gas Safety rule 1991 (amended on 2003).

2. Land development cost has been prepared on the basis of Public Works Department (PWD) standard and rate as on 2004 .

3. Accommodation area and Estimated cost for civil construction works have been prepared on the basis of Public Works Department (PWD) standard and rate as on 2004 .

4. Cost of machinery and equipment has been calculated on the basis of proportionate value of actual cost of being implemented Nalka-Bogra , Ashuganj –Monohordi project.

5. LC= Local Currency , FC=Foreign currency , Conversion Rate, 1US$=68.15 Taka (May, 2007)

Figure 5.1: Project Implementation Schedule of Hatikumrul-Rajshahi Project:

Activity	2008-2009												2009-2010												2010-2011											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Survey, land acquisition & Requisition																																				
Surface development, building and other civil works																																				
Design, engineering and document preparation																																				
Material Procurement and Transportation																																				
Construction and River crossing by HDD																																				
Testing and Commissioning																																				

5.1.3 Revenue from the investment

Wheeling charge from the volume of gas transmission through the pipeline is the only source of revenue. Presently in Bangladesh wheeling charge is calculated on the basis of postage stamp method. This means that wheeling charge depends only on volume of gas transmission through the pipeline and independent of distances. The wheeling charge for the year 2007 is Taka 0.32/ SCM. The project construction period assume 3 years from January 2008 to December 2010. Before completion of the pipeline project natural gas could not be transported. As a result no revenue could earn. The project financial analysis assumes that the current wheeling charge of taka 0.32/ SCM is increased by 5% every six month or 10.25% per annum. Details description of revenue earning from wheeling charge for 20 years period for low case (pessimistic), base case (most likely) and high case (optimistic) are shown in table 5.2 , 5.3 & 5.4 respectively.

Table 5.2: Income from investment (Low case scenario)
(Gas demand for low case scenario is explained in section 3.3.1.)

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge	Total Revenue
	MW	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF))	Gas Demand	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	MMSCF	TK/SCM	million Taka
0(2008)		0	0	0	0	0	0	0.320	0.000
1		0	0	0	0	0	0	0.353	0.000
2		0	0	0	0	0	0	0.389	0.000
3(2011)	60	10	3650	0	5.000	1825	5475	0.429	66.549
4	60	10	3650	0	5.600	2044	5694	0.473	76.305
5	60	10	3650	0	6.272	2289.28	5939.28	0.521	87.750
6	60	10	3650	0	7.025	2563.99	6213.9936	0.575	101.219
7	60	10	3650	0	7.868	2871.67	6521.6728	0.634	117.120
8	160	10	3650	0	8.812	3216.27	6866.2736	0.699	135.948
9	160	26	9490	0	9.517	3473.58	12963.575	0.770	282.979
10	160	26	9490	0	10.278	3751.46	13241.461	0.849	318.672
11	160	26	9490	0	11.100	4051.58	13541.578	0.936	359.298
12	160	26	9490	0	11.988	4375.7	13865.705	1.032	405.608
13	160	26	9490	0	12.947	4725.76	14215.761	1.138	458.473
14	160	26	9490	0	13.983	5103.82	14593.822	1.254	518.909
15	160	26	9490	0	15.102	5512.13	15002.128	1.383	588.103
16	160	26	9490	0	16.310	5953.1	15443.098	1.525	667.442
17	160	26	9490	0	17.615	6429.35	15919.346	1.681	758.548
18	160	26	9490	0	19.024	6943.69	16433.693	1.853	863.319
19	160	26	9490	0	20.546	7499.19	16989.189	2.043	983.983
20	160	26	9490	0	22.189	8099.12	17589.124	2.253	1123.150
21	160	26	9490	0	23.965	8747.05	18237.054	2.484	1283.887
22	160	26	9490	0	25.882	9446.82	18936.818	2.738	1469.798

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day, MMSCF = Million Standard Cubic Feet , SCM= Standard Cubic Meter)

Table 5.3: Income from investment (Base case scenario)
(Gas demand for base case scenario is explained in section 3.3.2.)

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge	Total Revenue
	MW	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF))	Gas Demand	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	MMSCF	TK / SCM	million Taka
0(2008)		0	0	0	0	0	0	0 320	0 000
1		0	0	0	0	0	0	0 353	0 000
2		0	0	0	0	0	0	0.389	0 000
3 (2011)	90	14.4	5256	0	5	1825	7081	0.429	86 070
4	90	14 4	5256	0	5 750	2098 75	7354 75	0 473	98 561
5	90	14 4	5256	0	6 613	2413 5625	7669.563	0 521	113.314
6	90	14 4	5256	0	7 604	2775 5969	8031.597	0.575	130 826
7	90	14.4	5256	0	8 745	3191 9364	8447.936	0 634	151.713
8	240	38.4	14016	0	10 057	3670.7269	17686.73	0.699	350 185
9	240	38 4	14016	0	11.062	4037 7996	18053 8	0 770	394 092
10	240	38 4	14016	0	12 169	4441.5795	18457 58	0 849	444 204
11	240	38 4	14016	0	13 386	4885 7375	18901 74	0 936	501.519
12	240	38.4	14016	0	14.724	5374.3112	19390 31	1 032	567 217
13	240	38 4	14016	0	16 197	5911.7423	19927.74	1.138	642 690
14	390	62 4	22776	0	17 816	6502 9166	29278 92	1.254	1041 062
15	390	62 4	22776	0	19 598	7153.2082	29929 21	1.383	1173 264
16	390	62 4	22776	0	21 558	7868 529	30644.53	1 525	1324 439
17	390	62.4	22776	0	23 713	8655 3819	31431 38	1 681	1497.687
18	390	62 4	22776	0	26.085	9520 9201	32296 92	1.853	1696 670
19	540	86 4	31536	0	28 693	10473 012	42009 01	2 043	2433.085
20	540	86 4	31536	0	31.563	11520 313	43056 31	2 253	2749 351
21	540	86 4	31536	0	34.719	12672.345	44208 34	2 484	3112.262
22	540	86 4	31536	0	38 191	13939 579	45175 58	2 738	3529.627

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet ; SCM= Standard Cubic Meter)

Table 5.4: Income from investment (High case scenario)
(Gas demand for high case scenario is explained in section 3.3.3.)

Year	Power			Fertilizer	Non bulk		Total gas Demand / Yr	Transmission charge / SCM	Total Income
	MW	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	Gas Demand	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	MMSCF	TK	Billion Taka
0(2008)		0	0	0	0	0	0	0.320	0.000
1		0	0	0	0	0	0	0.353	0.000
2		0	0	0	0	0	0	0.389	0.000
3 (2011)	90	14.4	5256	0	5	1825	7081	0.429	86.070
4	90	14.4	5256	0	6.000	2190	7446	0.473	99.784
5	90	14.4	5256	0	7.200	2628	7884	0.521	116.483
6	90	14.4	5256	0	8.640	3153.6	8409.6	0.575	136.984
7	90	14.4	5256	0	10.368	3784.32	9040.32	0.634	162.351
8	540	86.4	31536	0	12.442	4541.184	36077.2	0.699	714.304
9	540	86.4	31536	0	13.686	4995.3024	36531.3	0.770	797.433
10	540	86.4	31536	0	15.054	5494.83264	37030.8	0.849	891.191
11	540	86.4	31536	0	16.560	6044.3159	37580.3	0.936	997.118
12	540	86.4	31536	0	18.216	6648.74749	38184.7	1.032	1117.003
13	540	86.4	31536	0	20.037	7313.62224	38849.6	1.138	1252.939
14	540	86.4	31536	0	22.041	8044.98447	39581	1.254	1407.370
15	540	86.4	31536	0	24.245	8849.48292	40385.5	1.383	1583.163
16	540	86.4	31536	0	26.670	9734.43121	41270.4	1.525	1783.684
17	540	86.4	31536	0	29.337	10707.8743	42243.9	1.681	2012.896
18	540	86.4	31536	0	32.270	11778.6618	43314.7	1.853	2275.470
19	540	86.4	31536	0	35.497	12956.5279	44492.5	2.043	2576.925
20	540	86.4	31536	0	39.047	14252.1807	45788.2	2.253	2923.794
21	540	86.4	31536	0	42.952	15677.3988	47213.4	2.484	3323.818
22	540	86.4	31536	0	47.247	17245.1387	48781.1	2.738	3786.191

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet , SCM= Standard Cubic Meter)

5.2 Project Analysis

After calculation of investment cost, operating recurring cost and benefit any one or a combination of the following commonly used tools are applied in the analysis of a project from profitability point of view:

- Net Present Value (NPV)
- Benefit Cost Ratio (BCR)
- Internal Rate of Return (IRR)

The Net Present Value (NPV)

NPV is the difference between the present value of all cash inflows and present value of all cash outflows. NPV is the difference between an investment's market value and its cost. NPV of an investment project can be derived as the difference between the present value of benefits (PVB) and present value of costs (PVC) i.e. NPV= PVB- PVC.

Decision Rule:

Accept the project if NPV is positive and reject if it is negative. If NPV is zero it is a matter of indifference.

The Benefit-Cost Ratio (BCR)

The benefit-cost ratio (BCR) is the present value of an investment's future cash inflows divided by the present value of its cost. BCR is derived by dividing present value of benefit (PVB) by present value of cost (PVC) i.e. BCR = PVB/PVC.

Decision Rule:

If BCR is more than 1 , accept the project and reject if it is less than 1 . If BCR equals to 1 it is a matter of indifference.

The Internal Rate of Return (IRR)

IRR is that discount rate at which NPV is zero and BCR is one. IRR does not depend upon externally given social rate of discount. Conversely, what it represents is essentially the average earning power of money used in project over the project life. In the NPV calculation, we assume that the discount rate is known and determines the NPV of the

project. In the IRR calculation we set the present value equal to zero and determine the discount rate i.e. IRR There are two possible economic interpretation of IRR

- The IRR represents the rate of return on the unrecovered investment balance in the project.
- The IRR is the rate of return earned on the initial investment made in the project

Decision Rule:

Investment decision is taken by comparing the internal rate of return of a specific project, with a cut-off rate, which gives the minimum acceptable rate at which the capital invested should be compounded.

The cut-off rate is equal to the actual rate of interest on long-term loans in the capital market or to the interest rate paid by the borrower. If one has to choose among alternative projects, the one with the highest IRR will be selected, provided this IRR is higher than the cut-off rate.

IRR should be greater than or equal to the relevant discount rate. The relevant discount rate for a private investor would be the weighted average of the market rate of interest and the yield of alternative investment opportunities. For government it would be social discount rate.

Formula:

$$(r_b - r)/(r_b - r_a) = NPV_b / (NPV_b - NPV_a)$$

Where

r_b = higher discount rate.

r_a = lower discount rate

r^* = IRR to be calculated

NPV_a = Net present value at lower discount rate

NPV_b = Net present value at higher discount rate

IRR can also be calculated by using the formula:

$$IRR = r_a + (r_b - r_a) \times NPV_a / (NPV_a - NPV_b)$$

IRR can also be found from the graph of NPV vs discount rate. The point at which the curve intersects the X-axis shows IRR. The discount rate at that point (where NPV is zero) is the IRR.

5.2.1. Financial project analysis:

Investment cost, operating cost and revenue from wheeling charge are the basic input parameters for financial analysis. Using all these parameters Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) is calculated. Calculations of financial NPV, BCR and IRR for low case scenario (pessimistic) are tabulated in Table 5.5; the same for base case scenario (most likely) and high case scenario (optimistic) are shown in table 5.6 and 5.7 respectively. The summary of financial analysis is shown in Table 5.8.

Table 5.8: Summary of Financial Analysis

(Note: Assuming Present postage stamp method of wheeling charge)

Parameter	Low Case Scenario	Base Case Scenario	High Case Scenario
NPV(F)	-1690.746	-656.692	294.611
BCR(F)	0.43	0.78	1.10
IRR(F)	7.65 %	13 %	16%

Discussion of results:

The result shows that for and high case scenario (optimistic case) NPV is positive, BCR is greater than 1.0 and IRR is 16%. Hence the project is financially viable for optimistic case. But in low case scenario (pessimistic) and base case scenario (most likely) the project is not financially viable.

The above financial analysis is done on the basis of present postage stamp method of wheeling charge. This means that wheeling charge depends only on volume of gas transmission through the pipeline and independent of distances. But in Bangladesh most

of the sources of supply of natural gas (Gas Fields) are in the Eastern side i.e. greater Sylhet and Comilla division except the country's only offshore Sangu Gas Field which is in Chittagong. Greater Dhaka, the main gas consumption area of Bangladesh is about 250 KM away from these sources of supply whereas Rajshahi division is about 490 KM away from the sources. Thus the distance from gas source to Rajshahi is almost twice the distance from gas source to Dhaka. In this context exactly the same wheeling charge for Dhaka and Rajshahi is not justified. Wheeling charge should be based on distance travel. By applying the distance based wheeling charge after completion of the proposed project and assumes 10.25 % annual increment ; revenue earning for low case, base case and high case and calculations of financial parameters are shown in appendix D. Summary of financial analysis assuming distance based wheeling charge are shown in table 5.9.

Table 5.9: Summary of financial analysis applying distance based wheeling charge

(Note: Assuming distance based wheeling charge)

Parameter	Low Case Scenario	Base Case Scenario	High Case Scenario
NPV(F)	-334.512	1657.260	3559.867
BCR(F)	0.89	1.56	2.20
IRR(F)	13.89 %	19 %	23 %

From summary of financial analysis of Table 5.8 and Table 5.9 we conclude that the proposed project is financially viable for base & high case scenario if distance based wheeling charge is introduced instead of the present postage stamp method of wheeling charge.

Table 5.5: Calculation of Financial value of NPV, BCR, IRR for Low Case Scenario

Year	Investment cost (PV) (million Taka)	Operating cost (PV) (million Taka)	Total Cost (PV) (Million Taka)	Total Revenue (PV) (million taka)	Net Income (million Taka)	Discount Factor 15%	Discounted total Cost (million taka)	Discounted total Revenue (million taka)
1	2	3	4	5		6	7	8
0	-176 805		-176 805	0 000	-176 805	1.000	-176 805	0 000
1	-2055.694		-2055 694	0 000	-2055.694	0 870	-1788 454	0 000
2	-1249 684		-1249 684	0.000	-1249.684	0.756	-944 761	0 000
3		-12.960	-12.960	66 549	53 589	0 658	-8 528	43 789
4		-12 960	-12 960	76.305	63 345	0 572	-7 413	43 646
5		-12.960	-12 960	87.750	74 790	0 497	-6 441	43 612
6		-12 960	-12 960	101 219	88.259	0 432	-5 599	43.727
7		-12.960	-12 960	117 120	104 160	0.376	-4 873	44 037
8		-12 960	-12 960	135 948	122 988	0 327	-4 238	44 455
9		-12.960	-12 960	282.979	270 019	0.284	-3 681	80 366
10		-12 960	-12 960	318 672	305 712	0 247	-3.201	78 712
11		-12.960	-12 960	359.298	346 338	0 215	-2 786	77 249
12		-12.960	-12 960	405 608	392.648	0 187	-2.424	75 849
13		-12.960	-12 960	458.473	445 513	0.163	-2.112	74 731
14		-12 960	-12.960	518 909	505 949	0.141	-1 827	73 166
15		-12.960	-12.960	588.103	575 143	0.123	-1 594	72 337
16		-12 960	-12 960	667.442	654 482	0 107	-1.387	71 416
17		-12 960	-12.960	758 548	745 588	0.093	-1 205	70 545
18		-12 960	-12.960	863 319	850 359	0.081	-1.050	69 929
19		-12 960	-12 960	983 983	971.023	0 070	-0 907	68 879
20		-12 960	-12.960	1123 150	1110 190	0.061	-0 791	68 512
21		-12.960	-12 960	1283 887	1270.927	0 053	-0 687	68 046
22		-12.960	-12 960	1469 798	1456 838	0 046	-0 596	67 611
Total							-2,971.360	1,280 614

NPV= -1,690,746

BCR= 0 43

IRR= 7.65%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Table 5.6: Calculation of Financial value of NPV, BCR, IRR for Base Case Scenario

Year	Investment cost (PV)	Operating cost (PV)	Total Cost (PV)	Total Revenue (PV)	Net Income (PV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2	3	4	5	6	7	8	9
0 (2008)	-176 805		-176 805	0 000	-176 805	1.0000	-176 805	0 000
1	-2055 694		-2055 694	0 000	- 2055.694	0 8696	-1787.560	0 000
2	-1249 684		-1249 684	0 000	- 1249 684	0.7561	-944 941	0 000
3		-12 960	-12 960	86 070	73 110	0 6575	-8 521	56,592
4		-12 960	-12.960	98 561	85 601	0 5718	-7,410	56 352
5		-12 960	-12 960	113 314	100 354	0 4972	-6 443	56 337
6		-12 960	-12 960	130 826	117.866	0 4323	-5 603	56 560
7		-12.960	-12 960	151.713	138 753	0.3759	-4 872	57 034
8		-12,960	-12 960	350 185	337 225	0 3269	-4 237	114,476
9		-12 960	-12 960	394 092	381 132	0,2843	-3 684	112 025
10		-12,960	-12,960	444 204	431.244	0 2472	-3 204	109 800
11		-12 960	-12.960	501,519	488 559	0 2149	-2,786	107,798
12		-12,960	-12,960	567 217	554 257	0 1869	-2 422	106 017
13		-12 960	-12 960	642 690	629 730	0 1625	-2 106	104 455
14		-12 960	-12.960	1041,062	1028.102	0 1413	-1,832	147 132
15		-12 960	-12 960	1173 264	1160 304	0 1229	-1 593	144 188
16		-12 960	-12 960	1324 439	1311,479	0,1069	-1 385	141 536
17		-12 960	-12 960	1497 687	1484 727	0,0929	-1 204	139 174
18		-12 960	-12 960	1696 670	1683 710	0 0808	-1 047	137 100
19		-12.960	-12 960	2433 085	2420 125	0 0703	-0 911	170 961
20		-12 960	-12 960	2749 351	2736.391	0 0611	-0.792	167 986
21		-12,960	-12 960	3112 262	3099 302	0,0531	-0 689	165 357
22		-12.960	-12 960	3529 627	3516 667	0.0462	-0,599	163 071
Total							-2,970 645	2313.952

NPV= -656,692

BCR= 0 78

IRR= 13%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Table 5.7: Calculation of Financial value of NPV, BCR, IRR for High Case Scenario

Year	Investment cost (PV)	Operating cost (PV)	Total Cost (PV)	Total Revenue (PV)	Net Income(PV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2	3	4	5	6	7	8	9
0	-176 805		-176 805	0 000	-176 805	1 000	-176,805	0 000
1	-2055.694		-2055 694	0.000	-2055.694	0 870	-1787 560	0 000
2	-1249.684		-1249.684	0.000	-1249.684	0 756	-944.941	0 000
3		-12 960	-12,960	86 070	73.110	0 658	-8,521	56 592
4		-12 960	-12.960	99 784	86.824	0 572	-7 410	57 052
5		-12 960	-12 960	116 483	103 523	0 497	-6 443	57.912
6		-12,960	-12 960	136.984	124 024	0 432	-5 603	59 222
7		-12 960	-12 960	162.351	149.391	0 376	-4 872	61.034
8		-12 960	-12.960	714 304	701,344	0 327	-4 237	233 507
9		-12 960	-12,960	797 433	784 473	0 284	-3 684	226 680
10		-12 960	-12 960	891 191	878 231	0 247	-3.204	220 289
11		-12 960	-12,960	997,118	984.158	0 215	-2 786	214 324
12		-12 960	-12 960	1117 003	1104 043	0 187	-2 422	208.776
13		-12,960	-12 960	1252.939	1239,979	0 163	-2 106	203 638
14		-12 960	-12 960	1407 370	1394 410	0 141	-1.832	198 902
15		-12 960	-12 960	1583.163	1570 203	0 123	-1 593	194 562
16		-12 960	-12 960	1783 684	1770.724	0 107	-1 385	190 613
17		-12 960	-12.960	2012 896	1999,936	0 093	-1.204	187 050
18		-12 960	-12 960	2275 470	2262 510	0 081	-1.047	183 870
19		-12 960	-12 960	2576 925	2563.965	0.070	-0 911	181 068
20		-12 960	-12 960	2923 794	2910 834	0.061	-0 792	178.645
21		-12 960	-12.960	3323 818	3310.858	0 053	-0 689	176.597
22		-12 960	-12 960	3786 191	3773 231	0 046	-0 599	174 924
Total							-2,970 645	3,265 256

NPV= 294 611

BCR= 1.10

IRR= 16%

(Note NPV= Net Present Value ; BCR= Benefit Cost Ratio , IRR= Internal Rate of Return)

5.2.2. Economic project analysis:

The availability or scarceness of different goods, services and facilities are different for different countries. Hence economic values of costs and earnings are also different. In Bangladesh Standard Cost Factors (SCF) for different costs and values are given in Table 5.10, 5.11.and 5.12.

Table 5.10: Item wise Standard Cost Factor (SCF) for Investment Costs

Sl No.	Item of cost	SCF
1	Pre-construction expenditure	0.82
2	Construction of works	0 82
3	Foreign materials	1.22
4	Local materials	0.82
5	Transport vehicles	0.82
6	Managerial Manpower	1.00
7	Skilled Manpower	0.82
8	Unskilled manpower	0.72
9	Others	0.82

Table 5.11: Item wise Standard Cost Factor (SCF) for Operating Recurring Costs

Sl. No.	Item of cost	SCF
1	Maintenance cost (local)	0.82
2	Maintenance cost (foreign)	1.22
3	Fuel and power	0.82
4	Managerial Manpower	1.00
5	Skilled Manpower	0.82
6	Unskilled manpower	0.72
7	Others	0.82

Table 5.12: Item wise Standard Cost Factor (SCF) for Revenue

Sl No.	Item of cost	SCF
1	Wheeling charge for gas transmission	1.43

Applying the Standard Cost Factors (SCF) described above, economic value of investment cost, operating recurring cost are shown in appendix E and appendix F respectively. Detail of revenue earning from wheeling charge for 20 years period for low case(pessimistic), base case (most likely) and high case (optimistic) are shown in appendix G.

Required inputs & calculation of NPV(E) & BCR(E) and IRR(E) for low case scenario , base case and high case scenario are shown in Table 5.13 , 5.14 and 5.15 respectively. Summary of economic analysis assuming postage stamp method of wheeling charge are shown in table 5.16.

Table 5.16: Summary of Economic Analysis

(Applying Present Postage Stamp method of Wheeling Charge)

Parameter	Low Case	Base Case	High Case
NPV(E)	-1207.780	225.770	1631.013
BCR(E)	0.60	1.07	1.54
IRR(E)	10.40%	16%	19%

The result shows that for base case or most likely condition the project is economically viable but not financially viable. For optimistic case the project is both financially and economically viable but for pessimistic case the project is neither financially nor economically viable.

By applying distance based wheeling charge after completion of the proposed project and assumes 10.25 % annual increment revenue earning for low case, base case and high case

and calculations of economic parameters are shown in appendix-H. Summary of economic analysis assuming distance based wheeling charge are shown in table 5.17.

Table 5.17: Summary of Economic Analysis
(Applying Distance Based Wheeling Charge)

Parameter	Low Case	Base Case	High Case
NPV(E)	731.635	3489.841	6300.330
BCR(E)	1.24	2.15	3.07
IRR(E)	17.19 %	23 %	27 %

From summary of economic analysis of table 5.17 we conclude that the proposed project is economically viable even for low case scenario if distance based wheeling charge is applied.

Table 5.13 : Calculation of Economical value of NPV, BCR, IRR (Low case scenario)

Year	Investment cost (AV) (million Taka)	Operating cost (AV) (million Taka)	Total Cost (AV) (Million Taka)	Total Revenue (AV) (million taka)	Net Income (million Taka)	Discount Factor 15%	Discounted total Cost (million taka)	Discounted total Revenue (million taka)
1	2	3	4	5		6	7	8
0	-144.980		-144.980	0.000	-144.980	1 000	-144.980	0.000
1	-2153.210		-2153.210	0.000	-2153.210	0.870	-1873.293	0 000
2	-1267.885		-1267.885	0.000	-1267 885	0.756	-958.521	0.000
3		-13.155	-13.155	95.165	82.010	0.658	-8.656	62.619
4		-13.155	-13 155	109 116	95.961	0.572	-7.525	62 414
5		-13 155	-13.155	125.483	112.328	0.497	-6.538	62.365
6		-13 155	-13.155	144.744	131.589	0 432	-5.683	62.529
7		-13.155	-13.155	167.481	154.326	0 376	-4.946	62.973
8		-13.155	-13.155	194 405	181.250	0.327	-4.302	63.570
9		-13.155	-13 155	404 659	391.504	0.284	-3.736	114.923
10		-13.155	-13 155	455 700	442.545	0.247	-3.249	112.558
11		-13.155	-13.155	513.797	500.642	0.215	-2.828	110 466
12		-13.155	-13.155	580.019	566.864	0.187	-2 460	108 464
13		-13.155	-13.155	655.616	642 461	0.163	-2.144	106 865
14		-13.155	-13.155	742.039	728 884	0.141	-1.855	104.627
15		-13.155	-13 155	840 987	827.832	0.123	-1.618	103.441
16		-13.155	-13.155	954.442	941.287	0.107	-1.408	102.125
17		-13 155	-13.155	1084.723	1071.568	0 093	-1.223	100 879
18		-13.155	-13.155	1234 546	1221.391	0 081	-1.066	99.998
19		-13.155	-13.155	1407.095	1393 940	0.070	-0.921	98.497
20		-13.155	-13 155	1606.104	1592.949	0.061	-0.802	97.972
21		-13 155	-13.155	1835 958	1822.803	0.053	-0.697	97 306
22		-13 155	-13.155	2101.811	2088.656	0 046	-0 605	96.683
Total							-3,039.056	1,831.277

NPV= -1,207 780
BCR= 0.60
IRR= 10.40%

Table 5.14: Calculation of Economical value of NPV, BCR, IRR (Base case scenario)

Year	Investment cost (AV) (million Taka)	Operating cost (AV) (million Taka)	Total Cost (AV) (Million Taka)	Total Revenue (AV) (million taka)	Net Income (million Taka)	Discount Factor 15%	Discounted total Cost (million taka)	Discounted total Revenue (million taka)
1	2	3	4	5	6	7	8	9
0 (2008)	-144.980		-144.980	0	-144.980	1.0000	-144 980	0.000
1	-2153.210		-2153.210	0	-2153.210	0.8696	-1872.357	0.000
2	-1267.885		-1267 885	0	-1267.885	0.7561	-958.703	0 000
3		-13.155	-13.155	123.08	109.925	0.6575	-8.650	80.927
4		-13.155	-13.155	140 942	127.787	0.5718	-7.521	80 584
5		-13.155	-13.155	162.04	148.885	0 4972	-6.540	80.563
6		-13.155	-13 155	187 082	173.927	0.4323	-5.687	80.881
7		-13.155	-13 155	216.949	203.794	0.3759	-4.945	81.559
8		-13.155	-13 155	500.765	487.610	0.3269	-4.300	163.701
9		-13.155	-13 155	563.551	550.396	0.2843	-3.739	160.196
10		-13.155	-13.155	635.211	622.056	0.2472	-3.252	157 014
11		-13.155	-13.155	717.173	704.018	0.2149	-2.828	154 151
12		-13.155	-13.155	811.121	797.966	0 1869	-2.459	151.604
13		-13.155	-13.155	919.046	905.891	0 1625	-2.138	149.371
14		-13.155	-13.155	1488.719	1475 564	0.1413	-1.859	210.399
15		-13.155	-13 155	1677.767	1664.612	0.1229	-1 617	206.188
16		-13 155	-13 155	1893.948	1880.793	0.1069	-1.406	202.396
17		-13.155	-13.155	2141 692	2128 537	0.0929	-1.222	199 019
18		-13.155	-13.155	2305.59	2292.435	0.0808	-1.063	186.303
19		-13.155	-13.155	3346.297	3333.142	0.0703	-0.924	235.129
20		-13.155	-13.155	3784.924	3771.769	0.0611	-0.804	231.260
21		-13.155	-13.155	4288.856	4275.701	0 0531	-0.699	227.870
22		-13.155	-13.155	4869.115	4855.960	0 0462	-0.608	224.956
Total							-3,038.302	3264.072

NPV= 225 770
BCR= 1.07
IRR= 16%

Table 5.15: Calculation of Economical value of NPV, BCR, IRR (High Case Scenario)

Year	Investment cost (AV) (million Taka)	Operating cost (AV) (million Taka)	Total Cost (AV) (Million Taka)	Total Revenue (AV) (million taka)	Net Income (million Taka)	Discount Factor 15%	Discounted total Cost (million taka)	Discounted total Revenue (million taka)
1	2	3	4	5	6	7	8	9
0	-144.980		-144 980	0	-144.980	1.000	-144.980	0 000
1	-2153.210		-2153.210	0	-2153.210	0.870	-1872.357	0.000
2	-1267.885		-1267.885	0	-1267.885	0.756	-958.703	0.000
3		-13.155	-13.155	123.08	109.925	0.658	-8.650	80.927
4		-13.155	-13.155	142.69	129.535	0.572	-7.521	81 583
5		-13.155	-13 155	166.57	153 415	0.497	-6 540	82 815
6		-13.155	-13.155	195.886	182 731	0.432	-5 687	84 687
7		-13.155	-13.155	232.162	219 007	0 376	-4 945	87.278
8		-13.155	-13.155	1021 454	1008.299	0.327	-4.300	333.915
9		-13.155	-13.155	1140.328	1127.173	0.284	-3.739	324.152
10		-13.155	-13.155	1274.403	1261.248	0.247	-3.252	315.013
11		-13.155	-13.155	1425.878	1412.723	0.215	-2.828	306.483
12		-13.155	-13.155	1597.315	1584.160	0.187	-2.459	298.550
13		-13 155	-13.155	1791.703	1778 548	0.163	-2.138	291.202
14		-13.155	-13.155	2012.539	1999.384	0 141	-1.859	284.429
15		-13.155	-13 155	2263.923	2250.768	0.123	-1.617	278.224
16		-13.155	-13.155	2550.668	2537.513	0.107	-1.406	272 577
17		-13.155	-13.155	2878 441	2865.286	0.093	-1.222	267.482
18		-13.155	-13.155	3253.922	3240.767	0.081	-1.063	262 934
19		-13.155	-13.155	3685.003	3671 848	0.070	-0.924	258.928
20		-13.155	-13 155	4181.025	4167.870	0 061	-0.804	255.462
21		-13.155	-13 155	4753.06	4739.905	0.053	-0.699	252.533
22		-13.155	-13.155	5414.253	5401.098	0.046	-0 608	250.142
Total							-3,038.302	4,669.315

NPV= 1631.013
BCR= 1.54
IRR= 19%

5.3 Sensitivity Analysis

During investigating a new project, naturally the first thing is to estimate NPV based on projected cash flow. The initial set of projections is the base case. Now, however, the possibility of error in these cash flow projections is recognized. After completing the base case, it is wished to investigate the impact of different assumptions about the future on the estimates. One way of recognizing this investigation is to put an upper and lower bound on the various components of the project. In this project, the main variable for sensitivity analysis is power sector gas demand

5.3.1 Sensitivity analysis with power sector minimum gas demand

Sensitivity analysis has been made for minimum gas demand for power sector with minimum, base and optimistic gas demand for others sectors. The results of the analysis are shown in table 5.18.

Table: 5.18: Sensitivity analysis with power sector minimum demand

Gas Demand	NPV	BCR	IRR
Power sector-minimum Other sectors- minimum	-1690.746	0.43	7.65 %
Power sector-minimum Other sectors- base	-1558.079	0.48	8.58 %
Power sector-minimum Other sectors- maximum	-1423.396	0.52	9.37 %

5.3.2. Sensitivity analysis with power sector optimistic gas demand.

Sensitivity analysis has been made for maximum gas demand for power sector with minimum, base and optimistic gas demand for others sectors. The results of the analysis are shown in table 5.19.

Table: 5.19: Sensitivity analysis with power sector maximum demand

Gas Demand	NPV	BCR	IRR
Power sector-maximum Other sectors- minimum	27.051	1.01	15%
Power sector- maximum Other sectors- base	159.480	1.05	15%
Power sector- maximum Other sectors- maximum	294.611	1.10	16%

Comments: The result of the sensitivity analysis shows that the project viability is mostly depends on the power sector gas demand. If power sector gas demand is minimum then the project in not financially viable even with other sectors maximum demand. On the other hand with power sector maximum demand the project is financially viable even with other sectors minimum gas demand

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- Applying the present postage stamp method of wheeling charge for revenue calculation the project is financially viable only for optimistic case but economically it is viable for base case and optimistic case. On the other hand, if revenue is calculated on distance based wheeling charge then the project is financially viable for base case and optimistic case and economically viable even for pessimistic case

- Average cost of pipeline construction including materials and construction cost is US$25,000.00/KM/Inch Hence the total investment cost required for Monohordi-Elenga (30" OD, 87 KM) pipeline is US$ 65.25 million. Including this cost together with the present investment cost the project is not financially viable even for optimistic case.

- Presently only 80-100 MMSCFD gas can be supplied through the Brahmaputra Basin pipeline (Ashuganj-Elenga) for western zone, which is also reducing day by day with the increase of gas demand along the pipeline route. Supply security to this region should be ensured on priority basis by construction a loopline from Monohordi to Elenga parallel to the Brahmaputra Basin pipeline.

- At present pressure at Elenga is about 600 psig. After completion of Hatikumrul-Bonpara-Rajshahi project pressure at Rajshahi will be 350 psig and less in further distances. To increase the downstream pressure and pipeline flow capacity it needs to boost up the gas pressure at Elenga.

- Present supply is just meeting the present demand. To meet the future increasing demand it needs to increase supply rationally. Therefore, planned, work over and appraisal well on eastern gas fields should be completed in time.

6.2 Recommendations

- At present rate of wheeling charge gas supply to Rajshahi is not feasible. Distance based wheeling charge should be introduced instead of present postage stamp method for gas supply to Rajshahi and further distances.

- To ensure security of gas supply to the western zone a loopline from Monohordi to Elenga (87 Km) parallel to Bramaputra Basin pipeline needs to be constructed. Details study needs to be conducted for this loopline project. The loopline should be designed to meet the future demand of at least 20 years.

- Gas supply to Rajshahi at desired pressure and to increase the pipeline flow capacity a compressor station at Elenga needs to be considered. Details technical and financial study for this compressor station should be conducted.

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Appendix- A

Physical Construction Cost

Functional Building : Office Accommodation at Rajshahi

Sl.No.	Description	Physical Quantity	
A. office Accommodation			
1.	Manager	1 x 160ft² =	160ft²
2.	Dy. Manager	1 x 100 ft² =	100 ft²
3.	Asstt Engineer	4 x 100 ft² =	640 ft²
4.	Staff	6 x 60 ft² =	960 ft²
Sub-Total:			1860 ft²
B.	Allowance for Toilet, Varenda, Coridor stair-case etc. (70% of office space)		
Total (A+B) :			3160 ft² = 294m²
C.	Security building for 6 Armed security with Toilet, Kitchen, PC & APC's Room and one independent Magine Room	LS	60m²
D.	Generator Building	LS	30m²
E.	Security Guard Room	LS	25m²
F.	Garage	LS	30m²
Total (C+D+E+F) :			145m²
Grand Total:			439m²

Estimated Total cost = @ Tk. 12,500.00/ m² *439 m² = Taka 5.486 million

Note:

1. Gas flow through the pipeline to be monitored round the clock As such office accommodation at Rajshahi is required
2. It is a key point installation and round the clock shift duty will be performed. As such functional building is required.
3. Accommodation area and estimated cost has been calculated on the basis of Public Works Department (PWD) standard and latest rate schedule of 2005.

Appendix B : Total and Yearwise Investment Cost (Financial) in million Taka

Sl No.	Item of works	Total investment Cost	Cost in Year 1 (2008-2009)		Cost in Year 2 (2009-2010)		Cost in Year 3 (2010-2011)	
i	Pre-construction expenditure	in million Tk.	% of Item	in million Tk.	% of Item	in million Tk.	% of Item	in million Tk.
	(a) Route syrvey	1.000	100%	1.000	0%	0.000	0%	0 000
	(b) Soil/ Sub-surface investigation	2 000	100%	2.000	0%	0.000	0%	0 000
	(c) IEE , EIA & RP	1.000	100%	1.000	0%	0 000	0%	0.000
	(d) Resettlement compensation	10.500	0%	0.000	50%	5.250	50%	5.250
	(e) Land Acquisition	177 488	90%	159.739	10%	17.749		0.000
	(f) Land Requisition	55.755	0%	0.000	50%	27.878	50%	27.878
	(g) Land development	34.965	0%	0.000	40%	13 986	60%	20.979
	Sub Total	**282.708**		**163.739**		**64.862**		**54.107**
ii.	**Construction Works**							
	(a) Construction of pipeline and pipeline related facilities	367.500	0%	0.000	50%	183.750	50%	183.750
	(b) 2 nos River crossing by HDD method each 500m	217.626	0%	0.000	40%	87.050	60%	130.576
	(c) installation of manifold , regulating , CGs and intermediate valve station	24.000	0%	0.000	10%	2.400	90%	21.600
	(d) Fabrication , construction, transportation and Placing of Set-on-weight on 20 inch OD line pipe.	7.304	0%	0 000	50%	3.652	50%	3.652
	(e) Construction of CP system	6.000	0%	0.000	10%	0.600	90%	5.400
	(f)439 Sq. m Functional building	5.486	0%	0 000	10%	0.549	90%	4.937
	(g) 939 sq.m Residential building	12.766	0%	0.000	10%	1 277	90%	11.489
	(h) others (Boundary wall, internal road, surface drain , retaing wall, fencing, water supply etc)	8 716	0%	0.000	10%	0 872	90%	7 844
	(j) Civil construction for SCADA system	10.700	0%	0 000	10%	1.070	90%	9 630

Appendix B : Total and Yearwise Investment Cost (Financial) in million Taka

Sl No.	Item of works	Total investment Cost	Cost in Year 1 (2008-2009)		Cost in Year 2 (2009-2010)		Cost in Year 3 (2010-2011)	
	Sub Total	660.098		0.000		281.219		378.879
iii.	**Machneries & Equipments:**							
	(a) Imported							
	(i) Imported materials and equipments cost for linepipe	1417.500	0%	0.000	70%	992.250	30%	425.250
	(ii) Imported materials and equipment cost for SCADA system	100.000	0%	0 000	70%	70.000	30%	30 000
	(iii) Preshipment inspection (1% of material cost	15.175	0%	0.000	70%	10.623	30%	4.553
	(iv) CD-VAT (45% of FOB for linepipe etc materials)	637.875	0%	0.000	70%	446.513	30%	191 363
	(v) CD-VAT (20% of SCADA materials)	20.000		0.000	70%	14.000	30%	6.000
	(v) Landing charge , C&F , Insurance,Transportation cost etc.(7% of material cost)	99 225	0%	0 000	70%	69.458	30%	29.768
	(b) Locally procured :							
	(i) Off. equipment and fixtures	1 200	100%	1.200		0.000		0.000
	Sub Total	2290.975		1.200		1602.843		686.933
iv.	**Transpirt vehicles , Jeep , Pick up (double cabin)**	19.500	33 33%	6.499	33.33%	6.499	33.33%	6.499
v.	**(a) Manpower**							
	(i) Officer - 12 nos.	11 727	33.33%	3.909	33.33%	3.909	33.33%	3.909
	(ii) Staff- 08 nos.	2.999	33.33%	1.000	33 33%	1.000	33.33%	1.000
	(b) Human Resource development	1.375	33.33%	0.458	33 33%	0.458	33.33%	0.458
	Sub Total	16.101		5.366		5.366		5.366
vi.	**Other cost**							

Appendix B : Total and Yearwise Investment Cost (Financial) in million Taka

Sl No.	Item of works	Total investment Cost	Cost in Year 1 (2008-2009)		Cost in Year 2 (2009-2010)		Cost in Year 3 (2010-2011)	
	(a) cost of Engineering Design& construction supervision consultancy for SCADA system and testing & commissioning	15.700	0%	0.000	50%	7.850	50%	7.850
vii.	Total Base cost	3285.082		176 805		1968.640		1139.634
	(a) Interest during construction -5%)	164.254	0%	0.000	40%	65.702	60%	98.552
	(c) contingency (1%)	32 851	0%	0.000	65%	21.353	35%	11.498
viii.	**Total of sub totals**	3482.187		176.805		2055.694		1249.684

* Pipeline construction and other cost have been calculated on the basis of latest estimated cost of Ashuganj- Monohordi Project

** Cost of machinery and equipment has been calculated on the basis Actual cost of Ashuganj- Monohordi Project

Appendix C :Operating Recurring Cost

SL no.	Items of cost	Year-1 (2011)			Year-2			Year-3			Year-4		
	Raw materials and supplies	LC	FE	Total	LC	FE	Total	LC	FE	Total	LC	FE	Total
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	0.000	1.500	1.500	0.000	1.500	1.500	0.000	1.500	1.500	0.000	1.500	1.500
(ii)	CD-VAT	0.700	0.000	0.700	0 700	0.000	0.700	0 700	0.000	0.700	0.700	0.000	0.700
(b)	Locally procured materials and supplies and spares												
(i)	Ex-factory	0.000	0.000	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0 000	0.000	0.000
(ii)	VAT	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.000	0.000	0 000	0.000	0.000	0 000	0.000	0 000	0.000	0.000	0 000
	Sub Total I	0.700	1 500	2 200	0.700	1 500	2.200	0.700	1.500	2 200	0.700	1.500	2.200
II.	**Manpower**												
(a)	Officers-08 Nos.	1 360	0.000	1.360	1.360	0.000	1.360	1.360	0.000	1.360	1.360	0.000	1.360
(b)	Skilled Staff - 08 Nos.	0.480	0.000	0.480	0 480	0.000	0.480	0.480	0 000	0.480	0.480	0.000	0.480
©	Unskilled staff - 08 Nos.	0.720	0 000	0 720	0.720	0.000	0.720	0 720	0.000	0.720	0.720	0.000	0 720
	Sub total II	2.560	0.000	2.560	2.560	0.000	2.560	2.560	0.000	2 560	2.560	0 000	2.560
III.	**Others cost**												
(a)	Maintenance	2.500	5 000	7.500	2.500	5.000	7.500	2.500	5 000	7.500	2.500	5.000	7.500
(b)	Interest	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0.000
©	Miscellineous	0.500	0.000	0 500	0 500	0.000	0.500	0 500	0.000	0.500	0.500	0.000	0 500
(d)	Taxes if any	0.200	0.000	0.200	0.200	0.000	0 200	0.200	0.000	0 200	0.200	0 000	0.200
	Sub total III	3.200	5.000	8.200	3.200	5.000	8.200	3.200	5.000	8.200	3.200	5 000	8 200
	Total operating cost	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6 460	6.500	**12.960**

Appendix C :Operating Recurring Cost (Continued)

SL no.	Items of cost	Year-5)			Year-6			Year-7			Year-8		
I.	**Raw materials and supplies**	LC	FE	Total	LC	FE	Total	LC	FE	Total	LC	FE	Total
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	0.000	1.500	1.500	0.000	1.500	1.500	0.000	1.500	1.500	0.000	1.500	1.500
(ii)	CD-VAT	0.700	0.000	0.700	0.700	0.000	0.700	0.700	0.000	0.700	0.700	0.000	0.700
(b)	Locally procured materials and supplies and spares												
(i)	Ex-factory	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(ii)	VAT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sub Total I	0.700	1.500	2.200	0.700	1.500	2.200	0.700	1.500	2.200	0.700	1.500	2.200
II.	**Manpower**												
(a)	Officers-08 Nos	1.360	0.000	1.360	1.360	0.000	1.360	1.360	0.000	1.360	1.360	0.000	1.360
(b)	Skilled Staff - 08 Nos.	0.480	0.000	0.480	0.480	0.000	0.480	0.480	0.000	0.480	0.480	0.000	0.480
©	Unskilled staff - 08 Nos.	0.720	0.000	0.720	0.720	0.000	0.720	0.720	0.000	0.720	0.720	0.000	0.720
	Sub total II	2.560	0.000	2.560	2.560	0.000	2.560	2.560	0.000	2.560	2.560	0.000	2.560
III.	**Others cost**												
(a)	Maintenance	2.500	5.000	7.500	2.500	5.000	7.500	2.500	5.000	7.500	2.500	5.000	7.500
(b)	Interest	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(c)	Miscellineous	0.500	0.000	0.500	0.500	0.000	0.500	0.500	0.000	0.500	0.500	0.000	0.500
(d)	Taxes if any	0.200	0.000	0.200	0.200	0.000	0.200	0.200	0.000	0.200	0.200	0.000	0.200
	Sub total III	3.200	5.000	8.200	3.200	5.000	8.200	3.200	5.000	8.200	3.200	5.000	8.200
	Total operating cost	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6.460	6.500	**12.960**

Appendix C :Operating Recurring Cost (Continued)

SL no.	Items of cost	Year-9			Year-10			Year-11			Year-12		
I.	**Raw materials and supplies**	LC	FE	Total	LC	FE	Total	LC	FE	Total	LC	FE	Total
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	0.000	1.500	1.500	0.000	1.500	1.500	0 000	1.500	1.500	0 000	1.500	1.500
(ii)	CD-VAT	0.700	0.000	0.700	0.700	0.000	0.700	0.700	0.000	0.700	0.700	0.000	0.700
(b)	Locally procured materials and supplies and spares												
(i)	Ex-factory	0.000	0 000	0.000	0.000	0.000	0 000	0.000	0 000	0 000	0.000	0 000	0.000
(ii)	VAT	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.000	0 000	0 000	0.000	0.000	0 000	0.000	0.000	0.000	0.000	0.000
	Sub Total I	0.700	1.500	2.200	0.700	1.500	2.200	0.700	1.500	2.200	0.700	1.500	2 200
II.	**Manpower**												
(a)	Officers-08 Nos	1.360	0.000	1.360	1.360	0.000	1.360	1.360	0.000	1.360	1.360	0.000	1.360
(b)	Skilled Staff - 08 Nos.	0 480	0 000	0.480	0.480	0 000	0.480	0.480	0.000	0.480	0.480	0 000	0.480
©	Unskilled staff - 08 Nos.	0.720	0.000	0.720	0 720	0.000	0.720	0 720	0.000	0.720	0.720	0.000	0.720
	Sub total II	2.560	0.000	2 560	2.560	0.000	2.560	2.560	0.000	2.560	2.560	0.000	2.560
III.	**Others cost**												
(a)	Maintenance	2 500	5 000	7.500	2.500	5.000	7.500	2.500	5.000	7.500	2 500	5.000	7.500
(b)	Interest	0.000	0.000	0.000	0.000	0 000	0 000	0.000	0.000	0 000	0.000	0 000	0.000
(c)	Miscellineous	0.500	0.000	0.500	0.500	0 000	0.500	0.500	0.000	0.500	0.500	0 000	0.500
(d)	Taxes if any	0.200	0.000	0 200	0.200	0.000	0.200	0.200	0.000	0.200	0.200	0 000	0.200
	Sub total III	3 200	5 000	8.200	3.200	5.000	8.200	3.200	5.000	8.200	3.200	5.000	8 200
	Total operating cost	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6.460	6.500	**12.960**

Appendix C :Operating Recurring Cost (Continued)													
SL no.	Items of cost	Year-13			Year-14			Year-15			Year-16		
I.	**Raw materials and supplies**	LC	FE	Total	LC	FE	Total	LC	FE	Total	LC	FE	Total
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	0 000	1.500	1.500	0.000	1.500	1.500	0.000	1.500	1.500	0.000	1.500	1.500
(ii)	CD-VAT	0 700	0.000	0.700	0.700	0.000	0.700	0.700	0.000	0.700	0.700	0.000	0.700
(b)	Locally procured materials and supplies and spares												
(i)	Ex-factory	0.000	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0.000	0.000	0 000	0.000
(ii)	VAT	0.000	0 000	0.000	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0 000
	Sub Total I	0.700	1.500	2.200	0.700	1.500	2 200	0.700	1.500	2 200	0.700	1.500	2.200
II.	**Manpower**												
(a)	Officers-08 Nos.	1.360	0.000	1.360	1 360	0 000	1.360	1.360	0.000	1.360	1 360	0.000	1.360
(b)	Skilled Staff - 08 Nos.	0.480	0.000	0 480	0.480	0 000	0.480	0.480	0.000	0.480	0.480	0 000	0.480
©	Unskilled staff - 08 Nos.	0.720	0.000	0.720	0.720	0.000	0.720	0.720	0.000	0.720	0.720	0.000	0.720
	Sub total II	2.560	0.000	2.560	2.560	0.000	2.560	2 560	0 000	2.560	2.560	0.000	2.560
III.	**Others cost**												
(a)	Maintenance	2.500	5 000	7 500	2.500	5 000	7.500	2.500	5.000	7.500	2.500	5.000	7.500
(b)	Interest	0 000	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0 000	0.000	0.000
(c)	Miscellineous	0.500	0.000	0.500	0.500	0.000	0.500	0.500	0.000	0.500	0.500	0 000	0.500
(d)	Taxes if any	0.200	0.000	0.200	0.200	0.000	0.200	0 200	0.000	0.200	0.200	0.000	0.200
	Sub total III	3.200	5.000	8.200	3.200	5.000	8.200	3.200	5.000	8.200	3.200	5.000	8.200
	Total operating cost	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6 460	6.500	**12.960**

Appendix C :Operating Recurring Cost (Continued)

SL no.	Items of cost	Year-17			Year-18			Year-19			Year-20		
I.	**Raw materials and supplies**	LC	FE	Total	LC	FE	Total	LC	FE	Total	LC	FE	Total
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	0.000	1.500	1.500	0.000	1.500	1.500	0.000	1.500	1.500	0.000	1.500	1.500
(ii)	CD-VAT	0 700	0.000	0.700	0.700	0.000	0.700	0.700	0 000	0.700	0.700	0.000	0.700
(b)	Locally procured materials and supplies and spares												
(i)	Ex-factory	0.000	0.000	0.000	0 000	0.000	0.000	0 000	0.000	0.000	0.000	0 000	0.000
(ii)	VAT	0.000	0.000	0.000	0.000	0 000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Sub Total I	0.700	1.500	2 200	0.700	1.500	2 200	0.700	1.500	2.200	0.700	1.500	2.200
II.	**Manpower**												
(a)	Officers-08 Nos.	1.360	0 000	1.360	1.360	0.000	1.360	1.360	0.000	1.360	1 360	0 000	1.360
(b)	Skilled Staff - 08 Nos.	0.480	0.000	0.480	0 480	0.000	0.480	0.480	0.000	0.480	0.480	0.000	0.480
©	Unskilled staff - 08 Nos.	0.720	0.000	0 720	0.720	0 000	0.720	0.720	0.000	0.720	0.720	0.000	0.720
	Sub total II	2 560	0.000	2.560	2.560	0.000	2.560	2.560	0.000	2.560	2.560	0.000	2.560
III.	**Others cost**												
(a)	Maintenance	2.500	5.000	7.500	2.500	5.000	7.500	2.500	5.000	7.500	2 500	5 000	7.500
(b)	Interest	0.000	0 000	0.000	0 000	0.000	0.000	0.000	0.000	0.000	0 000	0.000	0 000
(c)	Miscellineous	0.500	0.000	0.500	0.500	0 000	0.500	0.500	0.000	0.500	0.500	0.000	0.500
(d)	Taxes if any	0.200	0.000	0.200	0 200	0.000	0.200	0.200	0.000	0 200	0.200	0.000	0.200
	Sub total IV	3.200	5.000	8 200	3.200	5.000	8 200	3.200	5 000	8.200	3.200	5.000	8.200
	Total operating cost	6.460	6.500	**12.960**	6.460	6.500	**12.960**	6.460	6 500	**12.960**	6.460	6.500	**12.960**

Appendix D1: Applying distance based wheeling charge income from investment for Low case scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge / SCM	Total Revenue
	MW	MMSCFD	MMSCF	Gas	(MMSCFD)	(MMSCF)	MMSCF	TK	Million Taka
0(2008)		0	0	0	0	0	0	0 320	0 000
1		0	0	0	0	0	0	0 353	0 000
2		0	0	0	0	0	0	0 389	0 000
3 (2011)	60	10	3650	0	5 000	1825 000	5475 000	0 858	133 098
4	60	10	3650	0	5 600	2044 000	5694 000	0.946	152 610
5	60	10	3650	0	6 272	2289 280	5939.280	1 042	175.500
6	60	10	3650	0	7 025	2563 994	6213 994	1.149	202 439
7	60	10	3650	0	7.868	2871.673	6521 673	1.267	234 240
8(2016)	160	26	9490	0	8 812	3216 274	12706 274	1.397	503.151
9	160	26	9490	0	9 517	3473.575	12963 575	1 540	565 957
10	160	26	9490	0	10 278	3751 461	13241.461	1 698	637 343
11	160	26	9490	0	11.100	4051 578	13541 578	1 872	718.597
12	160	26	9490	0	11.988	4375 705	13865 705	2 064	811.216
13	160	26	9490	0	12 947	4725 761	14215 761	2 276	916 945
14	160	26	9490	0	13.983	5103 822	14593.822	2.509	1037.817
15	160	26	9490	0	15 102	5512 128	15002 128	2 766	1176 206
16	160	26	9490	0	16 310	5953.098	15443 098	3 050	1334 884
17	160	26	9490	0	17 615	6429.346	15919.346	3 362	1517.095
18	160	26	9490	0	19 024	6943.693	16433 693	3.707	1726 638
19	160	26	9490	0	20 546	7499 189	16989 189	4 087	1967 965
20	160	26	9490	0	22 189	8099 124	17589 124	4 506	2246.299
21	160	26	9490	0	23 965	8747.054	18237.054	4 967	2567 773
22	160	26	9490	0	25 882	9446 818	18936 818	5 477	2939 595

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet ; SCM= Standard Cubic Meter)

Appendix D2: Applying distance based wheeling charge income from investment for Base Case Scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge	Total Revenue
	MW	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	Gas Demand	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	MMSCF	TK / SCM	million Taka
0(2008)		0	0	0	0	0	0	0 320	0 000
1		0	0	0	0	0	0	0 353	0 000
2		0	0	0	0	0	0	0 389	0 000
3 (2011)	60	10	3650	0	5	1825 000	5475 000	0 858	133 098
4	60	10	3650	0	5.750	2098 750	5748 750	0.946	154 077
5	60	10	3650	0	6 613	2413 563	6063.563	1.042	179.173
6	60	10	3650	0	7 604	2775.597	6425 597	1 149	209 332
7	60	10	3650	0	8 745	3191 936	6841.936	1 267	245 743
8(2016)	160	26	9490	0	10 057	3670,727	13160.727	1.397	521 147
9	160	26	9490	0	11.062	4037.800	13527 800	1 540	590 590
10	160	26	9490	0	12 169	4441.580	13931 580	1 698	670 560
11	160	26	9490	0	13 386	4885 737	14375.737	1.872	762 862
12	160	26	9490	0	14 724	5374.311	14864 311	2 064	869 640
13	160	26	9490	0	16 197	5911.742	15401.742	2 276	993 443
14(2022)	160	26	9490	0	17 816	6502 917	15992 917	2 509	1137 312
15	160	26	9490	0	19 598	7153.208	16643.208	2.766	1304 871
16	160	26	9490	0	21 558	7868 529	17358 529	3 050	1500.451
17	160	26	9490	0	23 713	8655 382	18145 382	3.362	1729 234
18	160	26	9490	0	26 085	9520 920	19010.920	3.707	1997.420
19(2027)	160	26	9490	0	28.693	10473.012	19963 012	4.087	2312 442
20	160	26	9490	0	31 563	11520 313	21010.313	4.506	2683 218
21	160	26	9490	0	34 719	12672 345	22162 345	4.967	3120 453
22	160	26	9490	0	38.191	13939 579	23429 579	5 477	3637.015

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet , SCM= Standard Cubic Meter)

Appendix D3: Applying distance based wheeling charge income from investment for High Case Scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand / Yr	Transmission charge / SCM	Total Income
	MW	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	Gas Demand	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	MMSCF	TK.	Billion Taka
0(2008)		0	0	0	0	0	0	0 320	0 000
1		0	0	0	0	0	0	0 353	0 000
2		0	0	0	0	0	0	0.389	0 000
3 (2011)	90	14.4	5256	0	5 000	1825 000	7081 000	0 858	172 140
4	90	14 4	5256	0	6 000	2190 000	7446.000	0.946	199 567
5	90	14 4	5256	0	7 200	2628 000	7884 000	1 042	232 965
6	90	14 4	5256	0	8 640	3153 600	8409.600	1.149	273.967
7	90	14 4	5256	0	10 368	3784 320	9040 320	1.267	324 702
8(2016)	540	86.4	31536	0	12 442	4541 184	36077.184	1 397	1428 607
9	540	86.4	31536	0	13 686	4995.302	36531.302	1.540	1594 865
10	540	86 4	31536	0	15 054	5494 833	37030 833	1 698	1782 382
11	540	86 4	31536	0	16 560	6044 316	37580 316	1 872	1994 235
12	540	86.4	31536	0	18 216	6648 747	38184.747	2 064	2234 007
13	540	86 4	31536	0	20 037	7313 622	38849 622	2 276	2505 878
14	540	86 4	31536	0	22 041	8044 984	39580 984	2 509	2814 741
15	540	86 4	31536	0	24.245	8849.483	40385 483	2.766	3166 326
16	540	86.4	31536	0	26 670	9734.431	41270 431	3.050	3567 369
17	540	86 4	31536	0	29 337	10707.874	42243.874	3.362	4025.792
18	540	86 4	31536	0	32 270	11778 662	43314 662	3.707	4550 940
19	540	86.4	31536	0	35 497	12956 528	44492 528	4 087	5153 851
20	540	86 4	31536	0	39 047	14252 181	45788 181	4 506	5847 588
21	540	86 4	31536	0	42,952	15677,399	47213,399	4,967	6647 636
22	540	86 4	31536	0	47.247	17245.139	48781 139	5.477	7572.382

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet ; SCM= Standard Cubic Meter)

Appendix D4: Calculation of Financial value of NPV, BCR, IRR for Low Case Scenario by applying distance based wheeling charge

Year	Investment cost (PV) (million Taka)	Operating cost (PV) (million Taka)	Total Cost (PV) (Million Taka)	Total Revenue (PV) (million taka)	Net Income (million Taka)	Discount Factor 15%	Discounted total Cost (million taka)	Discounted total Revenue (million taka)
1	2	3	4	5		6	7	8
0 (2008)	-176 805		-176 805	0	-176 805	1.000	-176 805	0 000
1	-2055 694		-2055 694	0	-2055 694	0 870	-1788 454	0 000
2	-1249 684		-1249 684	0	-1249 684	0 756	-944 761	0 000
3 (2011)		-12 960	-12 960	133 098	120.138	0 658	-8 528	87.578
4		-12 960	-12 960	152 61	139.650	0 572	-7 413	87 293
5		-12.960	-12 960	175 5	162,540	0 497	-6 441	87,224
6		-12.960	-12 960	202 439	189.479	0 432	-5 599	87 454
7		-12 960	-12 960	234 24	221 280	0.376	-4 873	88 074
8		-12.960	-12.960	503 151	490 191	0 327	-4 238	164 530
9		-12.960	-12 960	565.957	552 997	0 284	-3 681	160 732
10		-12 960	-12.960	637 343	624 383	0.247	-3 201	157.424
11		-12 960	-12 960	718 597	705 637	0 215	-2.786	154,498
12		-12 960	-12 960	811 216	798 256	0 187	-2 424	151 697
13		-12 960	-12 960	916 945	903 985	0 163	-2,112	149 462
14		-12 960	-12,960	1037 817	1024,857	0,141	-1,827	146,332
15		-12,960	-12 960	1176 206	1163 246	0 123	-1 594	144.673
16		-12 960	-12,960	1334 884	1321,924	0,107	-1,387	142,833
17		-12 960	-12 960	1517,095	1504 135	0 093	-1 205	141 090
18		-12,960	-12 960	1726 638	1713.678	0 081	-1 050	139 858
19		-12 960	-12 960	1967 965	1955 005	0 070	-0 907	137 758
20		-12 960	-12 960	2246 299	2233 339	0 061	-0 791	137.024
21		-12 960	-12 960	2567 773	2554 813	0 053	-0 687	136 092
22		-12 960	-12 960	2939.595	2926.635	0 046	-0 596	135,221
Total							-2,971,360	2,636 847

NPV= -334,512

BCR= 0,89

IRR= 13 85%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Appendix D5: Calculation of Financial value of NPV, BCR, IRR for Base Case Scenario by applying distance based wheeling charge

Year	Investment cost (PV)	Operating cost (PV)	Total Cost (PV)	Total Revenue (PV)	Net Income (PV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2	3	4	5	6	7	8	9
0 (2008)	-176 805		-176 805	0	-176.805	1 0000	-176 805	0 000
1	-2055.694		-2055.694	0	-2055 694	0 8696	-1787 560	0 000
2	-1249 684		-1249 684	0	-1249 684	0 7561	-944 941	0 000
3 (2011)		-12.960	-12 960	172 14	159 180	0 6575	-8,521	113 185
4		-12 960	-12 960	197,121	184 161	0 5718	-7,410	112 705
5		-12 960	-12,960	226 629	213 669	0 4972	-6 443	112 675
6		-12 960	-12 960	261 652	248.692	0 4323	-5 603	113 119
7		-12 960	-12 960	303 426	290 466	0 3759	-4,872	114 069
8		-12 960	-12.960	700 37	687.410	0.3269	-4,237	228 952
9		-12 960	-12 960	788 184	775 224	0 2843	-3.684	224 051
10		-12.960	-12,960	888 407	875 447	0.2472	-3 204	219 601
11		-12,960	-12.960	1003 039	990 079	0 2149	-2 786	215.596
12		-12,960	-12 960	1134.434	1121.474	0 1869	-2 422	212 034
13		-12 960	-12,960	1285 379	1272 419	0 1625	-2 106	208,910
14		-12.960	-12 960	2082 125	2069 165	0 1413	-1.832	294 264
15		-12,960	-12.960	2346 527	2333 567	0.1229	-1.593	288 375
16		-12 960	-12 960	2648 878	2635 918	0,1069	-1.385	283.072
17		-12 960	-12,960	2995 374	2982 414	0 0929	-1 204	278,348
18		-12 960	-12 960	3393 339	3380 379	0,0808	-1 047	274,199
19		-12,960	-12 960	4866 169	4853 209	0.0703	-0 911	341 923
20		-12 960	-12 960	5498 702	5485.742	0 0611	-0 792	335 972
21		-12.960	-12,960	6224 525	6211,565	0.0531	-0 689	330,713
22		-12 960	-12 960	7059 254	7046 294	0 0462	-0.599	326 142
Total							-2,970,645	4627 905

NPV= 1657,260

BCR= 1.56

IRR= 19%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Appendix D6: Calculation of Financial value of NPV, BCR, IRR for High Case Scenario by applying distance based wheeling charge

Year	Investment cost (PV)	Operating cost (PV)	Total Cost (PV)	Total Revenue (PV)	Net Income(PV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2	3	4	5	6	7	8	9
0 (2008)	-176 805		-176.805	0	-176.805	1.000	-176 805	0 000
1	-2055.694		-2055 694	0	-2055.694	0 870	-1787.560	0.000
2	-1249.684		-1249 684	0	-1249.684	0 756	-944 941	0.000
3 (2011)		-12,960	-12 960	172 14	159 180	0 658	-8 521	113 185
4		-12,960	-12 960	199 567	186 607	0 572	-7.410	114 103
5		-12 960	-12 960	232 965	220 005	0.497	-6 443	115 825
6		-12.960	-12 960	273.967	261 007	0 432	-5.603	118 443
7		-12 960	-12 960	324 702	311.742	0 376	-4 872	122 068
8		-12,960	-12.960	1428 607	1415 647	0 327	-4 237	467 014
9		-12 960	-12.960	1594 865	1581.905	0 284	-3 684	453 360
10		-12 960	-12 960	1782 382	1769.422	0 247	-3 204	440 578
11		-12,960	-12 960	1994 235	1981 275	0 215	-2.786	428.647
12		-12 960	-12 960	2234 007	2221 047	0 187	-2,422	417 552
13		-12.960	-12,960	2505 878	2492 918	0 163	-2 106	407.275
14		-12.960	-12,960	2814 741	2801.781	0,141	-1 832	397 804
15		-12 960	-12.960	3166 326	3153.366	0 123	-1.593	389 124
16		-12 960	-12.960	3567.369	3554 409	0 107	-1.385	381 226
17		-12 960	-12,960	4025 792	4012 832	0 093	-1.204	374.100
18		-12 960	-12.960	4550 94	4537 980	0 081	-1 047	367.739
19		-12 960	-12 960	5153.851	5140 891	0 070	-0.911	362 137
20		-12 960	-12 960	5847.588	5834 628	0 061	-0.792	357.289
21		-12.960	-12.960	6647 636	6634.676	0,053	-0 689	353.193
22		-12.960	-12,960	7572 382	7559.422	0 046	-0 599	349.849
Total							-2,970 645	6,530 511

NPV= 3559 867

BCR= 2 20

IRR= 23%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Appendix E: Economic Value of Investment Cost (in million Taka)

Sl No.	Item of works	Year 1 (2008-2009)			Year 2 (2009-2010)			Year 3 (2010-2011)		
		PV	SCF	AV	PV	SCF	AV	PV	SCF	AV
i.	**Pre-construction expenditure**									
	(a) Route survey	1.000	0.820	0.820	0.000	0.820	0.000	0.000	0 820	0.000
	(b)Soil/ Sub-surface investigation	2.000	0.820	1.640	0.000	0 820	0.000	0.000	0.820	0.000
	(c) IEE , EIA & RP	1 000	0.820	0 820	0 000	0.820	0.000	0.000	0.820	0 000
	(d) Resettlement compensation	0.000	0.820	0.000	5.250	0.820	4.305	5.250	0.820	4.305
	(e) Land Acquisition	159.739	0.820	130 986	17.749	0.820	14 554	0.000	0.820	0.000
	(f) Land Requisition	0.000	0.820	0.000	27.878	0.820	22.860	27.878	0.820	22.860
	(g) Land development	0.000	0 820	0.000	13.986	0 820	11.469	20.979	0.820	17.203
	Sub Total	163.739		134.266	64.863		53 188	54.107		44.368
ii.	**Construction Works**						0.000			0 000
	(a) Construction of 105 km 20 inch OD pipeline and pipeline related facilities	0.000	0.820	0.000	183.750	0.820	150.675	183.750	0.820	150 675
	(b) 2 nos each 500m River crossing by HDD method	0 000	1.220	0 000	87.050	1.220	106 201	130.576	1.220	159.303
	(c) Installation of manifold &Regulating station, CGS and Intermediate Valve Station	0.000	0.820	0.000	2 400	0.820	1.968	21.600	0.820	17 712
	(d) Fabrication, construction, transportation and placing of Set-on-weight on 20 inch OD pipeline	0.000	0.820	0.000	3.652	0.820	2.995	3.652	0.820	2.995
	(e) Construction of CP system	0 000	0 820	0.000	0.600	0.820	0.492	5.400	0.820	4 428
	(f) 439 Sq m Functional building	0.000	0.820	0 000	0.549	0.820	0.450	4.937	0 820	4.048
	(g) 939 sq.m Residential building	0.000	0.820	0.000	1 277	0.820	1.047	11.489	0.820	9.421

Appendix E: Economic Value of Investment Cost (in million Taka)										
Sl No.	Item of works	Year 1'(2008-2009)			Year 2 (2009-2010)			Year 3 (2010-2011)		
		PV	SCF	AV	PV	SCF	AV	PV	SCF	AV
	(h) Others (Boundary wall, internal road, surface drain , retaing wall, fencing, water supply etc.)	0.000	0 820	0.000	0.872	0.820	0.715	7.844	0.820	6.432
	(i) Civil construction for SCADA system	0.000	1.220	0.000	1.070	1 220	1.305	9.630	1.220	11.749
	Sub Total	0 000		0.000	281.220		265 848	378.878		366.762
iii.	**Machineries & equipments**									
	(a) Imported machineries and Equipments and materials :									
	(i) imported materials and equipment for linepipe	0.000	1.220	0.000	992.250	1.220	1210.545	425.250	1.220	518.805
	(ii) imported materials and equipment for SCADA	0.000	1.220	0.000	70.000	1.220	85.400	30 000	1.220	36.600
	(iii) Preshipment inspection (1% of material cost	0.000	1 220	0.000	10.623	1.220	12.960	4 553	1.220	5 555
	(iv) CD-VAT (45% of FOB on linepipe etc materials)	0.000	0.820	0.000	446.513	0 820	366.141	191.363	0.820	156 918
	(v) CD-VAT (20% of FOB cost of SCADA materials)	0.000	0.820	0.000	14.000	0.820	11.480	6.000	0.820	4.920
	(vi) Landing charge , C&F , Insurance, Transportation cost etc. (7% of linepipe etc material cost)	0.000	0.820	0 000	69.458	0.820	56.956	29 768	0.820	24.410
	(b) Locally procured :			0.000			0.000			0.000
	(i) Off. equipment and fixtures	1.200	0.820	0.984	0.000	0.820	0.000	0.000	0.820	0 000
	Sub Total	1.200		0.984	1602.844		1743.481	686 934		747 207

Appendix E: Economic Value of Investment Cost (in million Taka)										
Sl No.	Item of works	Year 1 (2008-2009)			Year 2 (2009-2010)			Year 3 (2010-2011)		
		PV	SCF	AV	PV	SCF	AV	PV	SCF	AV
iv.	Transpirt vehicles , Jeep - 5 nos. , Pick up- 01 no. (double cabin)	6.499	0 820	5.329	6.499	0.820	5.329	6.499	0.820	. 5.329
v.	(a) Manpower (Local)			0.000	0.000		0.000	0 000		0.000
	(i) Officer - 12 nos.	3.909	0.820	3.205	3.909	0.820	3.205	3.909	0.820	3 205
	(ii) Staff- 08 nos.	1.000	0.820	0 820	1.000	0.820	0.820	1.000	0.820	0 820
	(b) Human Resource development	0.458	0.820	0.376	0 458	0.820	0.376	0.458	0.820	0.376
	Sub Total	5.367		4.401	5.367		4.401	5 367		4.401
vi.	Other cost			0.000			0 000			0 000
	(a) Turn-key design, installation and commissioning of SCADA system	0.000	1.220	0.000	7.850	1 220	9.577	7.850	1.220	9.577
vii.	Total Base Cost	176.805		144.980	1968.643		2081.824	1139.635		1177.644
	(a) interest during construction (5%)	0.000	0.820	0.000	65.702	0.820	53 876	98 552	0.820	80.813
	(b) contingency (1%)	0.000	0.820	0.000	21.353	0.820	17.509	11.498	0.820	9.428
viii.	Total Investment Cost	176.805		144.980	2055.698		2153.210	1249.685		1267.885

* Pipeline construction and other cost have been calculated on the basis of latest estimated cost of Ashuganj- Monohordi Project

** Cost of machinery and equipment has been calculated on the basis Actual cost of Ashuganj- Monohordi Project

Appendix F :Economic Value of Operating Recurring Cost

SL no.	Items of cost	Year-1 (2011)			Year-2			Year-3			Year-4		
	Raw materials and supplies	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	1.500	1.220	1.830	1 500	1.220	1.830	1.500	1.220	1.830	1.500	1.220	1.830
(ii)	CD-VAT	0.700	0.820	0.574	0.700	0.820	0.574	0.700	0.820	0.574	0.700	0 820	0.574
(b)	Locally procured materials and supplies and spares			0.000			0.000			0.000			0.000
(i)	Ex-factory	0.000	0.820	0 000	0.000	0.820	0.000	0 000	0.820	0.000	0 000	0.820	0.000
(ii)	VAT	0.000	0 820	0.000	0.000	0.820	0.000	0 000	0.820	0.000	0.000	0.820	0.000
(iii)	Landing charge and Transportation cost to site	0 000	0.820	0.000	0.000	0 820	0.000	0.000	0.820	0.000	0.000	0 820	0.000
	Sub Total I	2.200		2 404	2.200		2.404	2.200		2.404	2.200		2.404
II.	**Manpower**												
(a)	Officers-08 Nos.	1.360	0.820	1.115	1 360	0.820	1.115	1 360	0.820	1.115	1.360	0.820	1.115
(b)	Skilled Staff - 08 Nos.	0.480	0 820	0.394	0.480	0.820	0 394	0.480	0.820	0.394	0.480	0.820	0 394
©	Unskilled staff - 08 Nos.	0.720	0.720	0.518	0.720	0 720	0.518	0.720	0.720	0 518	0.720	0.720	0.518
	Sub total II	2.560		2.027	2.560		2.027	2.560		2.027	2.560		2.027
III.	**Others cost**												
(a)	Maintenance -Local	2 500	0.820	2.050	2 500	0.820	2.050	2.500	0.820	2.050	2.500	0 820	2 050
(b)	Maintenance-Foreign	5 000	1.220	6.100	5 000	1.220	6.100	5.000	1.220	6.100	5.000	1 220	6.100
©	Interest	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000	0 000	0.820	0.000
(d)	Miscellineous	0.500	0.820	0 410	0.500	0.820	0.410	0 500	0.820	0.410	0 500	0.820	0.410
(e)	Taxes if any	0.200	0.820	0 164	0.200	0.820	0 164	0.200	0.820	0.164	0.200	0.820	0 164
	Sub total III	8 200		8.724	8 200		8.724	8.200		8.724	8.200		8.724
	Total operating cost	**12.960**		**13.155**	**12.960**		**13.155**	**12.960**		**13.155**	**12.960**		**13.155**

Appendix F:Economic Value of Operating Recurring Cost (continued)

SL no.	Items of cost	Year-5			Year-6			Year-7			Year-8		
	Raw materials and supplies	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	1.500	1.220	1.830	1.500	1 220	1.830	1.500	1.220	1.830	1.500	1 220	1 830
(ii)	CD-VAT	0.700	0.820	0.574	0.700	0.820	0.574	0 700	0 820	0.574	0.700	0.820	0.574
(b)	Locally procured materials and supplies and spares			0.000			0 000			0.000			0.000
(i)	Ex-factory	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0 820	0.000
(ii)	VAT	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0 000	0 000	0.820	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.820	0.000	0 000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000
	Sub Total I	2.200		2.404	2.200		2.404	2.200		2.404	2.200		2.404
II.	**Manpower**												
(a)	Officers-08 Nos.	1.360	0.820	1.115	1.360	0.820	1.115	1.360	0.820	1.115	1.360	0.820	1.115
(b)	Skilled Staff - 08 Nos.	0.480	0.820	0.394	0 480	0.820	0.394	0.480	0.820	0.394	0.480	0.820	0.394
©	Unskilled staff - 08 Nos.	0 720	0.720	0.518	0.720	0.720	0.518	0.720	0 720	0.518	0.720	0.720	0.518
	Sub total II	2.560		2.027	2.560		2.027	2 560		2.027	2.560		2.027
III.	**Others cost**												
(a)	Maintenance -Local	2.500	0.820	2.050	2 500	0.820	2.050	2.500	0.820	2.050	2.500	0.820	2.050
(b)	Maintenance-Foreign	5.000	1.220	6.100	5.000	1.220	6.100	5.000	1.220	6 100	5 000	1.220	6.100
©	Interest	0.000	0.820	0.000	0.000	0.820	0.000	0 000	0.820	0.000	0.000	0.820	0.000
(d)	Miscellineous	0.500	0.820	0.410	0.500	0.820	0 410	0.500	0.820	0.410	0.500	0.820	0 410
(e)	Taxes if any	0.200	0.820	0.164	0 200	0.820	0.164	0.200	0.820	0.164	0.200	0.820	0.164
	Sub total III	8.200		8.724	8.200		8.724	8.200		8 724	8 200		8.724
	Total operating cost	**12.960**		**13.155**	**12.960**		**13.155**	**12.960**		**13.155**	**12.960**		**13.155**

Appendix F:Economic Value of Operating Recurring Cost (continued)													
SL no.	Items of cost	Year-9			Year-10			Year-11			Year-12		
	Raw materials and supplies	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	1.500	1 220	1.830	1.500	1.220	1.830	1.500	1.220	1.830	1.500	1.220	1 830
(ii)	CD-VAT	0.700	0 820	0.574	0.700	0.820	0.574	0.700	0.820	0.574	0.700	0.820	0 574
(b)	Locally procured materials and supplies and spares			0 000			0.000			0.000			0.000
(i)	Ex-factory	0.000	0.820	0.000	0.000	0.820	0 000	0.000	0.820	0 000	0.000	0.820	0.000
(ii)	VAT	0.000	0.820	0.000	0.000	0.820	0.000	0 000	0.820	0.000	0 000	0.820	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.820	0.000	0.000	0.820	0.000	0 000	0.820	0.000	0.000	0.820	0.000
	Sub Total 1	2.200		2.404	2.200		2.404	2.200		2.404	2.200		2.404
II.	Manpower												
(a)	Officers-08 Nos.	1.360	0.820	1.115	1.360	0.820	1.115	1.360	0.820	1.115	1.360	0.820	1.115
(b)	Skilled Staff - 08 Nos.	0.480	0.820	0.394	0 480	0.820	0.394	0.480	0.820	0.394	0.480	0.820	0.394
©	Unskilled staff - 08 Nos	0.720	0.720	0.518	0.720	0.720	0.518	0.720	0.720	0.518	0.720	0.720	0.518
	Sub total II	2.560		2.027	2.560		2.027	2.560		2.027	2.560		2 027
III.	Others cost												
(a)	Maintenance -Local	2 500	0.820	2.050	2 500	0.820	2 050	2.500	0.820	2.050	2.500	0 820	2.050
(b)	Maintenance-Foreign	5 000	1.220	6.100	5 000	1.220	6 100	5.000	1.220	6.100	5.000	1.220	6.100
©	Interest	0 000	0.820	0.000	0 000	0 820	0 000	0.000	0.820	0 000	0.000	0.820	0.000
(d)	Miscellineous	0.500	0.820	0.410	0.500	0.820	0.410	0 500	0.820	0.410	0 500	0.820	0.410
(e)	Taxes if any	0.200	0.820	0.164	0.200	0.820	0.164	0 200	0.820	0 164	0 200	0.820	0.164
	Sub total III	8.200		8.724	8.200		8 724	8 200		8 724	8.200		8.724
	Total operating cost	**12.960**		**13.155**	**12.960**		**13.155**	**12.960**		**13.155**	**12.960**		**13.155**

Appendix F:Economic Value of Operating Recurring Cost (continued)

SL no.	Items of cost	Year-13			Year-14			Year-15			Year-16		
	Raw materials and supplies	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	1.500	1 220	1.830	1.500	1.220	1.830	1.500	1 220	1.830	1.500	1.220	1.830
(ii)	CD-VAT	0.700	0 820	0.574	0.700	0.820	0.574	0.700	0.820	0.574	0.700	0.820	0.574
(b)	Locally procured materials and supplies and spares			0.000			0.000			0.000			0.000
(i)	Ex-factory	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0 000
(ii)	VAT	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000
	Sub Total I	2.200		2.404	2.200		2.404	2.200		2.404	2.200		2.404
II.	**Manpower**												
(a)	Officers-08 Nos.	1.360	0.820	1 115	1.360	0.820	1.115	1 360	0.820	1.115	1.360	0.820	1.115
(b)	Skilled Staff - 08 Nos.	0.480	0.820	0.394	0 480	0.820	0.394	0.480	0 820	0.394	0.480	0.820	0.394
©	Unskilled staff - 08 Nos.	0.720	0.720	0.518	0.720	0.720	0.518	0 720	0.720	0 518	0.720	0 720	0.518
	Sub total II	2 560		2.027	2.560		2.027	2 560		2.027	2.560		2.027
III.	**Others cost**												
(a)	Maintenance -Local	2.500	0.820	2.050	2.500	0.820	2.050	2.500	0.820	2.050	2.500	0.820	2.050
(b)	Maintenance-Foreign	5.000	1 220	6.100	5.000	1.220	6.100	5.000	1.220	6.100	5.000	1.220	6.100
©	Interest	0.000	0 820	0.000	0.000	0 820	0.000	0.000	0.820	0.000	0.000	0.820	0.000
(d)	Miscellineous	0 500	0.820	0.410	0.500	0.820	0.410	0.500	0.820	0.410	0.500	0.820	0.410
(e)	Taxes if any	0.200	0 820	0.164	0.200	0.820	0 164	0.200	0 820	0.164	0.200	0.820	0.164
	Sub total III	8.200		8.724	8.200		8.724	8 200		8 724	8.200		8.724
	Total operating cost	12.960		13.155	12.960		13.155	12.960		13.155	12.960		13.155

Appendix F :Economic Value of Operating Recurring Cost (continued)

SL no.	Items of cost	Year-17			Year-18			Year-19			Year-20		
	Raw materials and supplies	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV	PV	SCF	AV
(a)	Imported materials , supplies and Spares												
(i)	CIF Cost	1.500	1.220	1.830	1.500	1.220	1.830	1 500	1.220	1.830	1.500	1.220	1.830
(ii)	CD-VAT	0 700	0.820	0.574	0.700	0.820	0.574	0.700	0.820	0.574	0.700	0.820	0.574
(b)	Locally procured materials and supplies and spares			0.000			0 000			0.000			0.000
(i)	Ex-factory	0 000	0.820	0.000	0 000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000
(ii)	VAT	0.000	0.820	0.000	0.000	0 820	0.000	0.000	0.820	0.000	0.000	0.820	0.000
(iii)	Landing charge and Transportation cost to site	0.000	0.820	0.000	0.000	0 820	0.000	0 000	0.820	0 000	0 000	0.820	0.000
	Sub Total I	2.200		2.404	2.200		2.404	2.200		2.404	2.200		2.404
II.	**Manpower**												
(a)	Officers-08 Nos.	1 360	0.820	1.115	1 360	0.820	1 115	1.360	0.820	1.115	1.360	0.820	1.115
(b)	Skilled Staff - 08 Nos.	0.480	0.820	0.394	0.480	0.820	0.394	0.480	0.820	0.394	0.480	0.820	0.394
©	Unskilled staff - 08 Nos.	0.720	0.720	0.518	0.720	0.720	0.518	0 720	0.720	0.518	0.720	0.720	0.518
	Sub total II	2.560		2.027	2.560		2.027	2 560		2 027	2 560		2.027
III.	**Others cost**												
(a)	Maintenance -Local	2.500	0 820	2.050	2.500	0.820	2.050	2.500	0.820	2.050	2.500	0.820	2.050
(b)	Maintenance-Foreign	5.000	1 220	6.100	5 000	1.220	6.100	5.000	1.220	6.100	5.000	1.220	6 100
©	Interest	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000	0.000	0.820	0.000
(d)	Miscellineous	0.500	0.820	0.410	0 500	0 820	0.410	0 500	0.820	0 410	0.500	0.820	0.410
(e)	Taxes if any	0.200	0.820	0.164	0.200	0 820	0.164	0.200	0.820	0.164	0 200	0 820	0.164
	Sub total III	8 200		8.724	8.200		8.724	8.200		8.724	8.200		8.724
	Total operating cost	**12.960**		**13.155**	**12.960**		**13.155**	**12.960**		**13.155**	**12.960**		**13.155**

Appendix G1: Applying postage stamp wheeling charge income from investment (economical) for Low Case Scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge / SCM	Total Revenue	SCF	Total Revenue (Economical)
	MW	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	Gas Demand	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	MMSCF	TK.	Million TK.		Million TK.
0 (2008)		0	0	0	0	0	0	0.320	0 000	1.43	0.000
1		0	0	0	0	0	0	0.353	0.000	1.43	0.000
2		0	0	0	0	0	0	0.389	0.000	1.43	0.000
3(2011)	60	10	3650	0	5 000	1825.000	5475.000	0 429	66.549	1.43	95.165
4	60	10	3650	0	5.600	2044.000	5694.000	0 473	76.305	1 43	109.116
5	60	10	3650	0	6.272	2289.280	5939.280	0.521	87.750	1.43	125 483
6	60	10	3650	0	7.025	2563.994	6213.994	0.575	101.219	1.43	144.744
7	60	10	3650	0	7.868	2871.673	6521.673	0.634	117.120	1.43	167.481
8	60	10	3650	0	8.812	3216.274	6866 274	0 699	135.948	1 43	194.405
9	160	26	9490	0	9.517	3473.575	12963.575	0 770	282.979	1 43	404 659
10	160	26	9490	0	10.278	3751.461	13241.461	0 849	318 672	1 43	455 700
11	160	26	9490	0	11.100	4051 578	13541.578	0.936	359 298	1.43	513 797
12	160	26	9490	0	11.988	4375.705	13865.705	1.032	405.608	1.43	580.019
13	160	26	9490	0	12 947	4725.761	14215 761	1.138	458.473	1 43	655 616
14	160	26	9490	0	13.983	5103 822	14593.822	1.254	518.909	1.43	742 039
15	160	26	9490	0	15.102	5512.128	15002.128	1.383	588.103	1.43	840.987
16	160	26	9490	0	16 310	5953.098	15443 098	1.525	667.442	1.43	954 442
17	160	26	9490	0	17.615	6429.346	15919.346	1.681	758.548	1.43	1084.723
18	160	26	9490	0	19.024	6943.693	16433 693	1.853	863.319	1.43	1234.546
19	160	26	9490	0	20.546	7499.189	16989 189	2.043	983.983	1.43	1407.095
20	160	26	9490	0	22.189	8099.124	17589.124	2.253	1123.150	1.43	1606.104
21	160	26	9490	0	23.965	8747.054	18237 054	2.484	1283.887	1.43	1835.958
22	160	26	9490	0	25.882	9446.818	18936 818	2.738	1469.798	1.43	2101.811

Appendix G2: Applying postage stamp wheeling charge income from investment (economical) for Base Case Scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge	Total Revenue	SCF	Total Revenue (Economical)
	MW	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF))	Gas Demand	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	MMSCF	TK./ SCM	million Taka		million Taka
0 (2008)		0	0	0	0	0	0	0 320	0.000	1.43	0.000
1		0	0	0	0	0	0	0.353	0.000	1 43	0.000
2		0	0	0	0	0	0	0.389	0.000	1.43	0.000
3	90	14.4	5256	0	5.000	1825 000	7081.000	0.429	86.070	1.43	123.080
4	90	14.4	5256	0	5 750	2098.750	7354.750	0.473	98.561	1.43	140.942
5	90	14.4	5256	0	6.613	2413.563	7669 563	0.521	113.314	1.43	162 040
6	90	14.4	5256	0	7.604	2775.597	8031 597	0.575	130 826	1.43	187.082
7	90	14.4	5256	0	8.745	3191.936	8447.936	0.634	151 713	1.43	216.949
8	240	38.4	14016	0	10 057	3670.727	17686.727	0.699	350 185	1.43	500.765
9	240	38 4	14016	0	11 062	4037.800	18053.800	0 770	394.092	1.43	563.551
10	240	38 4	14016	0	12.169	4441.580	18457.580	0 849	444.204	1.43	635.211
11	240	38.4	14016	0	13.386	4885.737	18901 737	0.936	501.519	1 43	717.173
12	240	38.4	14016	0	14.724	5374 311	19390.311	1.032	567.217	1.43	811.121
13	240	38.4	14016	0	16.197	5911 742	19927.742	1.138	642.690	1.43	919.046
14	390	62.4	22776	0	17.816	6502.917	29278.917	1.254	1041.062	1.43	1488.719
15	390	62.4	22776	0	19.598	7153.208	29929.208	1.383	1173.264	1.43	1677.767
16	390	62 4	22776	0	21 558	7868.529	30644.529	1.525	1324.439	1.43	1893 948
17	390	62.4	22776	0	23.713	8655.382	31431.382	1.681	1497.687	1.43	2141 692
18	390	58	21170	0	26.085	9520.920	30690.920	1 853	1612.301	1.43	2305.590
19	540	82	29930	0	28.693	10473.012	40403.012	2 043	2340.068	1.43	3346 297
20	540	82	29930	0	31.563	11520.313	41450 313	2.253	2646 800	1.43	3784.924
21	540	82	29930	0	34.719	12672.345	42602 345	2.484	2999 200	1.43	4288.856
22	540	82	29930	0	38.191	13939.579	43869.579	2.738	3404 976	1.43	4869.115

Appendix G 3: Applying postage stamp wheeling charge income from investment (economical) for High Case Scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge / SCM	Total Income	SCF	Total Inco (Economic
	MW	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	Gas Demand	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	MMSCF	TK.	Million Taka		Million Ta
0(2008)		0	0	0	0	0	0	0.320	0.000	1.43	
1		0	0	0	0	0	0	0 353	0.000	1.43	
2		0	0	0	0	0	0	0.389	0.000	1 43	
3 (2011)	90	14.4	5256	0	5	1825 000	7081.000	0.429	86.070	1.43	12
4	90	14.4	5256	0	6 000	2190.000	7446 000	0.473	99.784	1.43	14
5	90	14.4	5256	0	7.200	2628.000	7884.000	0.521	116.483	1.43	16
6	90	14.4	5256	0	8.640	3153.600	8409.600	0.575	136.984	1.43	19
7	90	14.4	5256	0	10.368	3784.320	9040.320	0.634	162.351	1.43	23
8	540	86 4	31536	0	12.442	4541.184	36077.184	0.699	714.304	1.43	102
9	540	86.4	31536	0	13 686	4995.302	36531.302	0 770	797.433	1.43	114
10	540	86.4	31536	0	15 054	5494.833	37030 833	0.849	891.191	1.43	127
11	540	86.4	31536	0	16.560	6044 316	37580.316	0.936	997.118	1.43	142
12	540	86.4	31536	0	18.216	6648.747	38184.747	1.032	1117.003	1.43	159
13	540	86.4	31536	0	20.037	7313.622	38849.622	1.138	1252.939	1.43	179
14	540	86 4	31536	0	22.041	8044 984	39580.984	1.254	1407 370	1.43	201
15	540	86.4	31536	0	24.245	8849.483	40385.483	1.383	1583.163	1.43	226
16	540	86.4	31536	0	26.670	9734.431	41270.431	1.525	1783.684	1.43	255
17	540	86.4	31536	0	29 337	10707.874	42243 874	1.681	2012 896	1.43	287
18	540	86.4	31536	0	32.270	11778.662	43314.662	1.853	2275.470	1.43	325
19	540	86 4	31536	0	35.497	12956.528	44492.528	2.043	2576.925	1.43	368
20	540	86.4	31536	0	39 047	14252.181	45788.181	2 253	2923.794	1.43	418
21	540	86.4	31536	0	42.952	15677.399	47213.399	2.484	3323.818	1 43	475
22	540	86 4	31536	0	47.247	17245.139	48781.139	2.738	3786.191	1.43	541

Appendix H1: Applying distance based wheeling charge income from investment (economical) for Low Case Scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge / SCM	Total Revenue	SCF	Total Revenue (Economical)
	MW	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	Gas Demand	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	MMSCF	TK.	Million TK.		Million TK.
0 (2008)		0	0	0	0	0	0	0.320	0.000	1.43	0.000
1		0	0	0	0	0	0	0.353	0.000	1.43	0 000
2		0	0	0	0	0	0	0 389	0.000	1 43	0.000
3(2011)	60	10	3650	0	5 000	1825.000	5475.000	0 858	133.098	1.43	190.330
4	60	10	3650	0	5.600	2044.000	5694.000	0 946	152.610	1.43	218 232
5	60	10	3650	0	6.272	2289.280	5939.280	1 042	175.500	1.43	250.966
6	60	10	3650	0	7.025	2563.994	6213.994	1 149	202.439	1.43	289.488
7	60	10	3650	0	7.868	2871.673	6521.673	1 267	234.240	1.43	334.963
8(2016)	160	26	9490	0	8 812	3216.274	12706.274	1.397	503.151	1.43	719.506
9	160	26	9490	0	9.517	3473.575	12963 575	1 540	565 957	1.43	809.319
10	160	26	9490	0	10.278	3751.461	13241 461	1 698	637.343	1.43	911.401
11	160	26	9490	0	11.100	4051.578	13541.578	1 872	718.597	1.43	1027 593
12	160	26	9490	0	11 988	4375.705	13865.705	2 064	811.216	1 43	1160 039
13	160	26	9490	0	12.947	4725.761	14215.761	2 276	916.945	1.43	1311.231
14	160	26	9490	0	13.983	5103 822	14593.822	2 509	1037.817	1.43	1484.078
15	160	26	9490	0	15.102	5512.128	15002.128	2 766	1176.206	1.43	1681.974
16	160	26	9490	0	16.310	5953.098	15443.098	3 050	1334.884	1.43	1908.884
17	160	26	9490	0	17.615	6429.346	15919 346	3 362	1517.095	1.43	2169.446
18	160	26	9490	0	19 024	6943.693	16433.693	3.707	1726.638	1.43	2469.093
19	160	26	9490	0	20.546	7499.189	16989.189	4 087	1967.965	1.43	2814 190
20	160	26	9490	0	22 189	8099.124	17589.124	4 506	2246.299	1 43	3212 208
21	160	26	9490	0	23.965	8747.054	18237.054	4 967	2567.773	1 43	3671.915
22	160	26	9490	0	25.882	9446.818	18936.818	5.477	2939 595	1 43	4203.621

Appendix H2: Applying distance based wheeling charge income from investment (economical) for Base Case Scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge	Total Revenue	SCF	Total Revenue (Economical)
	MW	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF))	Gas Demand	Gas Demand / day (MMSCFD)	Gas Demand / Year (MMSCF)	MMSCF	TK / SCM	million Taka		million Taka
0 (2008)		0	0	0	0	0	0	0.320	0.000	1.43	0 000
1		0	0	0	0	0	0	0 353	0,000	1.43	0.000
2		0	0	0	0	0	0	0.389	0.000	1.43	0.000
3(2011)	90	14.4	5256	0	5	1825.000	7081 000	0 858	172.140	1.43	246.160
4	90	14.4	5256	0	5.750	2098 750	7354.750	0 946	197.121	1 43	281.884
5	90	14 4	5256	0	6.613	2413.563	7669.563	1.042	226.629	1 43	324.079
6	90	14 4	5256	0	7 604	2775.597	8031.597	1.149	261 652	1.43	374 163
7	90	14.4	5256	0	8 745	3191.936	8447.936	1 267	303 426	1.43	433 899
8(2016)	240	38.4	14016	0	10.057	3670.727	17686.727	1 397	700 370	1.43	1001.529
9	240	38.4	14016	0	11.062	4037 800	18053.800	1 540	788.184	1.43	1127.103
10	240	38.4	14016	0	12.169	4441 580	18457 580	1 698	888.407	1.43	1270.422
11	240	38.4	14016	0	13.386	4885.737	18901.737	1 872	1003.039	1.43	1434.345
12	240	38 4	14016	0	14.724	5374.311	19390.311	2 064	1134.434	1 43	1622.241
13	240	38.4	14016	0	16.197	5911.742	19927.742	2 276	1285.379	1.43	1838.092
14(2022)	390	62.4	22776	0	17.816	6502.917	29278.917	2 509	2082.125	1.43	2977.439
15	390	62.4	22776	0	19.598	7153 208	29929.208	2 766	2346.527	1.43	3355.534
16	390	62.4	22776	0	21 558	7868.529	30644.529	3 050	2648.878	1.43	3787.895
17	390	62.4	22776	0	23 713	8655.382	31431 382	3 362	2995.374	1.43	4283 385
18	390	58	21170	0	26 085	9520.920	30690.920	3 707	3224.602	1.43	4611.180
19(2027)	540	82	29930	0	28.693	10473.012	40403 012	4.087	4680.136	1.43	6692.595
20	540	82	29930	0	31.563	11520.313	41450.313	4 506	5293.601	1 43	7569.849
21	540	82	29930	0	34.719	12672.345	42602.345	4.967	5998.401	1.43	8577.713
22	540	82	29930	0	38 191	13939.579	43869.579	5 477	6809.952	1.43	9738.231

Appendix H3: : Applying distance based wheeling charge income from investment (economical) for High Case Scenario

Year	Power			Fertilizer	Non bulk		Total gas Demand	Transmission charge / SCM	Total Income	SCF	Total Inco (Economi
	MW	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	Gas Demand	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	MMSCF	TK.	Million Taka		Million Ta
0(2008)		0	0	0	0	0	0	0 320	0.000	1.43	
1		0	0	0	0	0	0	0.353	0.000	1.43	
2		0	0	0	0	0	0	0 389	0 000	1.43	
3 (2011)	90	14.4	5256	0	5.000	1825 000	7081.000	0 858	172.140	1.43	24
4	90	14.4	5256	0	6.000	2190.000	7446.000	0 946	199.567	1.43	28
5	90	14.4	5256	0	7.200	2628 000	7884.000	1.042	232.965	1.43	33
6	90	14.4	5256	0	8.640	3153 600	8409.600	1.149	273.967	1.43	39
7	90	14.4	5256	0	10.368	3784.320	9040.320	1 267	324.702	1.43	46
8(2016)	540	86.4	31536	0	12.442	4541.184	36077 184	1.397	1428.607	1.43	204
9	540	86.4	31536	0	13 686	4995.302	36531.302	1.540	1594.865	1.43	228
10	540	86.4	31536	0	15 054	5494.833	37030.833	1.698	1782.382	1.43	254
11	540	86.4	31536	0	16 560	6044.316	37580.316	1.872	1994.235	1.43	285
12	540	86.4	31536	0	18 216	6648.747	38184 747	2 064	2234.007	1.43	319
13	540	86.4	31536	0	20 037	7313.622	38849 622	2 276	2505.878	1 43	358
14	540	86.4	31536	0	22.041	8044.984	39580 984	2.509	2814.741	1 43	402
15	540	86.4	31536	0	24 245	8849.483	40385.483	2 766	3166.326	1.43	452
16	540	86 4	31536	0	26.670	9734.431	41270.431	3 050	3567.369	1.43	510
17	540	86.4	31536	0	29.337	10707.874	42243.874	3.362	4025.792	1.43	575
18	540	86 4	31536	0	32.270	11778.662	43314.662	3 707	4550.940	1.43	650
19	540	86.4	31536	0	35.497	12956.528	44492.528	4 087	5153.851	1.43	737
20	540	86 4	31536	0	39.047	14252.181	45788.181	4 506	5847.588	1.43	836
21	540	86.4	31536	0	42.952	15677.399	47213.399	4 967	6647 636	1.43	950
22	540	86.4	31536	0	47.247	17245.139	48781.139	5.477	7572.382	1.43	1082

Appendix H 4: Calculation of economical value of NPV, BCR and IRR for low case scenario by applying distance based wheeling charge.

Year	Investment cost (AV) (million Taka)	Operating cost (AV) (million Taka)	Total Cost (AV) (Million Taka)	Total Revenue (AV) (million taka)	Net Income (million Taka)	Discount Factor 15%	Discounted total Cost (million taka)	Discounted total Revenue (million taka)
1	2	3	4	5		6	7	8
0(2008)	-144.980		-144.980	0	-144.980	1.000	-144.980	0.000
1	-2153 210		-2153.210	0	-2153.210	0.870	-1873 293	0.000
2	-1267.885		-1267.885	0	-1267.885	0.756	-958.521	0.000
3(2011)		-13.155	-13.155	190.33	177.175	0.658	-8.656	125.237
4		-13 155	-13.155	218.232	205.077	0.572	-7.525	124.829
5		-13.155	-13.155	250.966	237.811	0.497	-6.538	124.730
6		-13.155	-13.155	289.488	276.333	0.432	-5.683	125.059
7		-13 155	-13.155	334.963	321.808	0.376	-4.946	125.946
8(2016)		-13.155	-13.155	719.506	706.351	0.327	-4.302	235.278
9		-13.155	-13.155	809.319	796.164	0.284	-3.736	229.847
10		-13.155	-13.155	911.401	898.246	0.247	-3.249	225.116
11		-13.155	-13.155	1027 593	1014.438	0.215	-2.828	220.932
12		-13.155	-13.155	1160.039	1146.884	0.187	-2.460	216.927
13		-13.155	-13.155	1311 231	1298 076	0.163	-2.144	213.731
14		-13.155	-13.155	1484.078	1470 923	0.141	-1.855	209.255
15		-13.155	-13.155	1681.974	1668.819	0 123	-1.618	206.883
16		-13.155	-13.155	1908.884	1895 729	0.107	-1.408	204.251
17		-13.155	-13.155	2169.446	2156 291	0 093	-1.223	201.758
18		-13.155	-13.155	2469.093	2455.938	0 081	-1.066	199.997
19		-13.155	-13.155	2814.19	2801 035	0.070	-0.921	196.993
20		-13.155	-13.155	3212.208	3199.053	0 061	-0.802	195.945
21		-13.155	-13.155	3671.915	3658.760	0.053	-0.697	194.611
22		-13.155	-13.155	4203.621	4190 466	0.046	-0.605	193.367
Total							-3,039 056	3,770.692

NPV= 731.635
BCR= 1.24
IRR= 17.19%

Appendix H5: Calculation of Economical value of NPV, BCR and IRR for base case scenario by applying distance based wheeling charge.

Year	Investment cost (AV)	Operating cost (AV)	Total Cost (AV)	Total Revenue (AV)	Net Income (AV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2	3	4	5	6	7	8	9
0 (2008)	-144.980		-144.980	0	-144.980	1.0000	-144 980	0.000
1	-2153.210		-2153.210	0	-2153 210	0 8696	-1872.357	0.000
2	-1267.885		-1267.885	0	-1267.885	0.7561	-958.703	0.000
3		-13.155	-13 155	246.16	233 005	0.6575	-8.650	161.854
4		-13.155	-13.155	281.884	268.729	0.5718	-7.521	161 168
5		-13.155	-13.155	324.079	310.924	0.4972	-6.540	161.125
6		-13.155	-13.155	374.163	361.008	0.4323	-5 687	161.761
7		-13 155	-13.155	433 899	420.744	0.3759	-4.945	163.119
8		-13 155	-13.155	1001.529	988.374	0.3269	-4.300	327.402
9		-13.155	-13.155	1127.103	1113.948	0.2843	-3.739	320 393
10		-13.155	-13.155	1270.422	1257.267	0.2472	-3.252	314 029
11		-13.155	-13.155	1434.345	1421 190	0.2149	-2 828	308.303
12		-13.155	-13.155	1622.241	1609 086	0.1869	-2 459	303.208
13		-13.155	-13.155	1838.092	1824.937	0.1625	-2.138	298.741
14		-13 155	-13.155	2977.439	2964.284	0.1413	-1.859	420.797
15		-13.155	-13.155	3355.534	3342.379	0.1229	-1.617	412 377
16		-13.155	-13.155	3787.895	3774.740	0.1069	-1.406	404.793
17		-13.155	-13.155	4283.385	4270 230	0.0929	-1 222	398.037
18		-13.155	-13.155	4611.18	4598.025	0.0808	-1.063	372.607
19		-13.155	-13.155	6692.595	6679.440	0.0703	-0.924	470.257
20		-13 155	-13.155	7569.849	7556.694	0.0611	-0.804	462.520
21		-13.155	-13 155	8577.713	8564.558	0.0531	-0.699	455.740
22		-13.155	-13.155	9738 231	9725.076	0.0462	-0.608	449.912
Total							-3,038.302	6528.142

NPV= 3489.841
BCR= 2.15
IRR= 23%

Appendix H6: Calculation of Economical value of NPV, BCR and IRR for high case scenario by applying distance based wheeling charge.

Year	Investment cost (AV)	Operating cost (AV)	Total Cost (AV)	Total Revenue (AV)	Net Income(AV)	Discount Factor (15%)	Discounted total Cost	Discounted total Revenue
1	2	3	4	5	6	7	8	9
0	-144 980		-144.980	0	-144 980	1.000	-144.980	0.000
1	-2153.210		-2153.210	0	-2153.210	0.870	-1872.357	0 000
2	-1267.885		-1267.885	0	-1267.885	0.756	-958.703	0.000
3		-13.155	-13.155	246 16	233.005	0.658	-8.650	161.854
4		-13.155	-13 155	285.381	272.226	0 572	-7.521	163.168
5		-13.155	-13.155	333.14	319 985	0 497	-6.540	165.629
6		-13.155	-13.155	391 773	378 618	0.432	-5.687	169.374
7		-13.155	-13.155	464.324	451.169	0.376	-4.945	174.557
8		-13.155	-13.155	2042.908	2029.753	0.327	-4.300	667.830
9		-13.155	-13.155	2280.657	2267.502	0.284	-3.739	648.305
10		-13.155	-13.155	2548.807	2535 652	0.247	-3.252	630.026
11		-13.155	-13.155	2851.757	2838 602	0.215	-2.828	612.966
12		-13 155	-13.155	3194.63	3181.475	0.187	-2.459	597.099
13		-13.155	-13.155	3583.406	3570.251	0.163	-2.138	582.404
14		-13.155	-13 155	4025.079	4011.924	0.141	-1.859	568.859
15		-13 155	-13 155	4527.846	4514.691	0.123	-1.617	556.447
16		-13.155	-13.155	5101.337	5088.182	0.107	-1.406	545.153
17		-13.155	-13.155	5756 882	5743.727	0.093	-1.222	534.963
18		-13.155	-13.155	6507.844	6494.689	0.081	-1.063	525.867
19		-13.155	-13.155	7370.007	7356 852	0.070	-0 924	517.856
20		-13 155	-13 155	8362.051	8348.896	0.061	-0 804	510 924
21		-13.155	-13.155	9506.119	9492.964	0.053	-0.699	505.067
22		-13.155	-13.155	10828 506	10815.351	0.046	-0.608	500.283
Total							-3,038 302	9,338.632

NPV= 6300.330
BCR= 3.07
IRR= 27%

Appendix 1.1: Income from investment (Power Sector Low and others Base Demand Case)

Year	Power			Fertilizer	Non bulk		Total gas Demand / Yr	Transmission charge / SCM	Total Income
	MW	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	Gas Demand	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	MMSCF	TK	Billion Taka
0(2008)		0	0	0	0	0.000	0.000	0.320	0.000
1		0	0	0	0	0.000	0.000	0.353	0.000
2		0	0	0	0	0.000	0.000	0.389	0.000
3(2011)	60	10	3650	0	5	1825.000	5475.000	0.429	66.549
4	60	10	3650	0	5.750	2098.750	5748.750	0.473	77.039
5	60	10	3650	0	6.613	2413.563	6063.563	0.521	89.586
6	60	10	3650	0	7.604	2775.597	6425.597	0.575	104.666
7	60	10	3650	0	8.745	3191.936	6841.936	0.634	122.871
8	160	10	3650	0	10.057	3670.727	7320.727	0.699	144.945
9	160	26	9490	0	11.062	4037.800	13527.800	0.770	295.295
10	160	26	9490	0	12.169	4441.580	13931.580	0.849	335.280
11	160	26	9490	0	13.386	4885.737	14375.737	0.936	381.431
12	160	26	9490	0	14.724	5374.311	14864.311	1.032	434.820
13	160	26	9490	0	16.197	5911.742	15401.742	1.138	496.722
14	160	26	9490	0	17.816	6502.917	15992.917	1.254	568.656
15	160	26	9490	0	19.598	7153.208	16643.208	1.383	652.435
16	160	26	9490	0	21.558	7868.529	17358.529	1.525	750.226
17	160	26	9490	0	23.713	8655.382	18145.382	1.681	864.617
18	160	26	9490	0	26.085	9520.920	19010.920	1.853	998.710
19	160	26	9490	0	28.693	10473.012	19963.012	2.043	1156.221
20	160	26	9490	0	31.563	11520.313	21010.313	2.253	1341.609
21	160	26	9490	0	34.719	12672.345	22162.345	2.484	1560.227
22	160	26	9490	0	38.191	13939.579	23429.579	2.738	1818.507

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet ; SCM= Standard Cubic Meter)

Appendix I.2: Income from investment (Power Sector Low and others High demand case)

Year	Power			Fertilizer	Non bulk		Total gas Demand / Yr.	Transmission charge / SCM	Total Income
	MW	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	Gas Demand	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	MMSCF	TK	Billion Taka
0(2008)		0	0	0	0	0 000	0 000	0 320	0.000
1		0	0	0	0	0.000	0 000	0 353	0 000
2		0	0	0	0	0 000	0 000	0 389	0 000
3(2011)	60	10	3650	0	5	1825 000	5475.000	0 429	66 549
4	60	10	3650	0	6 000	2190 000	5840 000	0 473	78 262
5	60	10	3650	0	7.200	2628 000	6278 000	0 521	92 755
6	60	10	3650	0	8 640	3153 600	6803.600	0 575	110 823
7	60	10	3650	0	10.368	3784 320	7434 320	0 634	133 510
8	160	10	3650	0	12 442	4541 184	8191 184	0.699	162 180
9	160	26	9490	0	13.686	4995 302	14485 302	0.770	316.196
10	160	26	9490	0	15 054	5494.833	14984 833	0 849	360 628
11	160	26	9490	0	16.560	6044.316	15534 316	0 936	412 172
12	160	26	9490	0	18 216	6648 747	16138.747	1.032	472.100
13	160	26	9490	0	20.037	7313 622	16803 622	1 138	541.934
14	160	26	9490	0	22 041	8044.984	17534.984	1.254	623.487
15	160	26	9490	0	24.245	8849 483	18339 483	1.383	718 931
16	160	26	9490	0	26 670	9734 431	19224 431	1.525	830 869
17	160	26	9490	0	29.337	10707.874	20197 874	1 681	962 417
18	160	26	9490	0	32 270	11778 662	21268.662	1.853	1117 317
19	160	26	9490	0	35.497	12956.528	22446.528	2 043	1300 062
20	160	26	9490	0	39 047	14252.181	23742.181	2 253	1516 052
21	160	26	9490	0	42.952	15677 399	25167 399	2 484	1771.782
22	160	26	9490	0	47 247	17245 139	26735 139	2 738	2075.071

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet ; SCM= Standard Cubic Meter)

Appendix I.3: Calculation of Financial value of NPV, BCR, IRR (Power Sector Low & Others Base Demand Case)

Year	Investment cost (PV) (million Taka)	Operating cost (PV) (million Taka)	Total Cost (PV) (Million Taka)	Total Revenue (PV) (million taka)	Net Income (million Taka)	Discount Factor 15%	Discounted total Cost (million taka)	Discounted total Revenue (million taka)
1	2	3	4	5		6	7	8
0	-176 805		-176 805	0 000	-176,805	1.000	-176,805	0 000
1	-2055 694		-2055 694	0.000	-2055 694	0 870	-1788 454	0.000
2	-1249.684		-1249 684	0 000	-1249 684	0 756	-944 761	0 000
3		-12 960	-12 960	66 549	53 589	0 658	-8 528	43 789
4		-12 960	-12 960	77.039	64.079	0 572	-7.413	44 066
5		-12.960	-12 960	89 586	76 626	0 497	-6,441	44 524
6		-12 960	-12 960	104 666	91,706	0.432	-5 599	45 216
7		-12 960	-12,960	122 871	109,911	0 376	-4 873	46 200
8		-12 960	-12 960	144 945	131 985	0 327	-4 238	47 397
9		-12,960	-12 960	295 295	282 335	0.284	-3 681	83 864
10		-12,960	-12 960	335.280	322.320	0,247	-3 201	82 814
11		-12 960	-12,960	381 431	368 471	0 215	-2,786	82.008
12		-12.960	-12 960	434 820	421 860	0 187	-2 424	81 311
13		-12 960	-12.960	496 722	483 762	0 163	-2.112	80 966
14		-12 960	-12,960	568 656	555.696	0 141	-1,827	80.180
15		-12 960	-12,960	652 435	639.475	0 123	-1,594	80 250
16		-12,960	-12 960	750 226	737.266	0,107	-1 387	80,274
17		-12.960	-12 960	864 617	851,657	0.093	-1 205	80 409
18		-12,960	-12 960	998.710	985 750	0 081	-1.050	80,895
19		-12 960	-12 960	1156 221	1143,261	0 070	-0 907	80 935
20		-12,960	-12 960	1341.609	1328 649	0 061	-0 791	81 838
21		-12 960	-12,960	1560 227	1547 267	0 053	-0 687	82.692
22		-12 960	-12 960	1818 507	1805 547	0,046	-0 596	83,651
Total							-2,971,360	1,413 281

NPV= -1,558 079

BCR= 0 48

IRR= 8 58%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Appendix I.4: Calculation of Financial value of NPV, BCR, IRR (Power Sector Low & Others High Demand Case)

Year	Investment cost (PV) (million Taka)	Operating cost (PV) (million Taka)	Total Cost (PV) (Million Taka)	Total Revenue (PV) (million taka)	Net Income (million Taka)	Discount Factor 15%	Discounted total Cost (million taka)	Discounted total Revenue (million taka)
1	2	3	4	5		6	7	8
0	-176 805		-176.805	0.000	-176 805	1 000	-176 805	0.000
1	-2055 694		-2055.694	0 000	-2055.694	0.870	-1788 454	0.000
2	-1249 684		-1249 684	0 000	-1249.684	0.756	-944 761	0 000
3		-12 960	-12.960	66 549	53 589	0 658	-8.528	43 789
4		-12 960	-12 960	78 262	65.302	0 572	-7 413	44.766
5		-12 960	-12 960	92.755	79 795	0.497	-6 441	46 099
6		-12.960	-12 960	110 823	97 863	0.432	-5 599	47.876
7		-12.960	-12 960	133 510	120 550	0.376	-4 873	50 200
8		-12 960	-12 960	162 180	149.220	0.327	-4 238	53 033
9		-12.960	-12.960	316.196	303 236	0.284	-3.681	89.800
10		-12 960	-12 960	360 628	347 668	0.247	-3 201	89 075
11		-12.960	-12 960	412.172	399 212	0 215	-2 786	88.617
12		-12 960	-12 960	472.100	459 140	0 187	-2 424	88 283
13		-12 960	-12 960	541 934	528.974	0 163	-2 112	88 335
14		-12 960	-12 960	623.487	610 527	0 141	-1 827	87 912
15		-12.960	-12 960	718 931	705 971	0.123	-1.594	88 429
16		-12 960	-12 960	830 869	817.909	0.107	-1 387	88 903
17		-12 960	-12.960	962 417	949 457	0 093	-1 205	89 505
18		-12 960	-12 960	1117 317	1104.357	0.081	-1.050	90 503
19		-12.960	-12 960	1300 062	1287 102	0 070	-0.907	91 004
20		-12 960	-12 960	1516.052	1503 092	0 061	-0 791	92 479
21		-12 960	-12.960	1771 782	1758 822	0 053	-0.687	93 904
22		-12.960	-12.960	2075.071	2062 111	0.046	-0 596	95 453
Total							-2,971.360	1,547.964

NPV= -1,423 396

BCR= 0.52

IRR= 9 37%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Appendix I.5: Income from investment (Power Sector High & Others Low demand case)

Year	Power			Fertilizer	Non bulk		Total gas Demand / Yr	Transmission charge / SCM	Total Income
	MW	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	Gas Demand	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	MMSCF	TK	Billion Taka
0(2008)		0	0	0	0	0	0	0 320	0 000
1		0	0	0	0	0	0	0 353	0.000
2		0	0	0	0	0	0	0 389	0.000
3 (2011)	90	14 4	5256	0	5 000	1825	7081	0 429	86 070
4	90	14 4	5256	0	5.600	2044	7300	0 473	97 827
5	90	14.4	5256	0	6 272	2289 28	7545.28	0 521	111.478
6	90	14.4	5256	0	7 025	2563 9936	7819 9936	0 575	127 379
7	90	14 4	5256	0	7 868	2871 6728	8127 6728	0 634	145 961
8	540	86.4	31536	0	8 812	3216.2736	34752.274	0.699	688 071
9	540	86.4	31536	0	9 517	3473.5755	35009 575	0 770	764 215
10	540	86.4	31536	0	10 278	3751.4615	35287.461	0.849	849 235
11	540	86 4	31536	0	11.100	4051 5784	35587.578	0 936	944.244
12	540	86 4	31536	0	11 988	4375.7047	35911.705	1 032	1050 511
13	540	86 4	31536	0	12.947	4725 7611	36261.761	1.138	1169.478
14	540	86 4	31536	0	13 983	5103.8219	36639 822	1.254	1302 792
15	540	86 4	31536	0	15 102	5512 1277	37048 128	1,383	1452.334
16	540	86.4	31536	0	16 310	5953 0979	37489 098	1 525	1620 257
17	540	86 4	31536	0	17 615	6429 3458	37965 346	1 681	1809.027
18	540	86 4	31536	0	19.024	6943 6934	38479 693	1,853	2021 472
19	540	86 4	31536	0	20,546	7499 1889	39035.189	2.043	2260 846
20	540	86 4	31536	0	22 189	8099.124	39635 124	2 253	2530.892
21	540	86 4	31536	0	23 965	8747 0539	40283.054	2 484	2835 922
22	540	86 4	31536	0	25 882	9446 8182	40982 818	2 738	3180.917

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet ; SCM= Standard Cubic Meter)

Appendix I.6: Income from investment (Power Sector High & Others Base Demand Case)

Year	Power			Fertilizer	Non bulk		Total gas Demand / Yr	Transmission charge / SCM	Total Income
	MW	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	Gas Demand	Gas demand / day (MMSCFD)	Gas demand / Year (MMSCF)	MMSCF	TK	Billion Taka
0(2008)		0	0	0	0.000	0.000	0	0.320	0.000
1		0	0	0	0.000	0.000	0	0.353	0.000
2		0	0	0	0.000	0.000	0	0.389	0.000
3 (2011)	90	14.4	5256	0	5.000	1825.000	7081	0.429	86.070
4	90	14.4	5256	0	5.750	2098.750	7354.75	0.473	98.561
5	90	14.4	5256	0	6.613	2413.563	7669.563	0.521	113.314
6	90	14.4	5256	0	7.604	2775.597	8031.597	0.575	130.826
7	90	14.4	5256	0	8.745	3191.936	8447.936	0.634	151.713
8	540	86.4	31536	0	10.057	3670.727	35206.73	0.699	697.069
9	540	86.4	31536	0	11.062	4037.800	35573.8	0.770	776.531
10	540	86.4	31536	0	12.169	4441.580	35977.58	0.849	865.843
11	540	86.4	31536	0	13.386	4885.737	36421.74	0.936	966.377
12	540	86.4	31536	0	14.724	5374.311	36910.31	1.032	1079.723
13	540	86.4	31536	0	16.197	5911.742	37447.74	1.138	1207.727
14	540	86.4	31536	0	17.816	6502.917	38038.92	1.254	1352.539
15	540	86.4	31536	0	19.598	7153.208	38689.21	1.383	1516.667
16	540	86.4	31536	0	21.558	7868.529	39404.53	1.525	1703.041
17	540	86.4	31536	0	23.713	8655.382	40191.38	1.681	1915.096
18	540	86.4	31536	0	26.085	9520.920	41056.92	1.853	2156.863
19	540	86.4	31536	0	28.693	10473.012	42009.01	2.043	2433.085
20	540	86.4	31536	0	31.563	11520.313	43056.31	2.253	2749.351
21	540	86.4	31536	0	34.719	12672.345	44208.34	2.484	3112.262
22	540	86.4	31536	0	38.191	13939.579	45475.58	2.738	3529.627

(Note: MW=Mega Watt; MMSCFD= Million Standard Cubic Feet Per Day; MMSCF = Million Standard Cubic Feet ; SCM= Standard Cubic Meter)

Appendix I.7: Calculation of Financial value of NPV, BCR, IRR (Power Sector High & Others Low demand case)

Year	Investment cost (PV)	Operating cost (PV)	Total Cost (PV)	Total Revenue (PV)	Net Income(PV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2	3	4	5.000	6.000	7	8	9
0	-176 805		-176 805	0 000	-176 805	1 000	-176.805	0 000
1	-2055.694		-2055.694	0 000	-2055.694	0 870	-1787 560	0 000
2	-1249 684		-1249.684	0 000	-1249 684	0 756	-944 941	0 000
3		-12 960	-12.960	86 070	73 110	0 658	-8 521	56 592
4		-12.960	-12.960	97 827	84 867	0.572	-7.410	55 933
5		-12 960	-12 960	111.478	98.518	0 497	-6 443	55.424
6		-12 960	-12 960	127 379	114 419	0.432	-5 603	55 070
7		-12 960	-12.960	145 961	133 001	0 376	-4 872	54.872
8		-12.960	-12 960	688 071	675.111	0.327	-4 237	224 932
9		-12.960	-12 960	764.215	751 255	0 284	-3 684	217.238
10		-12 960	-12 960	849 235	836.275	0 247	-3 204	209 918
11		-12.960	-12 960	944 244	931.284	0 215	-2.786	202 959
12		-12 960	-12 960	1050.511	1037 551	0 187	-2 422	196.348
13		-12.960	-12 960	1169 478	1156 518	0 163	-2 106	190 073
14		-12 960	-12 960	1302 792	1289 832	0 141	-1.832	184 122
15		-12 960	-12 960	1452 334	1439 374	0 123	-1.593	178 484
16		-12 960	-12 960	1620 257	1607 297	0 107	-1 385	173 148
17		-12 960	-12 960	1809.027	1796.067	0 093	-1 204	168 105
18		-12 960	-12 960	2021 472	2008 512	0 081	-1 047	163 345
19		-12 960	-12.960	2260 846	2247.886	0 070	-0 911	158 859
20		-12.960	-12 960	2530.892	2517 932	0 061	-0.792	154 638
21		-12.960	-12 960	2835 922	2822 962	0 053	-0 689	150.674
22		-12 960	-12 960	3180 917	3167.957	0.046	-0.599	146 960
Total							-2,970.645	2,997 696

NPV= 27 051

BCR= 1.01

IRR= 15%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Appendix I.8: Calculation of Financial value of NPV, BCR, IRR -(Power Sector High & Others Base Demand Case)

Year	Investment cost (PV)	Operating cost (PV)	Total Cost (PV)	Total Revenue (PV)	Net Income(PV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2	3	4	5	6	7	8	9
0	-176 805		-176 805	0	-176 805	1 000	-176 805	0 000
1	-2055 694		-2055.694	0	-2055 694	0.870	-1787 560	0 000
2	-1249 684		-1249 684	0	-1249.684	0 756	-944.941	0.000
3		-12 960	-12 960	86.0699976	73 110	0 658	-8 521	56 592
4		-12 960	-12.960	98.5606841	85 601	0 572	-7.410	56.352
5		-12 960	-12.960	113 314369	100 354	0 497	-6 443	56.337
6		-12.960	-12.960	130 82625	117.866	0 432	-5 603	56 560
7		-12.960	-12 960	151.7128	138 753	0 376	-4.872	57 034
8		-12.960	-12 960	697 06911	684.109	0 327	-4 237	227 873
9		-12 960	-12 960	776 531431	763.571	0 284	-3 684	220 739
10		-12 960	-12 960	865 843348	852.883	0 247	-3.204	214 023
11		-12 960	-12.960	966.377124	953 417	0 215	-2 786	207 716
12		-12 960	-12.960	1079 72284	1066.763	0 187	-2 422	201 808
13		-12 960	-12.960	1207.72712	1194.767	0 163	-2.106	196 289
14		-12 960	-12 960	1352 53937	1339 579	0 141	-1.832	191.153
15		-12 960	-12 960	1516 66692	1503 707	0 123	-1.593	186.390
16		-12 960	-12 960	1703.04104	1690 081	0 107	-1.385	181 995
17		-12.960	-12 960	1915 09582	1902 136	0 093	-1 204	177 962
18		-12 960	-12 960	2156 86288	2143 903	0 081	-1 047	174.286
19		-12 960	-12 960	2433 08474	2420 125	0 070	-0 911	170 961
20		-12 960	-12.960	2749 35111	2736 391	0 061	-0 792	167 986
21		-12 960	-12 960	3112 26248	3099 302	0,053	-0.689	165.357
22		-12.960	-12 960	3529 62689	3516 667	0 046	-0.599	163.071
Total							-2,970 645	3,130 485

NPV= 159 840

BCR= 1,05

IRR= 15%

(Note. NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Appendix I. 9 : Calculation of Financial value of NPV, BCR, IRR for High Case Scenario (Using Postage Stamp tariff and Including the average cost of Monohordi-Elenga Project)

Year	Investment cost of Hatikumrul-Rajshahi Proj	Investment cost of Monohordi-Elenga Proj	Operating cost (PV)	Total Cost (PV)	Total Revenue (PV)	Net Income(PV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2		3	4	5	6	7	8	9
0	-176 805	-1500 666		-1677 471	0 000	-1677.471	1 000	-1677 471	0 000
1	-2055 694	-1500.666		-3556.360	0 000	-3556 360	0 870	-3092.487	0.000
2	-1249 684	-1500 666		-2750 350	0 000	-2750 350	0.756	-2079 660	0 000
3			-12,960	-12 960	86 070	73 110	0.658	-8 521	56 592
4			-12 960	-12 960	99 784	86 824	0 572	-7.410	57 052
5			-12 960	-12 960	116 483	103.523	0 497	-6 443	57,912
6			-12 960	-12,960	136 984	124 024	0 432	-5,603	59 222
7			-12 960	-12 960	162 351	149 391	0 376	-4 872	61,034
8			-12,960	-12 960	714 304	701,344	0 327	-4 237	233 507
9			-12 960	-12 960	797 433	784 473	0 284	-3,684	226 680
10			-12 960	-12 960	891,191	878 231	0 247	-3 204	220 289
11			-12 960	-12 960	997 118	984 158	0 215	-2 786	214 324
12			-12,960	-12 960	1117 003	1104 043	0.187	-2 422	208 776
13			-12 960	-12,960	1252.939	1239 979	0.163	-2.106	203 638
14			-12 960	-12,960	1407.370	1394.410	0 141	-1 832	198 902
15			-12 960	-12,960	1583.163	1570 203	0.123	-1 593	194 562
16			-12 960	-12 960	1783.684	1770.724	0 107	-1.385	190 613
17			-12,960	-12.960	2012 896	1999 936	0 093	-1,204	187 050
18			-12.960	-12 960	2275 470	2262 510	0 081	-1.047	183 870
19			-12.960	-12 960	2576 925	2563.965	0 070	-0 911	181.068
20			-12 960	-12 960	2923 794	2910 834	0 061	-0 792	178 645
21			-12.960	-12 960	3323 818	3310 858	0 053	-0 689	176 597
22			-12 960	-12,960	3786 191	3773.231	0 046	-0.599	174.924
Total								-6,910 957	3,265 256

NPV= -3645.701

BCR= 0 47

IRR= 9%

(Note; NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)

Appendix I.10: Calculation of Financial value of NPV, BCR, IRR for High Case Scenario (Using Distance Based Tariffs and Including the average cost of Monohordi-Elenga Project)

Year	Investment cost of Hatikumrul-Rajshahi Proj	Investment cost of Monohordi-Elenga Proj	Operating cost (PV)	Total Cost (PV)	Total Revenue (PV)	Net Income(PV)	Discount Factor 15%	Discounted total Cost	Discounted total Revenue
1	2		3	4	5	6	7	8	9
0 (2008)	-176 805	-1500 666		-1677 471	0	-1677.471	1 000	-1677 471	0 000
1	-2055 694	-1500 666		-3556.360	0	-3556 360	0.870	-3092.487	0 000
2	-1249.684	-1500 666		-2750.350	0	-2750.350	0.756	-2079.660	0 000
3 (2011)			-12 960	-12 960	172.14	159 180	0 658	-8 521	113.185
4			-12.960	-12 960	199.567	186 607	0 572	-7 410	114 103
5			-12.960	-12.960	232 965	220 005	0 497	-6 443	115 825
6			-12.960	-12.960	273.967	261 007	0 432	-5 603	118 443
7			-12 960	-12 960	324.702	311 742	0 376	-4.872	122 068
8			-12.960	-12 960	1428.607	1415 647	0 327	-4.237	467.014
9			-12 960	-12 960	1594 865	1581 905	0.284	-3.684	453 360
10			-12 960	-12 960	1782 382	1769 422	0.247	-3.204	440 578
11			-12 960	-12 960	1994 235	1981 275	0 215	-2 786	428 647
12			-12.960	-12 960	2234 007	2221 047	0 187	-2 422	417.552
13			-12 960	-12 960	2505 878	2492.918	0 163	-2 106	407 275
14			-12.960	-12 960	2814.741	2801.781	0.141	-1.832	397.804
15			-12 960	-12 960	3166.326	3153.366	0 123	-1 593	389 124
16			-12.960	-12 960	3567.369	3554 409	0 107	-1 385	381 226
17			-12 960	-12 960	4025 792	4012 832	0 093	-1 204	374 100
18			-12 960	-12 960	4550 94	4537 980	0.081	-1 047	367 739
19			-12.960	-12 960	5153 851	5140.891	0 070	-0 911	362.137
20			-12.960	-12.960	5847 588	5834 628	0 061	-0 792	357.289
21			-12.960	-12 960	6647.636	6634.676	0 053	-0 689	353 193
22			-12 960	-12 960	7572 382	7559.422	0.046	-0 599	349.849
Total								-6,910 957	6,530 511

NPV= -380 445

BCR= 0.94

IRR= 14%

(Note: NPV= Net Present Value ; BCR= Benefit Cost Ratio ; IRR= Internal Rate of Return)