CAPACITY ANALYSIS OF TRANSMISSION PIPELINE FOR SUSTAINABLE GAS SUPPLY TO SHAHJIBAZAR INDUSTRIAL AREA

Submitted for the partial fulfillment of the requirements for the degree of

Master of Engineering in Petroleum Engineering

Department of Petroleum and Mineral Resources Engineering

Bangladesh University of Engineering and Technology (BUET)

CANDIDATE'S DECLARATION

It is hereby declared that this project report 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 EXAMINER'S

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DEDICATED TO MY BELOVED PARENT AND MY FAMILY WITH RESPECTED TEACHERS OF PETROLEUM AND MINERAL RESOURCES ENGINEERING DEPARTMENT

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Acronyms and Abbreviations

AGA	American Gas Association
BAPEX	Bangladesh Petroleum Exploration and Production Company Limited
BBLD	Barrel Per Day
BGDCL	Bakhrabad Gas Distribution Company Limited
BGFCL	Bangladesh Gas Fields Company Limited
CMS	Customer Metering Station
CNG	Compressed Natural Gas
dia.	Diameter
E&P	Exploration & Production
EVC	Electronic Volume Corrector
GTCL	Gas Transmission Company Ltd.
JGTDSL	Jalalabad Gas Transmission and Distribution System Limited
IOCs	International Oil Companies
KGDCL	Karnaphuli Gas Distribution Company Limited
km	Kilo-meter
LDCs	Local Distribution Companies
LNG	Liquefied Natural Gas
mmcfd	Million cubic feet per day
NPS	Nominal Pipe Size
PGCL	Pashchimanchal Gas Company Limited
Psig	Pound per square inch gauge
R-LNG	Re-gasified Liquefied Natural Gas
RMS	Regulating and Metering Station
TBS	Town Bordering Station
TCF	Trillion cubic feet
TGTDCL	Titas Gas Transmission and Distribution Company Limited
Tx	Transmission
USCS	U.S. Customary System
SCFD	Standard cubic feet per day
SGCL	Sundarban Gas Company Limited
SGFL	Sylhet Gas Fields Limited

Abstract

In 2011-12, Jalalabad Gas Transmission and Distribution System Limited (JGTDSL) constructed about 6 km; 10"/8" diameter transmission line from Shahjibazar TBS to provide gas connection to PRAN-RFL. Later, JGTDSL constructed a 8-9 km; 8" diameter transmission line to supply gas to various customers along the Dhaka-Sylhet highway. Due to the proximity of the gas fields, many investors and renowned companies like SQUARE GROUP, RAK PAINT, STAR CERAMICS, COOPER TECH etc. constructed new plants along the Dhaka-Sylhet Highway around Shahjibazar area. As a result, low gas pressure problem gradually arises and these establishments are not able to run at full capacity. The current pipeline system cannot cope up with the growing industrial activities in this area. Moreover, the expansion of the Dhaka-Sylhet highway compels the said pipelines to be relocated.

Considering the economic lifespan of the factories it is necessary to conduct a thorough study on the current network. The proposed project aims to examine the current gas supply infra-structure in this area and to analyze the current system capacity, and propose solutions for future gas demand for the purpose of building a sustainable gas supply infrastructure.

Under this project, the gas supply situation of existing gas network has been reviewed using simulation software. An attempt has been made to find out the best option by considering four alternative scenarios for developing a sustainable gas supply infrastructure. It is proposed to construct a new transmission pipeline of 16"dia x 18.7 km × 150 Psig. to supply gas at the right pressure and quantity to the industrial customers in Shahjibazar area.

CHAPTER-1
INTRODUCTION

1.1 Introduction

Since the early 1960's, indigenous natural gas has been playing a very important role in the economy of Bangladesh. Due to its versatile use and affordable price, natural gas has been the principal fuel in the country for quite a long time. Natural gas is a non-renewable energy resource. It provides about three-quarters of the total consumption of commercial energy of our country and as such, our economic development largely depends on sufficient supply as well as efficient utilization of this indigenous energy resource. Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), as the apex organization in providing primary energy to diverse users- power plants, Captive power industries, fertilizer factories, tea estate, Transport sector (CNG), commercial concerns and others, has been assigned this key responsibility through six distribution company (namely TGTDCL, BGDCL, JGTDSL, PGCL, SGCL and KGDCL) (Apendix-A).

Everyone is well aware that the energy intensity and the sustainable development are reciprocally linked. To highlight energy, towards the higher economy growth trajectory, the intensive and optimum efficient use of natural gas is unique. As a relatively low-cost fuel, natural gas provides a competitive edge of our industrial products at home and abroad.

The natural gas distribution companies are responsible for connecting the customers, supplying of gas at contract pressure and rate, and billing. However, since they do not produce gas, they must purchase it from other sources such as the production fields. The rapid economic transition of Bangladesh hinges on the fast-growing industrial sector, but the challenges to meet the energy demand of this sector is also formidable. As the domestic gas production and reserves are declining, the increasing demand is being met by importing Liquefied Natural Gas (LNG) [1-4]. The Jalalabad Gas Transmission and Distribution System Limited (JGTDSL) supplies gas to the Sylhet division (Sylhet, Sunamgonj, Moulvibazar and Hobigonj districts) (Apendix-B). JGTDSL opening the activities of Shahjibazar regional distribution office at October 1987 after the completion of Hobigonj Tea Valley Project.

In 2011-12, Jalalabad Gas constructed about 6 km: 10"/8" dia. transmission line with customer financing from Shahjibazar TBS to provide gas connection to PRAN-RFL factory near Olipur rail gate. Later, Jalalabad Gas constructed another 8-9 km: 8"dia. transmission line south along the Dhaka-Sylhet highway from the junction of Saiham Nagar-Shahjibazar road and Dhaka-Sylhet highway with its own

funding to supply gas to various customers built and under construction along the Dhaka-Sylhet highway. Provides connectivity to the customers.

Due to the proximity of the gas fields, many investors and other renowned Group of companies like SQUARE GROUP, RAK PAINT, STAR CERAMICS, COOPER TECH etc., are constructed new plants along the Dhaka-Sylhet Highway around Shahjibazar area of Hobigonj district during the last 7-8 years. Gas load of Shaiham Group's industrial companies also transferred to this newly constructed pipeline [Fig-1.1]. As a result, low gas pressure problem gradually arises and the establishments are not able to run at full load. Apart from this, initial consent letter has been given from Jalalabad Gas for gas supply to several other companies. Also, the development work of Dhaka-Sylhet highway to four lanes is ongoing by roads and highway department. Road development work will be start in Shahjibazar area of Hobigonj district very soon. As a result, the existing transmission pipeline will need to be relocated.

Considering the economic lifespan of the factories it is necessary to plan for sustainable gas supply to these newly established plants and the potential growth of this area [5-6] and Steady supply of gas to these newly established factories requires well designed gas transmission and distribution network [7-10]. It is therefore necessary to examine the current gas supply infra-structure in this area.

Therefore, this study project has been considered and it aims to examine the current gas supply infra-structure in this area and to analyze the current system capacity, and proposed solutions for future considering different gas demand for the purpose of building a sustainable gas supply infrastructure in shahjibazar area.

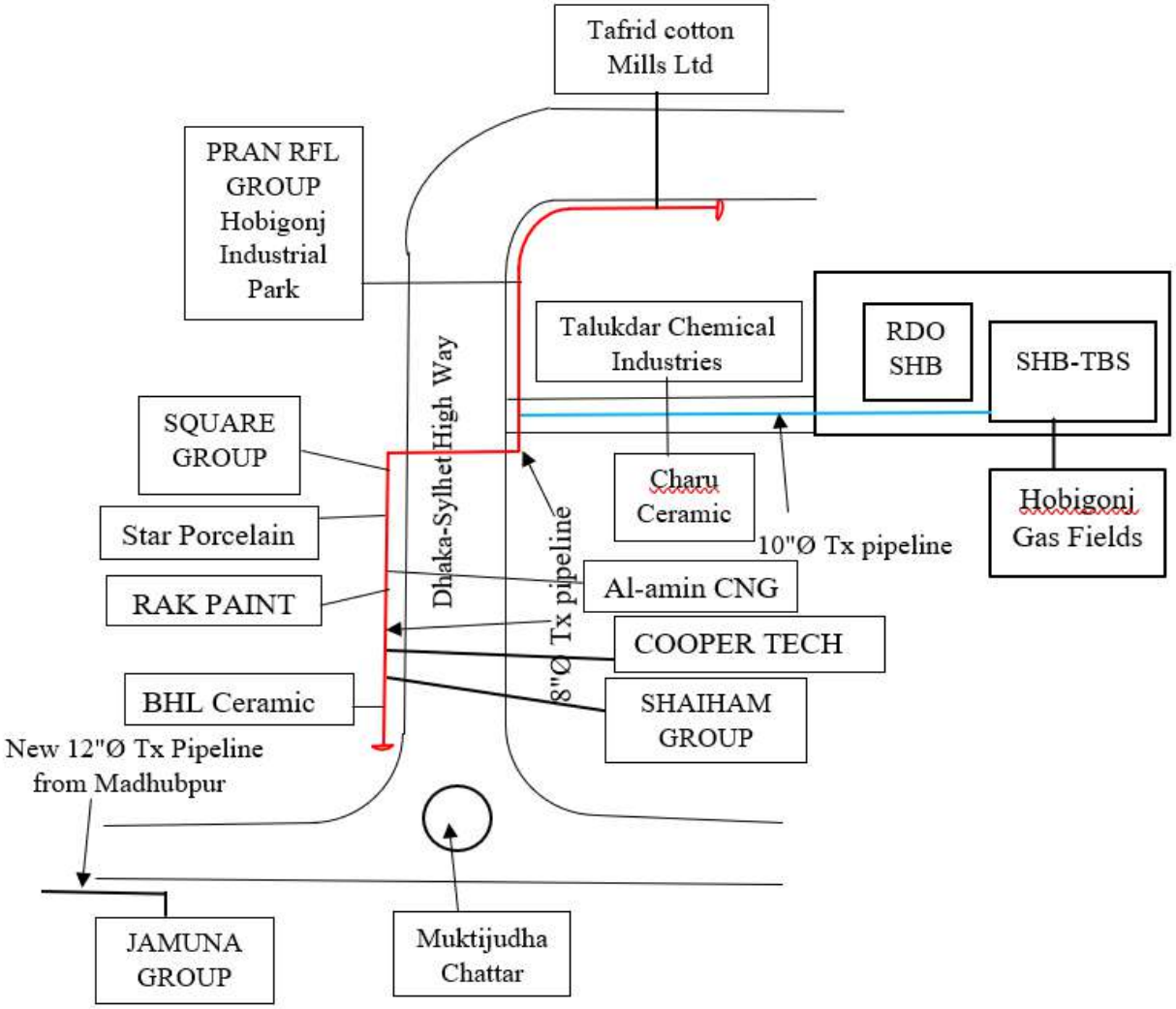

Figure-1.1: Schematic diagram of Industrial Area of RDO Shahjibazar along Dhaka-Sylhet Highway

1.2 Objectives with specific aims

i. To analyze the supply, demand and pressure trends in the Shahjibazar area.

ii. To model the main pipeline segments.

iii. To analyze the existing pipeline capacity by analytical and simulation techniques.

iv. To simulate various growth scenarios and propose options for long term gas supply.

1.3 Possible Outcomes

i. A better understanding of the supply and demand situation of the Shahjibazar industrial area.

ii. Practical solutions to long term demand of natural gas in the Shahjibazar area.

iii. A methodology and a set of options which might be used for zones with similar industrial growth scenarios.

1.4 Outlines of Methodology

i). All relevant data and information will be collected from authentic sources such as reports of Petrobangla, Jalalabad Gas Transmission and Distribution Systems Ltd, and Gas Transmission Company Ltd.

ii). Understanding of the current gas supply demand situation, and the state of the existing gas infrastructure in the Shahjibazar area.

iii). Site visits to the growing industrial zones that help in understanding the current limitations and requirements.

iv). Capacity analysis of the pipelines by simulation software. The industry standard software 'Pipeline Studio' will be used for simulation study.

v). Sourcing options for future, such as increasing the gas field production and feeding regasified LNG into the network.

CHAPTER-2

BRIEF OVER VIEW OF SHAHJIBAZAR AREA

2.1 Brief history of JGTDSL

The natural gas was first discovered in Sylhet during mid-fifties and its commercial use began during early sixties with the supply of gas to the Chhatak Cement Factory and Fenchuganj Fertilizer Factory in the sacred soil of Hazrat Shahjalal (R). The activities of Jalalabad gas were initially started as a project in 1977. With the completion of Hobigonj Tea Valley Project, a Program on Sylhet Town Gas Supply Project was initiated by Petrobangla. On merging of the said two projects in 1977, formal gas distribution on Sylhet town was started in 1978. With the implementation of Sylhet Tea Estate Gas Supply Project-1, Sunamgonj Town Gas Supply Project, Kailashtilla-Chhatak Pipeline Project and Chhatak Town Gas Supply Project, the Gas Supply network recorded a significant expansion in the region.

To meet the growing demand, Jalalabad Gas Transmission and Distribution System Limited (JGTDSL) was formed on December 1, 1986 under the company Act with an authorized capital of Tk.150 crores. The objective was to help developing the socio-economic condition of the people of Sylhet region.

The Company has been playing an important role since its inception in reducing dependency on imported fuel, saving of foreign currency and maintenance of ecological balance through construction of pipeline, installation and maintenance of related facilities to ensure uninterrupted transmission and distribution of gas throughout the franchise area [Appendix-B] (Sylhet Sadar, South Surma, Fenchuganj, Golapganj, Beanibazar, Sunamganj Sadar Chhatak, Doarabazar, Moulvibazar Sadar, Kulaura, Baralekha, Kamalganj, Srimangal ,Habiganj Sadar, Madhabpur, Bahubal, Chunarughat and Nabiganj Upazilas [3]. JGTDSL opening the activities of Shahjibazar regional distribution office at October 1987 after the completion of Hobigonj Tea Valley Project.

2.2 Brief over view of Shahjibazar

Shahjibazar is a popular place in Madhubpur Upozilla of Hobigonj District. It is located at an elevation of 2 meters above sea level. Its coordinates are 24°16'0" N and 91°22'60" E in DMS (Degrees Minutes Seconds) or 24.2667 and 91.3833 (in decimal degrees). There are 5 no. of power plant (70 MW, 50 MW, 86 MW, 330 MW, 110 MW), one gas field (Hobigonj Gas Fields), one rubber garden (Shahjibazar Rubber Garden), one rail station (Shahjibazar Rail station), one reginal gas distribution office of JGTDSL. There is an easy communication to the capital of Bangladesh and commercial capital of Bangladesh, Chittagong by road and railway. Before the 2011-12, there is no export-oriented factory.

The Dhaka-Sylhet highway cross over the Shahjibazar area. There is a plenty of plain agricultural land beside the Dhaka-Sylhet highway at Shahjibazar area. Due to the gas supply crisis over the Bangladesh, the investors are searching the suitable place to established the new factory. At a time, they are established their new factory in Shahjibazar area along the Dhaka-Sylhet highway in mid-2011-12 due to proximity of source of energy and easy communication to Dhaka, Chittagong and Sylhet. Now Shahjibazar area is a popular industrial area in North -East region of Bangladesh. The aerial view of Shahjibazar industrial area is shown in Appendix-C.

2.3 Pipeline network and customers information of JGTDSL

JGTDSL is responsible for distribution and marketing of natural gas to all categories of customers in its franchise area of Sylhet, Sunamganj, Moulvibazar and Habiganj district under Sylhet Division [Appendix-B]. Up to January, 2022 the company owned the total pipeline network is 3866.763 km which included about 525.120 km transmission lines, 1339.479 km distribution lines, 1224.721km feeder main and service lines and the rest 777.443 km pipelines constructed under customer financing.

Table- 2.1: Gas pipeline network of JGTDSL

SL.No	Types of built gas pipeline	Length (km)
1.	Transmission Pipeline	525.120
2.	Distribution Pipeline	1,339.479
3.	Feeder Main & Service Pipeline	1,224.721
4.	Others (built at customer's expense)	777.443
	Total	3,866.763

The total number of customers of JGTDSL is 2,21,459 (Power-19, Captive Power-125, Fertilizer- 01, CNG- 59, Industrial- 118, Tea Estate- 100, Small and Cottage Industries- 459, Hotel & Restaurant-803, Domestic (Burner)- 219,775) up to Up to June, 2021[3].

Table-2.2: Number of Customer Connection of JGTDSL

SL. No	Class of Customer	Number Of Customer
1.	Power	19
2.	Fertilizer	01

SL. No	Class of Customer	Number Of Customer
3.	Industry	130
4.	Tea-garden	100
5.	Captive power	127
6.	CNG	59
7.	Hotel & Restaurant	803
8	Small and Cottage Industries	458
9	Domestic	2,19,764
	Total	2,21,461

2.4 Sources of gas for JGTDSL

The Jalalabad gas purchase their natural gas from different source. Sources of gas for JGTDSL are:

- Horipur Gas Field (SGFL).
- Kailashtila Gas Field (SGFL).
- Beanibazar Gas Field (SGFL).
- Hobigonj Gas Field (BGFCL).
- Jalalabad Gas Field (IOC-Chevron).
- Bibiyana Gas Field (IOC-Chevron).
- Moulvibazar Gas Field (IOC-Chevron).
- North-South (N-S) Pipeline (GTCL).
- Hobigonj-Ashugonj Pipeline (Erstwhile TGTDCL pipeline).

A part of imported R-LNG can be supplied through N-S pipeline in near future to meet gas demand.

2.5 Value chain of natural gas in Bangladesh

Natural gas is a mixture of gases which are rich in hydrocarbons. Natural gas is colourless highly flammable gaseous hydrocarbon consisting primarily of methane and ethane. Natural gas, also called methane gas or natural methane gas. It is a type of petroleum that commonly occurs in association with crude oil. Natural gas reserves are deep inside the earth near other solid & liquid hydrocarbons beds like coal and crude oil. Natural gas is not used in its pure form; it is processed and converted into

cleaner fuel for consumption. Many by-products are extracted while processing of natural gas like propane, ethane, butane, carbon dioxide, nitrogen etc. which can be further used.

Everyone enjoy the benefits of natural gas in one way or the other, directly or indirectly, without questioning how the BTU of natural gas is made available to us. However, a lot of integrated processes requiring huge investments along the whole value chain are involved before it reaches us. First, the Exploration & Production (E&P) companies need to explore, drill and extract natural gas from the ground. Then the transmission companies link the gas fields to major consuming areas either via pipelines or LNG. Finally, the Local Distribution Companies (LDCs) deliver the natural gas to our respective homes.

Upstream, midstream and downstream activities for Oil & Gas in Bangladesh are carried out by both the public sector represented by Petrobangla and by the private sector represented by the International Oil Companies (IOCs) (Chevron & Tullow) currently operating in the country. The public participation in the oil and gas industry in Bangladesh is organized into four distinct segments with individual companies, which are subsidiaries of Petrobangla, responsible for exploration, production, transmission and distribution of natural gas.

The main functions of BAPEX are to undertake geological and geophysical surveys, and drilling operations for the purpose of exploring oil and gas in the country. Aside from exploring oil and gas and drilling, BAPEX is producing and supplying gas to the national grid from its 7 gas fields, namely Saldanadi, Fenchuganj, Shahbazpur, Semutang, Sundalpur, Begumganj and Sreekail. Bangladesh Gas Fields Company Limited (BGFCL) is the largest state-owned natural gas production company in the country. BGFCL produces natural gas and processes condensate into petrol and diesel. Presently, BGFCL owns 6 gas fields - Titas, Habiganj, Bakhrabad, Narsingdi, Meghna and Kamta. This company continued gas production from 5 gas fields except Kamta. Sylhet Gas Fields Limited (SGFL) is the second largest state-owned gas producing company in the country. The company, under its umbrella, currently operates Sylhet (Haripur), Kailashtila, Rashidpur and Beanibazar Gas Fields. A total of 11 wells (1 at Sylhet, 4 at Kailashtila, 5 at Rashidpur and 1 at Beanibazar) are presently on stream. Rupantarita Prakritik Gas Company Limited (RPGCL) is responsible for promoting compressed natural gas (CNG), building a transport infrastructure in the country based on CNG, and production and distribution of LPG, petrol and diesel obtained from NGL. The Government has decided to import liquefied natural gas (LNG) to meet the ever-increasing demand of natural gas against a backdrop of its shortage. As per government decision, all activities related to LNG have been vested to RPGCL.

Two terminal use agreements were signed with Excelerate Energy Bangladesh Limited and Summit LNG Terminal Co. (Pvt.) Ltd. to install two FSRUs at Moheshkhali approximately 90 kilometers south of Chattogram for supplying 500 MMscfd of LNG each. Six marketing or distribution companies under Petrobangla are entrusted with the responsibility of marketing of natural gas to the customers. These companies are: (1) Titas Gas Transmission and Distribution Company Limited (TGTDCL), (2) Bakhrabad Gas Distribution Company Limited (BGDCL), (3) Jalalabad Gas Transmission and Distribution System Limited (JGTDSL), (4) Paschimanchal Gas Company Limited (PGCL), (5) Karnaphuli Gas Distribution Company Limited (KGDCL) and (6) Sundarban Gas Company Limited (SGCL). Each company has its own marketing franchise area, covered by a fairly extensive distribution network [Appendix-A][1].

The physical workflow architecture for the natural gas business in Bangladesh is built around a capital-intensive asset base. Figure-2.1 shows a simple cartoon as is commonly used to depict the natural gas value chain.

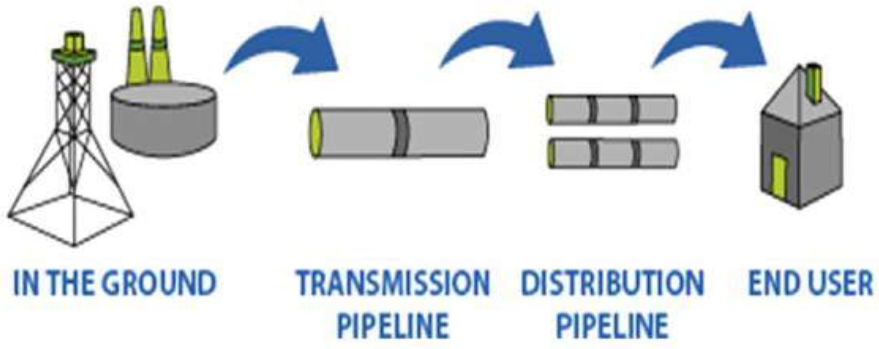

Figure-2.1: Typical cartoon for value chain of natural gas business

The detailed breakdown of the physical value chain of natural gas in Bangladesh as shown in Figure -2.2. The assets of each of the three principal business segments are held by Exploration & Production companies (Upstream), gas transmission providers (Midstream) and Local Distribution Companies (Downstream), the latter often owned by end user.

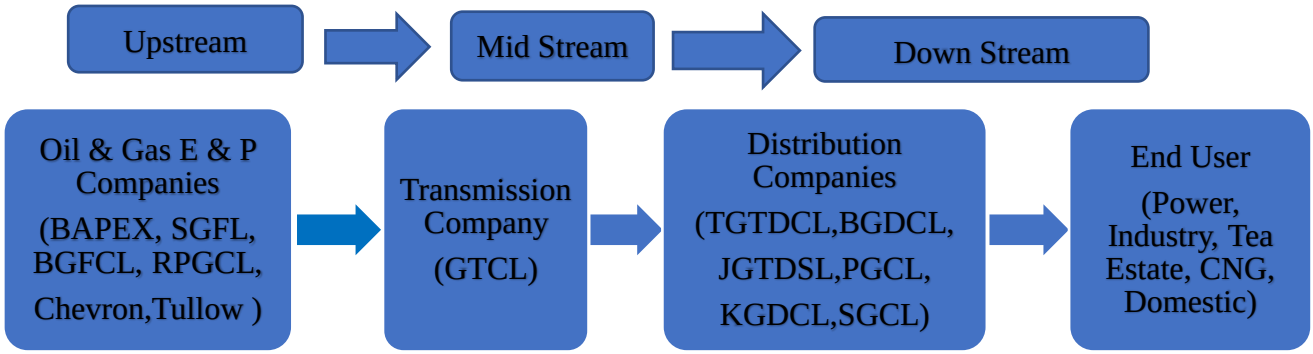

Figure-2.2: Value chain of natural gas in Bangladesh

2.6 Total gas production and remaining reserve of **Bangladesh**

There are three national companies (BAPEX, BGFCL, SGFL) operating under Petrobangla producing 850-875 mmcfd natural gas and the international oil company (IOCs- Chevron and Tullow) are producing 1450-1475 mmcfd natural gas. The gas reserve is 28.59 TCF, cumulative production of natural is 19.53 TCF and 9.06 TCF are remaining [11]. The number of gas fields are 28 and 20 fields are producing at present.

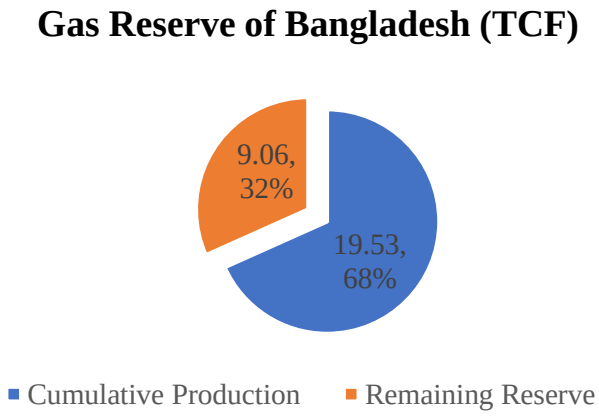

Figure-2.3: Gas Reserve of Bangladesh [11]

2.7 Gas supply in Shahjibazar industrial area

The daily average gas sales of JGTDSL were 396 MMCFD during the financial year 2020-21 [3]. The gas supply scenario of Shahjibazar industrial area (without power) during the financial year 2019-20 to 20-22 are in shown in table-2.3. During the study project area visit it has been found that the investors are establishing the new factory in Shahjibazar industrial area, consequently the gas sales are increasing till now. New connection of CNG and Commercial category are not given in last three financial year in shahjibazar area but one in FY-2020-21 and three in FY 2021-22 of industrial category are given.

Table-2.3: Gas Supply in Shahjibazar industrial area (without power) (Source: RDO- Shahjibazar)

Unit: mmcf

Customer Category	FY 2019-20		FY 2020-21		FY 2021-22	
	No of Customers	Gas Supply	No of Customers	Gas Supply	No of Customers	Gas Supply
CNG	01	65.24	01	70.34	01	74.61
Industry	23	3,226.53	24	3,713.22	27	5,823
Captive Power	18	4,684.94	18	6,193.41	19	6,917
Commercial	14	6.7	14	6.88	14	6.93
Total =		7,983.41		9,983.85		12,822.08

The main source of said gas is Habiganj Gas Field and North-South pipeline of GTCL. After abandoned the existing gas field the R-LNG will be used for gas supply to established industries.

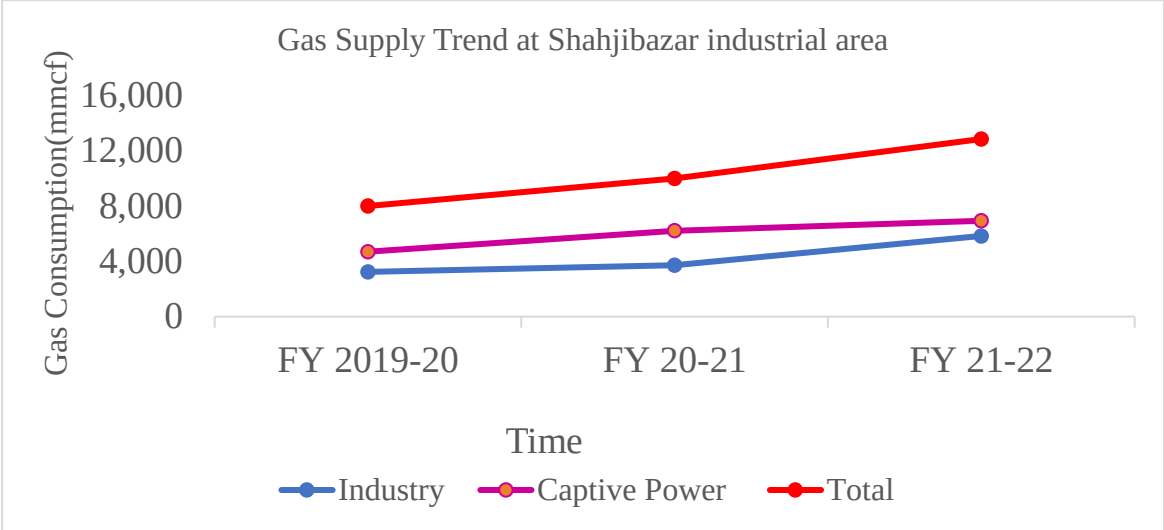

Figure-2.4: Gas Supply Trend in Shahjibazar Industrial Area

The gas supply trend for last three year shows that the gas consumption is increasing and linear in shahjibazar industrial area. The captive power gas consumption is greater than industry. The total gas consumption in FY 2021-22 is about 61% higher than FY 2019-20.

2.8 Gas demand in Shahjibazar industrial area

The category wise gas demand in Shahjibazar industrial area (without power) are shown in table-2.4. At present gas demand is around 70 mmscfd for existing CNG, Commercial, Captive power and industry category connection. Some new application for Commercial, Captive and industry category connection application are pending and another three industrial connections are approved by JGTDSL's

board by constructing a new 16" dia. transmission pipeline from Shahjibazar TBS by customer's finance. Hence total gas demand will be around 100 mmscfd shortly.

Table-2.4: Gas demand in Shahjibazar Industrial Area (without power)
(Up to June 2022) (Source: RDO- Shahjibazar)

Customer Category	**Approved Load**	**Unit**
CNG	750	cm/hr
Industry	33,621.43	cm/hr
Captive Power	41,525.46	cm/hr
Commercial	69.67	cm/hr
New & Extension	28,846.11	cm/hr
Alternative 16" Pipeline	13,445.00	cm/hr
Total=	118,257.67	cm/hr
	2,838,183.984	cm/day
	100,229,615.9	cf/day
	100.23	mmcfd

CHAPTER-3
LITERATURE REVIEW

3.1 Basic knowledge of pipelines

Pipelines first carried water to villager and dwellings centuries ago. The history of oil ang gas pipelines as they are used today begins after what is considered the first commercial oil well was drilled in Pennsylvania in 1859. The first cross country oil pipeline was laid in Pennsylvania in 1879., a 109-mile long, 6-in diameter line from Bradford to Allentown. In 1886 an 87-mile, 8 in. diameter natural gas line from Kane, Pennsylvania to Buffalo, New York was built [7].

Most oil and gas pipelines fall into one of three groups: gathering, trunk/transmission, or distribution. Other pipelines are needed in producing fields to inject gas, water or other fluids into the formation to improve oil and gas recovery and to dispose of salt water often produced with oil. Small diameter pipelines within an oil or gas field, called flowlines are usually owned by the producer. They connect oil or gas wells to central treating storage, or processing facilities with in field. Another gathering system made up of larger diameter lines, normally owned by a pipeline company rather than the oil or gas producer, connects these field facilities to the large-diameter, long-distance trunk or transmission line. In some cases, individual wells are tied directly to the pipeline company's gathering system. Gas transmission lines carry natural gas from producing areas to city utility companies and other customers. Through distribution networks of small pipelines and metering facilities, utilities distribute natural gas to commercial, residential and industrial users.

A network of sophisticated pipeline systems transports oil, natural gas and petroleum products from producing fields and refineries around the world to customer in every nation. Oil and gas pipeline systems are remarkable for their efficiency and low transportation cost.

The pipeline throughput (flow rate) will depend upon the gas properties, pipe diameter and length, initial gas pressure and temperature, and the pressure drop due to friction. The throughput of a gas pipeline can be increase by using intermediate compressor stations and installing pipe loops. With intermediate compressor stations, the flow rate can be increased to fully utilize pipe MAOP. However, adding compressor stations causes increased capital cost as well as annual operating and maintenance costs. On the other hand, by installing a pipe loop, the effective diameter of the pipe is increased, resulting in a lower pressure drop. Therefore, additional flow rate can be realized without installing an intermediate compressor station. Looping an existing pipeline causes increase in capital but very little increase in operating and maintenance costs compared to installing intermediate compressor stations [8].

3.2 Brief history of natural gas pipeline of Bangladesh

The first gas field discovered in Bangladesh territory was in 1955 by the Burma Oil Company. In 1959 the Chhatak Cement Factory started using natural gas from Chhatak gas field after construction of 6″dia. pipe line; this was the beginning of the industrial use of gas in the country. In the same region, from 1961, the Fenchuganj Fertiliser Factory started using natural gas from the Sylhet gas field.

The discovery of a huge gas field on the bank of the Titas River in Bhramanbaria in 1962 created a new horizon for the utilization of natural gas. The TGTDCL began its commercial operation with the commissioning of gas supply to Siddhirganj Thermal Power Station on April 28, 1968 after construction of 14″dia.× 58-mile-long Titas-Demra gas pipeline by the then East Pakistan Industrial Development Corporation.

Before the formation of GTCL the distribution company's construct the transmission and distribution pipeline in their respected franchise area. At present as per transmission strategy GTCL operates, maintains and constructs all high-pressure gas transmission pipeline. Moreover, GTCL shall solely be responsible for construction of future high pressure transmission pipeline.

3.3 Pressure-Temperature Rating (P-T Rating)

Pressure-Temperature ratings are maximum allowable working pressure allowed as per ASME B 16.5. All Pipes and various pipe fittings are most commonly classified based on their pressure-temperature rating or commonly known as P-T Rating. The most common way of specifying pipe pressure temperature rating is given by ASME 16.5, using pound ratings (or lb ratings) #150, #300, #400, #600, #900, #1500 and #2500. The pressure rating or pound rating for a pipe is determined using the design pressure and design temperature for the pipe.

Pressure rating or pound rating of a pipe is dependent on the pipe material and design temperature. The pipe pressure rating for the same material changes at different temperatures. For the same material and constant design pressure, different pressure ratings are applicable over different ranges of design temperatures. As the design temperature increases the pressure rating requirement for the pipe also increases for the same design pressure. Pressure temperature ratings are defined on the basis of definitions of design pressure, design temperature stated in code ASME B31.3 and & Material group (ref B16.5).

Table-3.1: Temperature and Pressure Ratings for ASTM 105 Carbon Steel Flange [13]

Pressure class	#150	#300	#400	#600	#900	#1500	#2500
Service Temperature (ºF)	Maximum Non-Shock Pressure (Psig)						
100	285	740	990	1480	2200	3705	6170
200	260	675	900	1350	2025	3375	5625
300	230	655	875	1315	1970	3280	5470
400	200	635	845	1270	1900	3170	5280
500	170	600	800	1200	1795	2995	4990
600	140	550	730	1095	1640	2735	4560
650	125	535	715	1075	1610	2685	4475
700	110	535	710	1065	1600	2665	4440
750	95	505	670	1010	1510	2520	4200
800	Not recommended above 800						

All the piping components are not designated by Pressure class, only flanges and items related to flanges like gaskets (not bolts) are designated as class. Also socket welded components are designated by Pressure class eg 3000, 6000 & 9000 AND SCREWED COMPONENTS Eg 2000, 3000 & 6000 based on the thickness as per ASME 16.11. Rest all components are designated by thickness (either sch or thickness). **We have seen from table 3.1 that maximum non-shock pressure for #150 class is 285 psig for 100 ºF service temperature.**

3.4 Commonly used formulas for pipeline capacity analysis

Several equations are available that relate the gas flow rate with gas properties, pipe diameter and length, and upstream and downstream pressures [8]. These equations are:

1. General Flow Equation (Steady-state isothermal flow in a gas pipeline, relating the pressure drop with flow rate.)
2. Colebrook-White Equation (Relationship between the friction factor and the Reynolds number, pipe roughness and inside diameter of pipe.)
3. Modified Colebrook-White Equation (Used for higher friction factor and smaller value of the transmission factor)
4. AGA Equation (Relating transmission factor F)
5. Weymouth Equation (Used for high pressure, high flow rate, and large diameter gas gathering systems.)

6. Panhandle-A Equation (Used in NG pipelines, incorporating an efficiency factor for N(Reynolds) 5 to 11million.)
7. Panhandle-B Equation (Used in large diameter, high pressure Tx lines; Turbulent flow, N(Reynolds) 4 to 40 million.)
8. IGT Equation (Institute of Gas Technology proposed this distribution equation.)
9. Spitzglass Equation (used in fuel gas piping calculations)
10. Mueller Equation (Another form of the flow rate vs. pressure relationship in gas pipelines.)
11. Fritzsche Equation (Extensively used in compressed air and gas piping.)

3.5 Comparison of flow equations

A pipeline 100 mi long, NPS 16 with 0.250 in. wall thickness, operating at a flow rate of 100 MMSCFD. The gas flowing temperature is 80°F. With the upstream pressure fixed at 1400 psig, the downstream pressure was calculated using the different flow equations. A pipe roughness of 700 μin. was used for both the AGA and Colebrook equations, where as a pipeline efficiency of 0.95 was used in the Panhandle and Weymouth equations [8].

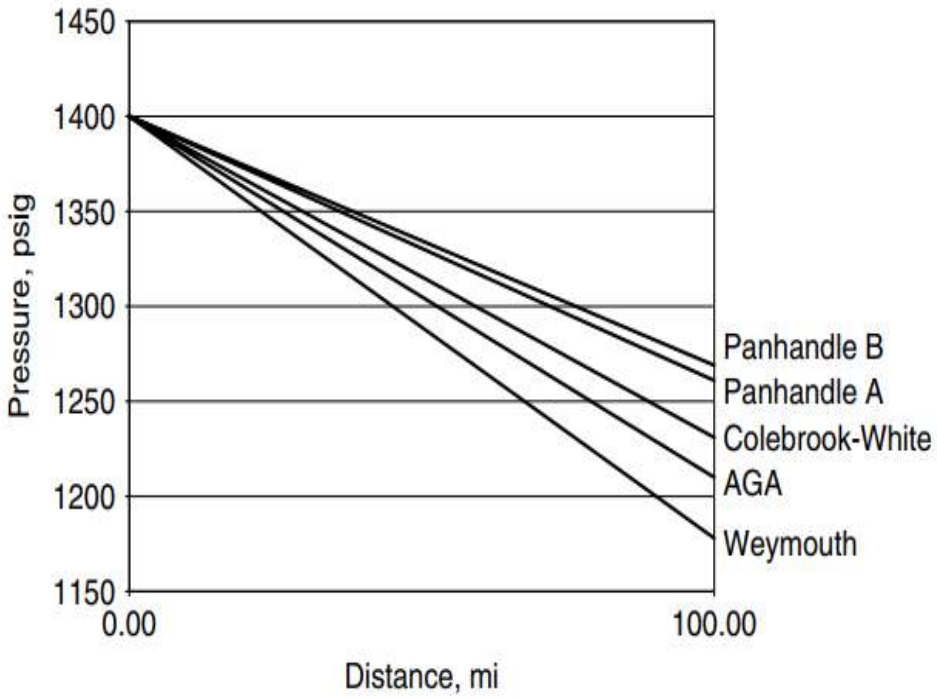

Figure-3.1: Comparison of flow equations [8]

On the other hand, the upstream pressure was calculated, required for an NPS 30 pipeline,100 miles long, holding the delivery pressure constant at 800 psig. The upstream pressure required for various flow rates, ranging from 200 to 600 MMSCFD, was calculated using the five flow equations [8].

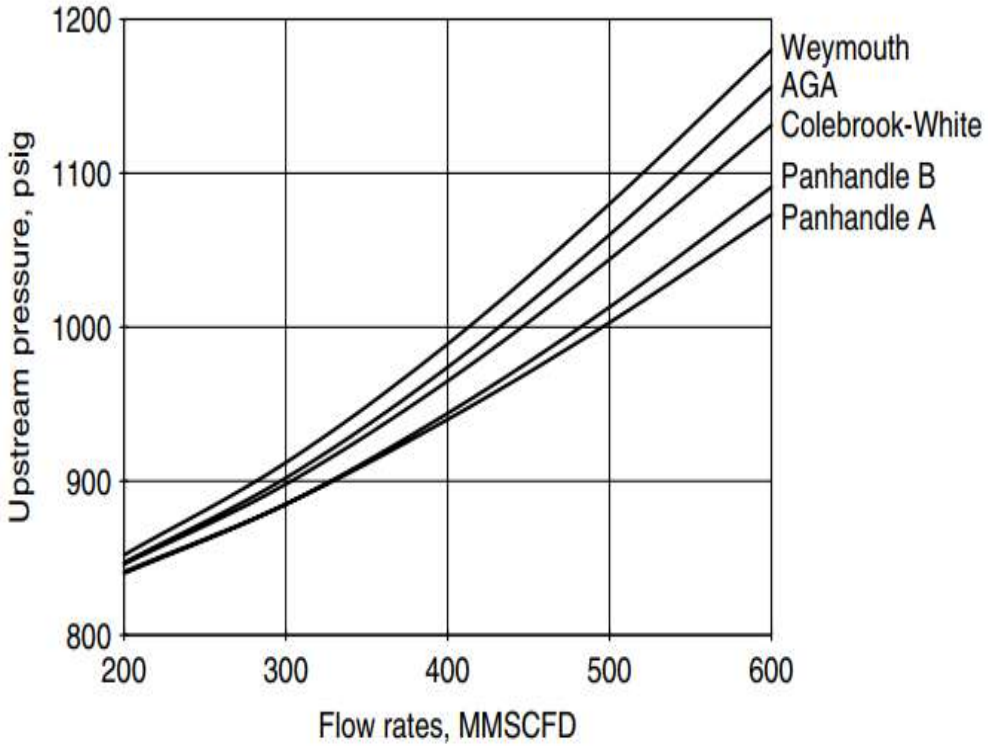

Figure-3.2: Upstream pressures for various flow equations [8]

The highest-pressure drop is predicted by the Weymouth equation and the lowest pressure drop is predicted by the Panhandle B equation. Weymouth equation predicts the highest upstream pressure at any flow rate, whereas the Panhandle A equation calculates the least pressure. Hence the **most conservative** flow equation is the **Weymouth equation** and the **least conservative** flow equation is **Panhandle A** [8].

The focused transmission pipeline moderately lager diameter (10"/8" dia.), operates at moderately high pressure (150 Psig) and total length about 16 Km. Since the Weymouth Equation is used for high pressure, high flow rate, and large diameter gas gathering systems and most conservative flow equation. **Hence, we used the Weymouth Equation for capacity analysis of transmission pipeline at Shahjibazar industrial area.**

3.6 Weymouth equation

The Weymouth equation is used for high pressure, high flow rate, and large diameter gas gathering systems. This formula directly calculates the flow rate through a pipeline for given values of gas gravity, compressibility, inlet and outlet pressures, pipe diameter and length [8].

In USCS units, the Weymouth equation is stated as follows:

$$Q = 433.5E\left(\frac{T_b}{P_b}\right)\left(\frac{P_1^2 - e^s P_2^2}{GT_f L_e Z}\right)^{0.5} D^{2.667}$$

where

Q = volume flow rate, standard ft3/day (SCFD)

E = pipeline efficiency, a decimal value less than or equal to 1.0

P_b = base pressure, psia

T_b= base temperature, °R (460 + °F)

P_1 = upstream pressure, psia

P_2 = downstream pressure, psia

G = gas gravity (air = 1.00)

T_f= average gas flow temperature, °R (460 + °F)

Le = equivalent length of pipe segment, mi

Z = gas compressibility factor, dimensionless

D = pipe inside diameter, in.

s = elevation adjustment parameter, dimensionless

CHAPTER-4
METHODOLOGY

4.1 Brief description of methodology

On 26 th June 2022, visited the regional distribution office-Shahjibazar of JGTDSL and collect information about the existing infrastructure of providing gas to industrial establishments along the Dhaka-Sylhet highway in Shahjibazar area. At present gas is being supplied from Shahjibazar TBS at 150 psig pressure through 10"dia. pipeline. A 10"dia. pipeline has been laid from Shahjibazar TBS to Dhaka-Sylhet highway (about 1.2 Km) and an 8"dia. pipeline from near Muktijoddha Chattar to Olipur rail gate (about 15 Km). From the said pipeline, gas connections have been provided to industrial plants, commercial, CNG and residential customers located on both sides of the road. In addition, we collect information about the authorized gas load of the customers connected to the said pipeline from the regional distribution office-Shahjibazar, the amount of gas supplied daily and the gas demand to be supplied through the said pipeline in the future. The installed 10"/8" dia. pipeline is 150 class Schedule 40 ERW pipe.

On 27th June 2022, existing several RMSs built for supplying gas to various industrial establishments in Shahjibazar industrial area were inspected. No pressure gauge is installed to monitor the pressure at the inlet of RMS. At the outlet of the RMS away from the network, less pressure is observed from contracted outlet pressure. The information obtained from regional distribution office-Shahjibazar and during the inspection it was observed that the outlet gas pressure of most of the factories is 10-15 Psig and the factories are located approximately 400-500 meters apart. Some establishments have more than one category of gas connections within the same compound and have more than one factory.

A model network is created based on the data collected and the experience gained from the inspection to analyze the gas supply system for Steady State isothermal flow condition through the existing 10"/8"dia. x 150 Psig x 16 km pipeline using ‘Pipeline Studio’ simulation software. Loads are divided into nine clusters while constructing the model network due to the fact that the existing factories are located nearby and their outlet pressures are almost the same.

In the gas supply system through the existing pipeline, low gas pressure condition is observed in the remote factories. Consequently, there is a need to increase the capacity of network to alleviate the stress situation itself. Addressing the problem of low pressure of gas found in the review, with the aim of supplying gas to the customers at the right pressure and quantity, developing and rebuilding the existing gas transmission network to build a sustainable gas supply infrastructure, considering four alternative

scenarios and analyzing them through 'Pipeline Studio™' simulation software and trying to find the best option. The simulation study is performed, segmenting the existing & proposed gas load considering the fixed load and minimum maintaining 50 Psig transmission pressure i.e., minimum RMS inlet pressure at customer end for steady state isothermal flow condition for network analysis by 'Pipeline Studio™' simulation software.

For sustainable gas infrastructure constructing four alternative measures are considered as follows:

i) A CMS with a capacity of 85 mmcfd is being constructed to supply gas to Jamuna Industrial Park by constructing a pipeline of about 12 km×500 Psig by modifying Madhabpur DRS. Tie-in of 8"dia. transmission pipeline (south side) of the existing 10"/8"dia.×150 Psig transmission pipeline with the 1st stage of said CMS.

ii) Along with taking the existing 10"/8"dia. ×150 Psig transmission, constructing a parallel pipeline of 12"dia. and tie-in with the existing pipeline.

iii) Construction of new pipeline of 16"dia. instead of 8"dia. pipeline during transfer of pipeline for development work of Dhaka-Sylhet highway and connecting with 1st stage of CMS constructed for Jamuna Industrial Park.

iv) Since the existing 8"dia. pipeline has to be shifted during the development work of Dhaka-Sylhet highway, therefore, construction of a 16"dia. pipeline from Shahjibazar TBS and establish a connection with the 1st stage of CMS built for Jamuna Industrial Park.

4.2 Limitation of the work

i) As there is no pressure gauge at the inlet of the customers RMS located at the end of the existing network, it was not possible to measure the actual RMS inlet pressure. However, the inability to supply gas at the contracted outlet pressure predicts that low pressure is prevailing in remote areas of the network.

ii) Allotted gas load of installed and under construction plants has been divided into 9 clusters to facilitate the analysis of gas flow and gas pressure at the customer inlet end of the network through 'Pipeline Studio™' simulation software.

iii) The existing customer RMS equipment's P-T rating is #150. Hence it is not possible to increase the flow capacity by increasing TBS outlet pressure much more.

CHAPTER-5
PIPELINE SIMULATION

5.1 Pipeline simulation

Pipeline simulation is the process whereby a computer model of a pipeline is used to simulate an actual pipeline system. The idea is to have the computer model duplicate or predict what is occurring in the actual pipeline system.

Pipeline Studio™ is the industry-leading pipeline management design software and engineering solution that combines graphical configuration and reporting tools with industry-proven simulation engines. A complete pipeline engineering tool that delivers rapid and accurate offline pipeline management design, planning and hydraulic analysis for natural gas and liquid pipelines through advanced simulation techniques. Engineers and planners are able to use reliable and accurate information to make decisions, leading to improvements in pipeline design, performance, and throughput. Achieve optimum system performance and create emergency plans without interrupting online production [12].

It is currently in use by more than 300 pipeline operators and engineering firms worldwide to mitigate these challenges. This advanced system combines graphical configuration and reporting tools with industry-proven simulation. A unique combination of steady-state and transient simulation allows facility design and operational planning from a single product. With Pipeline Studio™ engineers and planners are able to use reliable and accurate information to make decisions, leading to improvements in pipeline design, performance, and throughput. Engineers can achieve optimum system performance and create emergency plans without interrupting online production. Pipeline Studio™ reduces the costs of pipeline operation by supplying effective and innovative engineering solutions to most challenging issues. Updates to operational strategy for efficiency gains are quick and easy to implement.

5.2 Feature of Pipeline Studio™ software

Some basic features are listed in below:

- Run steady-state or transient simulations interactively or unattended.
- Easy-to-use, intuitive interface that includes sensible defaults, wizards, templates, and libraries.
- Multiple equations of state, multiple friction factor correlations, and multiple MOP and DRA correlations are provided for maximum flexibility related to your specific needs.
- Comprehensive solutions where detailed models are provided for pipes block valves check valves, supply, delivery, regulator valves, heaters, coolers, centrifugal and reciprocating compressors, drivers, pumps.

- Flow assurance.
- Designing, routing, sizing of pipeline networks.
- Upset, leak and survival time analysis.
- Strategic, operational and capacity planning.
- Line pack management.
- Rapid assessment of unscheduled changes in operation.
- Fuel consumption calculations and Surge analysis.

CHAPTER-6
RESULTS AND DISCUSSIONS

6.1 Simulation Study:

Case-1-Existing 10"dia. X 1.2 km & 8" dia. X 15 km X 150 Psig Transmission Pipeline: Supplying gas at 150 psig pressure through the existing 10"/8" dia. pipeline will allow a maximum gas supply of 46 mmscfd as per the simulation study. Due to which it is not possible to supply gas according to the demand of industrial factories in Shahjibazar area. Due to low pressure problem, extreme plants in the southern part of the network are not receiving gas. Figure-6.1 shows the simulation study result for existing condition and network drawing is shown in appendix-E.

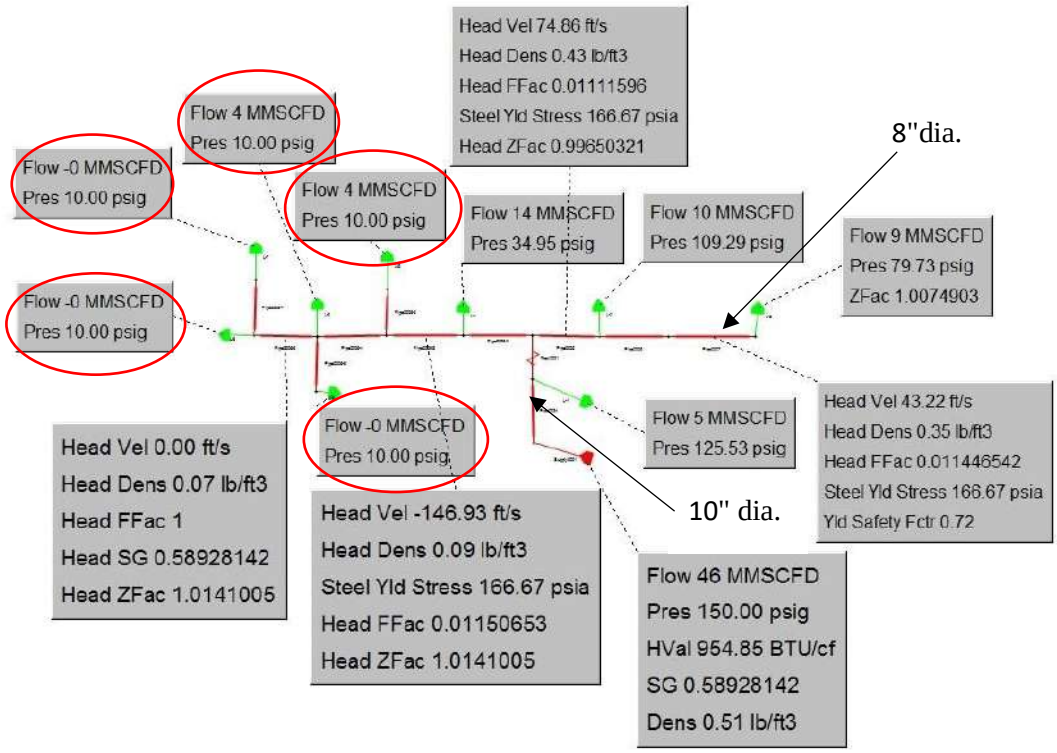

Figure-6.1: Simulation Study of Case-1

(Existing 10"dia.x 1.2 km/8" dia. X15 km X 150 Psig Transmission Pipeline)

Key Findings:

i) Low Pressure is existing at the extreme southern part of the network.

ii) It is not possible to supply gas at contact pressure and quantity to customer.

Case-2-1st stage tie-in of CMS to be constructed for Jamuna Industrial Park with existing 10"dia. X 1.2 Km /8"dia. X 15 Km transmission network for supply of gas at 150 psig pressure: A CMS with a capacity of 85 mmcfd is being constructed by modifying the Madhabpur DRS and constructing an approximately 12 "dia. × 300 psig approximately12 km pipeline to supply gas to jamuna Industrial Park. According to the simulation study, if gas is supplied at 150 psig pressure by tie-in the 8 " dia. pipeline (Constructing 8 "dia. x 2.5Km ×150 psig transmission pipeline) at the southern end of the existing 10"dia.x1.2 Km /8"dia.x15 Km network with the 1st stage of the CMS, it will be possible to supply gas at a maximum of 77 mmcfd and there will be sufficient gas pressure everywhere in network. Figure 6.2 shows the simulation study result for proposed solution-(i) and the network drawing is shown in appendix-F.

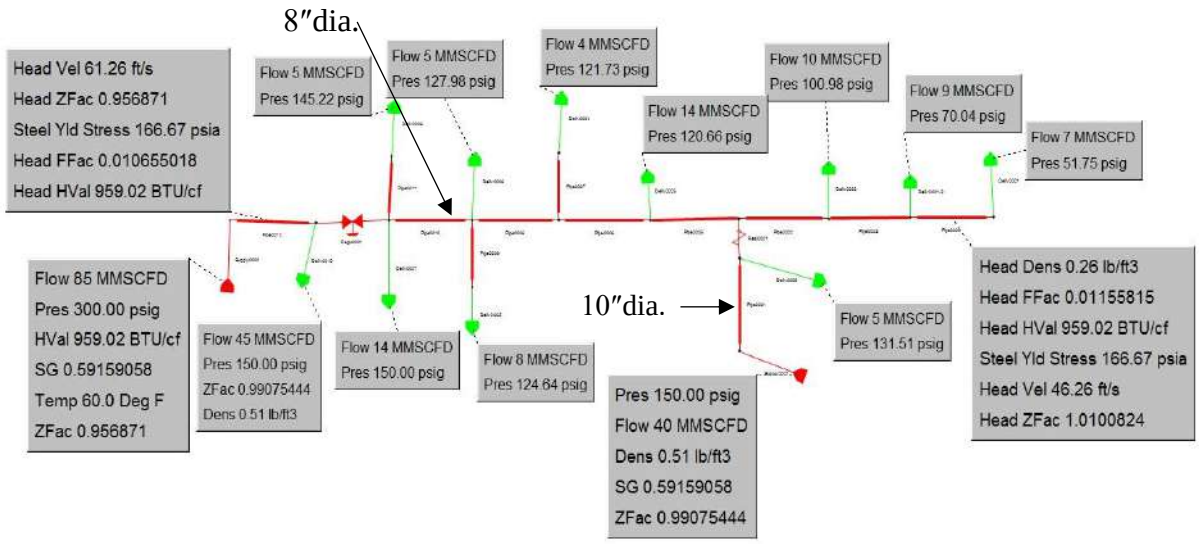

Figure 6.2: Simulation Study Result of Case-2

(Existing 10" dia X 1.2 Km /8"dia. X 15 Km X150 Psig Transmission network tie-in with 1st Stage of Jamuna Industrial Park CMS)

Key Findings:

i) There will be sufficient gas pressure everywhere in network.

ii) It is possible to supply gas at contact pressure and quantity to the present customer.

Case-3-Construction a parallel pipeline of 12"dia. along with the existing 10"dia.X1.2 Km/8"dia. X 15Km X 150 Psig transmission pipeline: By constructing a 12"dia. X 15Km pipeline parallel to the existing 10"dia. X 1.2 Km /8"dia. X 15Km transmission network's 8"dia. pipeline to supply gas at a pressure of 150 psig, according to the simulation study, maximum gas supply of 105 mmcfd will be possible and there will be sufficient gas pressure throughout the network. Figure 6.3 shows the simulation study for proposed solution-(ii) and the network drawing is shown in appendix-G.

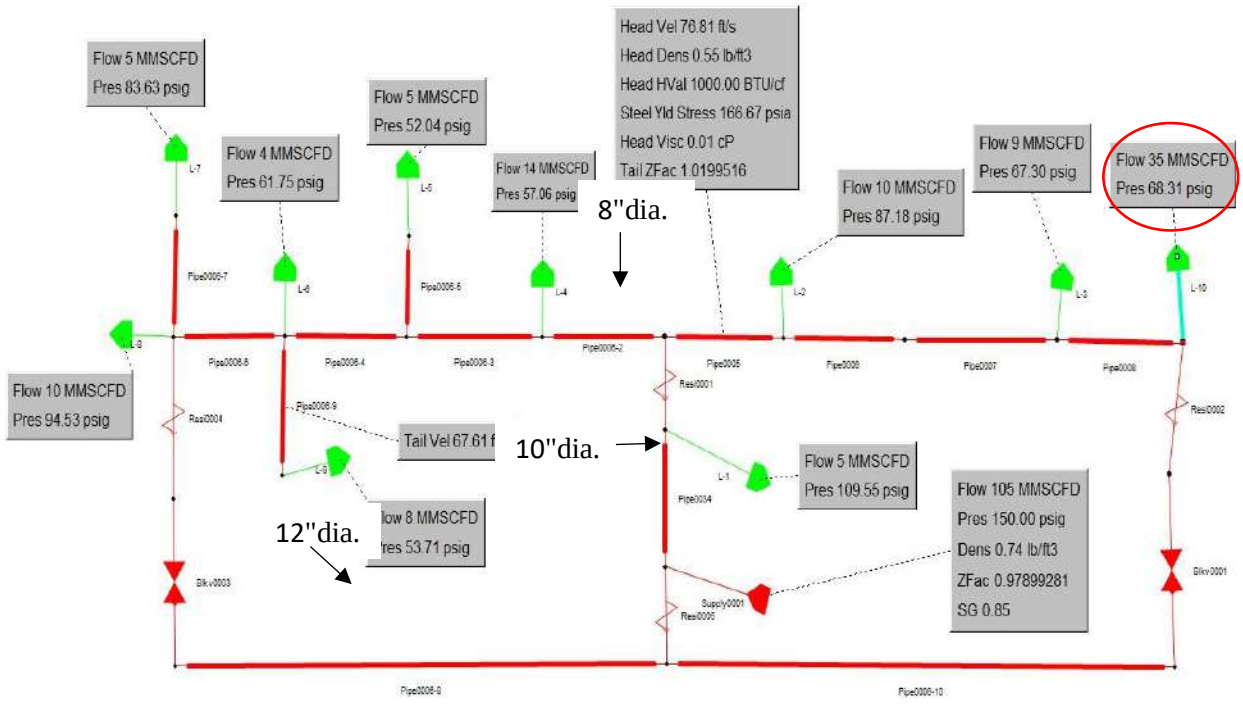

Figure-6.3: Simulation Study of Case-3

(Existing 10"dia. X 1.2 Km/8"dia. X 15Km X 150 Psig Transmission network with 12"dia. X 15 Km Parallel Balancing pipeline)

Key Findings:

i) There will be sufficient gas pressure everywhere in network.

ii) It is possible to supply gas at contact pressure and quantity to the current approved load (100 mmcfd).

iii) The network capacity will be more about 5 mmscfd than the current approved load (100 mmcfd).

Case-4-During the development work of Dhaka-Sylhet highway, constructing 16"dia.x17.5Km pipeline instead of 8"dia. X 15Km pipeline of existing 10 "dia. X 1.2Km /8 "dia. X 15Km transmission network and tie-in the 1st stage of CMS to be constructed for Jamuna Industrial Park for gas supply at 150 psig: By constructing a 16"dia. X 17.5Km pipeline instead of the existing 10"dia. X 1.2Km /8"dia. X 15Km transmission network's 8"dia. pipeline and tie-in with the 1st stage of CMS to be constructed to supply gas to Jamuna Industrial Park, and supplying gas at a pressure of 150 psig, maximum 114 mmcfd of gas supply will be possible according to the simulation study and adequate gas pressure will be maintained throughout network. Figure-6.4 shows the simulation study result for proposed solution-(iii) and the network drawing is shown in appendix-H.

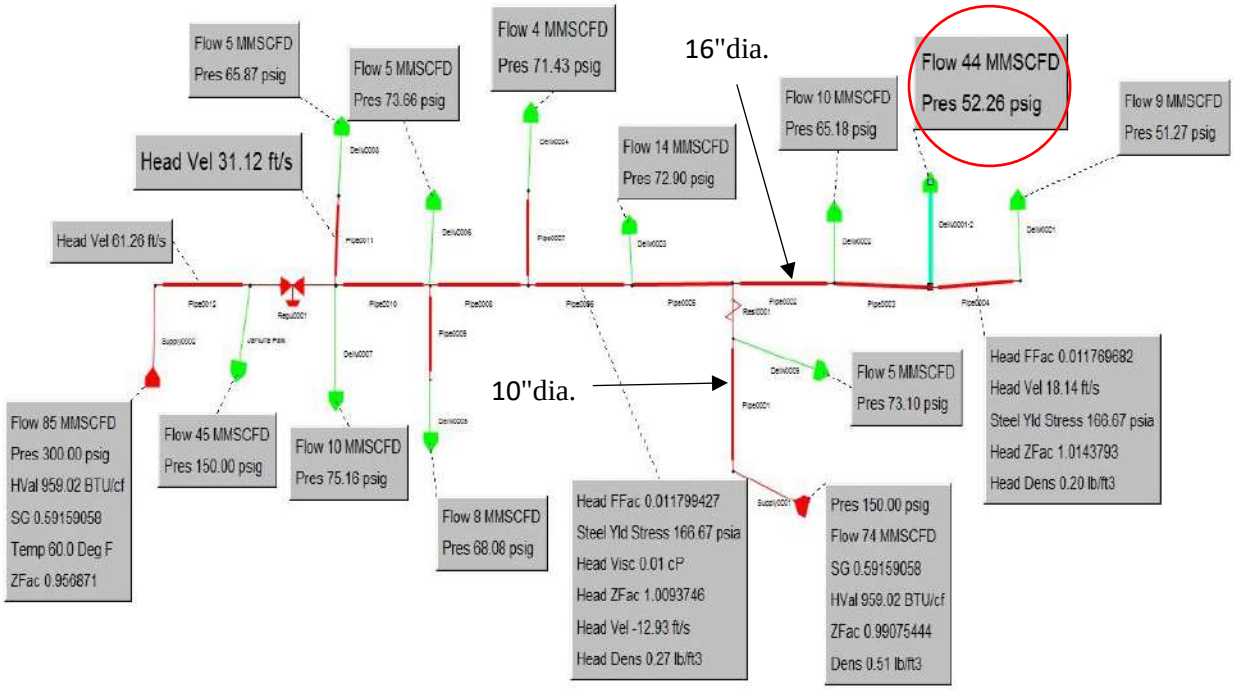

Figure-6.4: Simulation Study Result of Case-4

(Proposed 10"dia. inlet with 16"dia. X 17.5Km X150 Psig Transmission Pipeline with Jamuna Industrial Park CMS tie-in)

Key Findings:

i) There will be sufficient gas pressure everywhere in network.

ii) It is possible to supply gas at contact pressure and quantity to the current approved load (100 mmcfd).

iii) The network capacity will be more about 14 mmscfd than the current approved load (100 mmcfd).

Case-5- Construction of 16"dia. X 18.7 Km pipeline network from Shahjibazar TBS instead of existing 10"dia. X 1.2km/8"dia. X 15 km transmission network during development work of Dhaka-Sylhet highway and tie-in to 1st stage of CMS to be constructed for Jamuna Industrial Park and supply gas at 150 psig pressure: During the development work of Dhaka-Sylhet highway, instead of the existing 10"dia. X 1.2Km/8"dia. X 15 Km transmission network, a 16"dia. X 18.7Km pipeline is constructed from Shahjibazar TBS and tie-in to the 1st stage of CMS to be constructed to Jamuna industrial Park and supply gas at a pressure of 150 psig, according to the study, maximum gas supply of 185 mmcfd will be possible. Adequate gas pressure will be maintained throughout network and the current approved load demand will be met (100 mmcfd) and in future 85 mmcfd of gas will be possible to supply to meet up the future demand. Figure 6.5 shows the simulation study result for proposed solution-(iv) and the network drawing is shown in appendix-I.

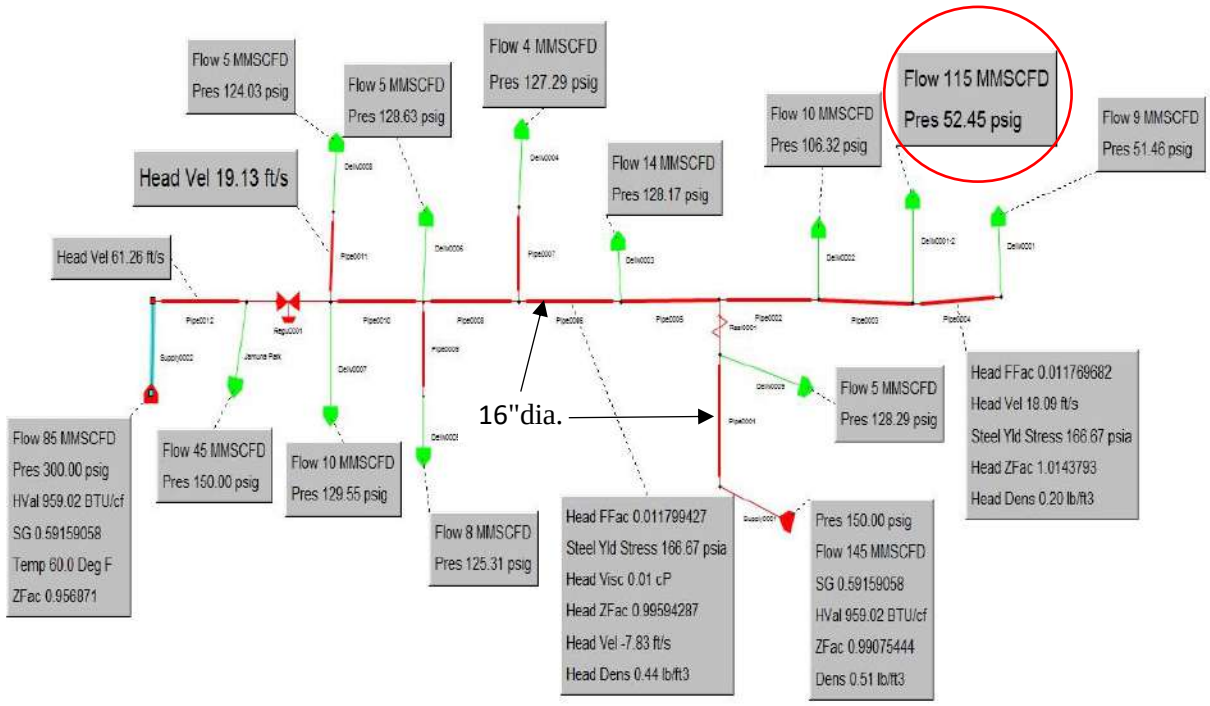

Figure- 6.5: Simulation Study of Case-5

(Proposed 16"dia. X 18.7Km X 150 Psig Transmission Pipeline with Jamuna Industrial Park CMS Tie-in)

Key Findings:

i) There will be sufficient gas pressure everywhere in network.

ii) It is possible to supply gas at contact pressure and quantity to the current approved load (100 mmcfd).

iii) The network capacity will be more about 85 mmscfd than the current approved load (100 mmcfd).

iv) It is possible to supply additional 85 mmscfd gas to the future customer.

6.2 Comparison of Results

The network capacity of existing and proposed network is listed in table 6.1. Low Pressure is existing at the extreme part of the network due to lower gas supply than current connected load (70mmscfd). It is not possible to supply gas at contact pressure and quantity to the present connected customer as per case-1. As per case-2, there will be sufficient gas pressure everywhere in network. It is possible to supply gas at contact pressure and quantity to the present connected customer. As per case-3 & case-4, there will be sufficient gas pressure everywhere in network. It is possible to supply gas at contact pressure and quantity to the current approved load (100 mmcfd). The network capacity will be more about 5 mmscfd and 14 mmscfd respectively than the current approved load. As per case-5, The network capacity will be more about 85 mmscfd than the current approved load. It is possible to supply 85 mmscfd gas to the future customer.

Table-6.1: Comparison of Results

Case	**Case Descriptions**	**Simulated Capacity** (mmcfd)
Case -1	Existing 10"dia.x 1.2 km/8" dia. X15 km X 150 Psig Transmission Pipeline.	46
Case -2	Existing 10" dia X 1.2 Km /8"dia. X 15 Km X150 Psig Transmission network tie-in with 1st Stage of Jamuna Industrial Park CMS (Constructing 8" dia. X 2.5 Km X150 psig transmission pipeline).	77
Case -3	Existing 10"dia. X 1.2 Km/8"dia. X 15Km X 150 Psig Transmission network with 12"dia. X 15 Km Parallel Balancing pipeline.	105
Case -4	Proposed 10"dia. inlet with 16"dia. X 17.5Km X150 Psig Transmission Pipeline with Jamuna Industrial Park CMS tie-in.	114
Case -5	Proposed 16"dia. X 18.7Km X 150 Psig Transmission Pipeline with Jamuna Industrial Park CMS Tie-in.	185

CHAPTER-7
PIPELINE CONSTRUCTION COST

7.1 Components of pipeline construction and operation cost

The economic pipe size required for a particular throughput will be arrived at considering the various costs that make up a pipeline system. The initial capital cost of pipeline and ancillary facilities along with the annual operating and maintenance costs [8]. In a gas pipeline system, the major components that contribute to the initial capital cost are the pipeline, compressor stations, mainline valve stations and metering facilities, telecommunications, and supervisory control and data acquisition (SCADA).

Other costs include environmental and permitting costs, right of way (ROW), acquisition cost, engineering and construction management, legal and regulatory costs, contingency, and allowance for funds used during construction (AFUDC). The recurring annual costs will include operating and maintenance (O&M) costs, fuel, energy and utility costs, rental, permitting, and annual right of way costs. The O&M costs will include payroll and general and administrative (G&A) costs. In any pipeline system constructed to provide transportation of gas, there will be (A) capital costs and (B) annual operating costs.

A) Capital Costs: The capital cost of a pipeline project consists of the following major components:

- Pipeline
- Compressor stations
- Mainline valve stations
- Meter stations
- Pressure regulator stations
- SCADA and telecommunication
- Environmental and permitting
- Right of way acquisitions
- Engineering and construction management

In addition, there are other costs such as allowance for funds used during construction (AFUDC) and contingency.

B) Annual Operating Costs: Once the pipeline, compressor stations, and ancillary facilities are constructed and the pipeline is put into operation, there will be annual operating costs over the useful life of the pipeline, which might be 30 to 40 years or more. These annual costs consist of the following major categories:

- Compressor station fuel or electrical energy cost

- Compressor station equipment maintenance and repair costs
- Pipeline maintenance costs, such as pipe repair, relocation, aerial patrol, and
- monitoring
- SCADA and telecommunication
- Valve, regulator, and meter station maintenance
- Utility costs, such as water and natural gas
- Annual or periodic environmental and permitting costs
- Lease, rental, and other recurring right of way costs
- Administrative and payroll costs

Compressor station costs include periodic equipment maintenance and overhaul costs.

7.2 Construction cost for the proposed four alternative pipeline

For the analysis of construction cost of the proposed four alternative pipeline of this study project, only the pipeline construction cost is considered. The following cost component are considered for cost estimation:

- Pipeline Material
- Pipeline Fittings (Valve, Tee, Elbow, Long radius bend and ancillary fittings)
- Coating Material and
- Pipeline Construction Cost (Laying, Welding, Radiography, Testing & Commissioning, Wrapping etc.)

Contractor's profit margin, land acquisition, Equipment mobilization & demobilization, Khal/Pond/ Ditch/Water Way crossing, Highway/Major Road Crossing/Boring cost are not considered for estimation. Pipeline material, Pipeline Fittings and Coating Material cost are estimated as per JGTDSL & TGTDCL previous purchase order. Pipeline Construction Cost per kilometer are estimated as per unified cost for pipeline construction-2021of Petrobangla and Rangpur- Syedpur distribution project cost.

The estimated cost and supply capacity are tabulated in Table-7.1. For case-2 & 3 permission is required from roads and highway department. Also, the cost will be bear by JGTDSL from its own fund. The development work of Dhaka-Sylhet highway to four lanes is ongoing by roads and highway department. Road development work will be start in Shahjibazar area of Hobigonj district very soon. As a result, the existing transmission pipeline should need to be relocated for road safely. The roads and highways department will be paid the compensation for its demurrage. The estimated cost for proposal four is

higher with Tk. 2.2 crore approx. than the proposal three. Also, there is no bottleneck for transmission network. A small portion of estimated cost may spend by JGTDSL from its own funds to build a sustainable gas transmission and distribution network. It is better to build a durable network of 16 "dia. X 18.7 Km pipeline by replacing the entire part of the existing 10"dia./8"dia. transmission line from Shahjibazar TBS. Maximum portion of estimated cost will be claimed as demurrage to the roads and highway department by JGTDSL. The details estimation is attached in appendix -D.

Table-7.1: Estimated Cost Comparison of four alternative Proposal

Case	Brief description of Alternative	Estimated Material Cost (Tk)	Estimated Construction Cost (Tk)	Total Estimated Cost (Tk)	Simulated Capacity (mmscfd)	Remarks
Case-1	Existing Transmission Pipeline.	0	0	0	46	No investment
Case-2	Existing 8in. Pipeline Tie-in with 1St Stage of JIP CMS	49,376,229	2,595,000	51,971,229	77	JGTDSL Own Fund
Case-3	12 in. parallel pipeline	160,995,643	4,255,000	185,250,643	105	JGTDSL Own Fund
Case-4	16 in. x 17.5 Km Pipeline (With 10 in existing inlet) Construction and Tie in with 1St Stage of JIP CMS	272,562,662	1,538,800	324,101,462	114	JGTDSL Own Fund and R&H Fund
Case-5	16 in. x 18.7 Km Pipeline Construction and Tie in with 1St Stage of JIP CMS	1,036,491	55,060,500	346,096,991	185	JGTDSL Own Fund and R&H Fund

7.3 Cost-Benefit Analysis of proposed pipeline

The proposed pipeline construction cost and supply capacity is shown in table 7.1. The pipeline construction for case-4 is Tk 32.42 crore but network supply capacity only 114 mmscfd. This network capacity meets only the current approved load. Only 14 mmscfd gas can be supply to future customer. This is too conservative for pipeline capacity. But for case-5, the pipeline construction is Tk 34.61 crore and network supply capacity will be 185 mmscfd. It is possible to supply additional 85 mmscfd gas to the future customer. This is more flexible for pipeline capacity as compared to the cost. With which it will be possible to provide gas connection to various categories of customers to be built in the area in the future. Redundancy of the network will be 1.85. In industry practice, a safety factor of 1.25 to 2 is considered while designing a sustainable gas transmission and

distribution network taking into account various factors (current gas demand, possibility of future gas demand increase, customer type etc.). Out of the mentioned options, in case-5 the network redundancy will be1.85. As a result, the network can be considered as an ideal network. To build a sustainable gas transmission and distribution network, it is better to build a 16 "dia. x 18.7Km pipeline by replacing the entire part of the existing 10"dia./8"dia. transmission line from Shahjibazar TBS. The benefit of gas supply for case-5 is higher compared to the pipeline construction cost.

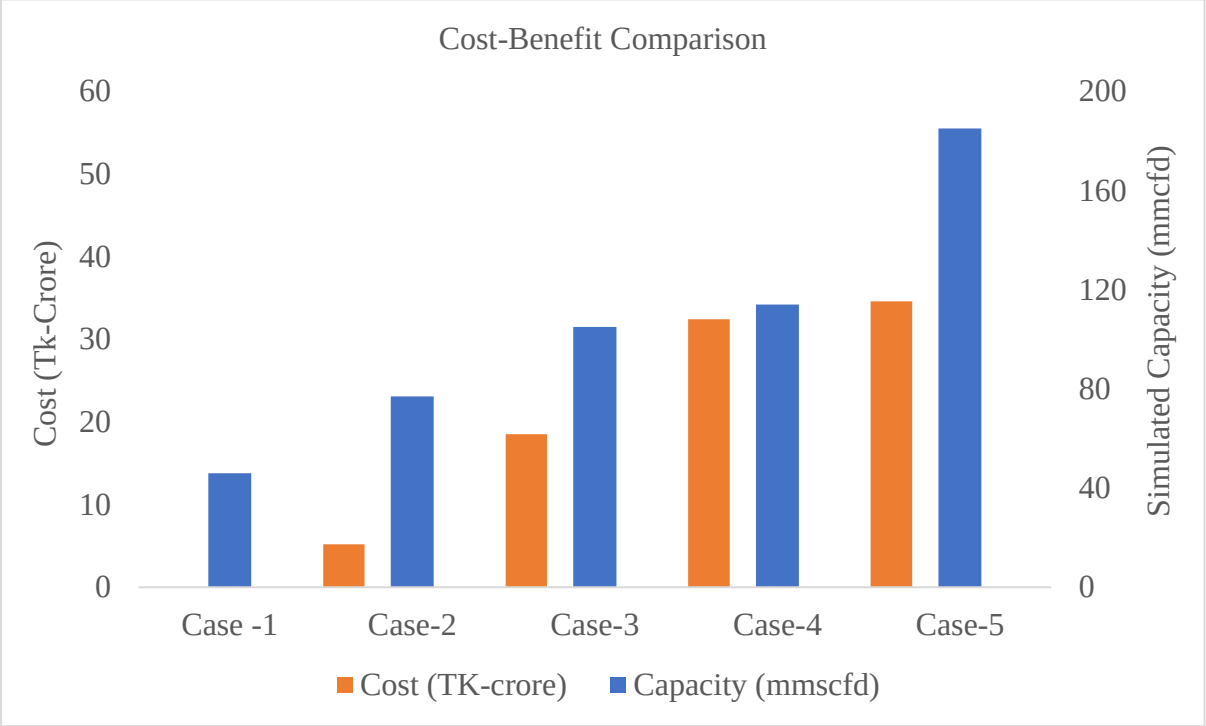

Figure-7.1: Cost-Benefit of proposed pipeline

CHAPTER-8
CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

In fact, from the observation and simulation study of the gas supply system of the Shahjibazar industrial area, it is seen that there is a low gas pressure situation due to the connection to the gas load in excess of the gas supply capacity of network. Factories located in remote areas are not getting gas supply in proper pressure and quantity. As a result, there is an urgent need to develop the network to solve the problem. Existing network capacity enhancement includes tie-in with high-capacity network, construction of parallel balancing lines and construction of a sustainable gas infrastructure through construction of new pipelines. Four options have been investigated. Alternative solutions are explored through simulations using Pipeline Studio software. Based on the results obtained, the following conclusions can be reached:

1) Low gas pressure situation predominates in the existing gas supply network which can only be addressed by new transmission network construction.

2) As per the simulation study and cost-benefit analysis, a new 16"dia. X 18.7Km pipeline with tied-in to the 1st stage of the CMS to be built for Jamuna Industrial Park, seems to be the best option.

8.2 Recommendations

1) At the inlet of the customer's RMS pressure gauge should be installed with proper sealing with titanium putting material to monitor the network pressure.
2) Since the maximum non-shock pressure for # 150 class is 285 Psig for 100^{o} F service temperature and the design & operating pressure of existing pipe line is 150 Psig and hydro-test pressure is 1.5 times of design pressure, hence as a short-term plan, the operating pressure may be increased by 10% ~20% from 150 Psig to 165~180 Psig pending any development in the existing network, this will increase the gas supply and temporarily reduce the low-pressure problem in the existing network.
3) Turbine meters with EVC can be installed to protect the consumers from financial loss.
4) Finally, it is highly recommended to build-up the 16" dia. X 18.7Km × 150 Psig transmission line as a long-term plan to meet gas demand in Shahjibazar industrial area for sustainable gas infrastructure.

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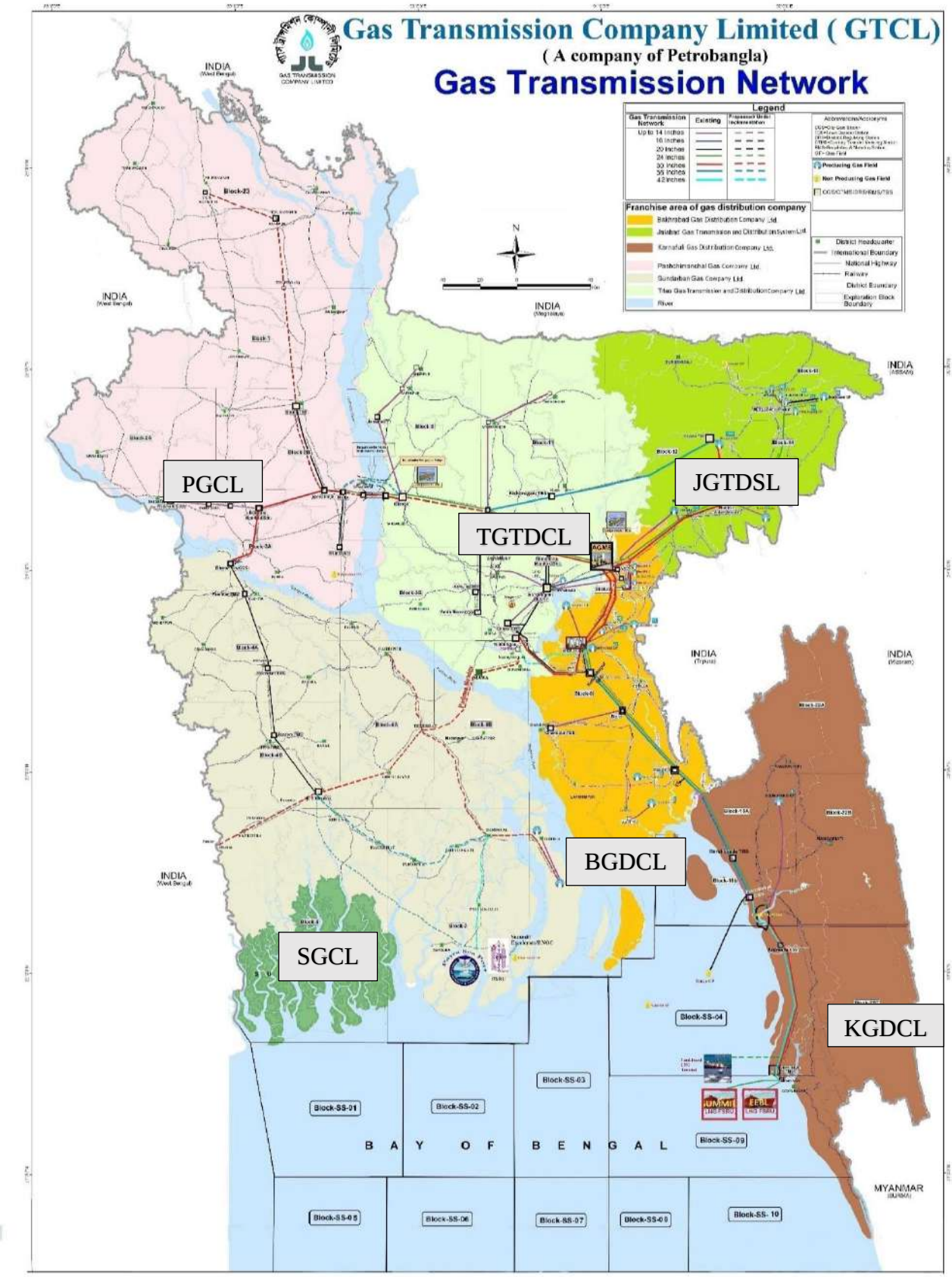
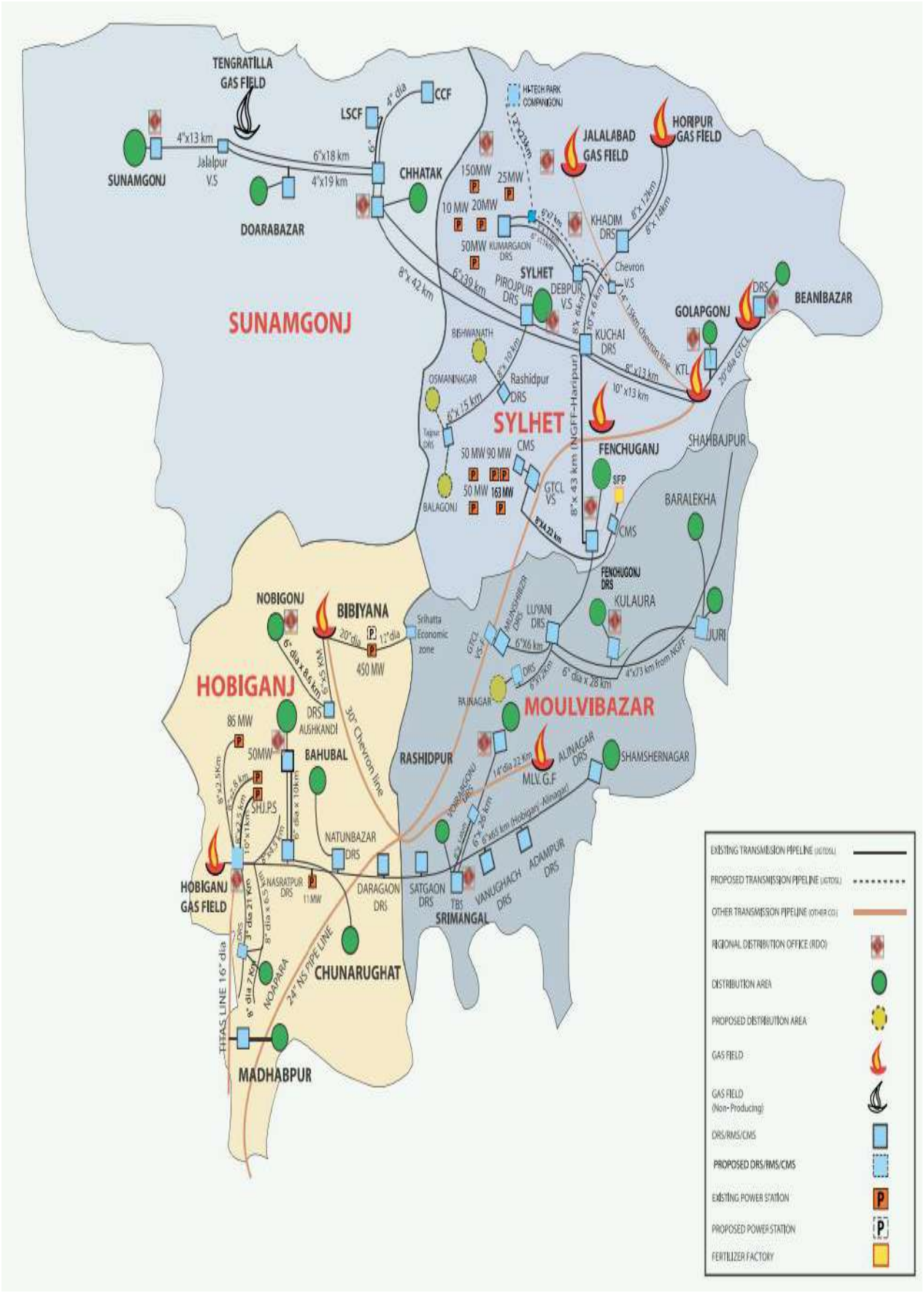
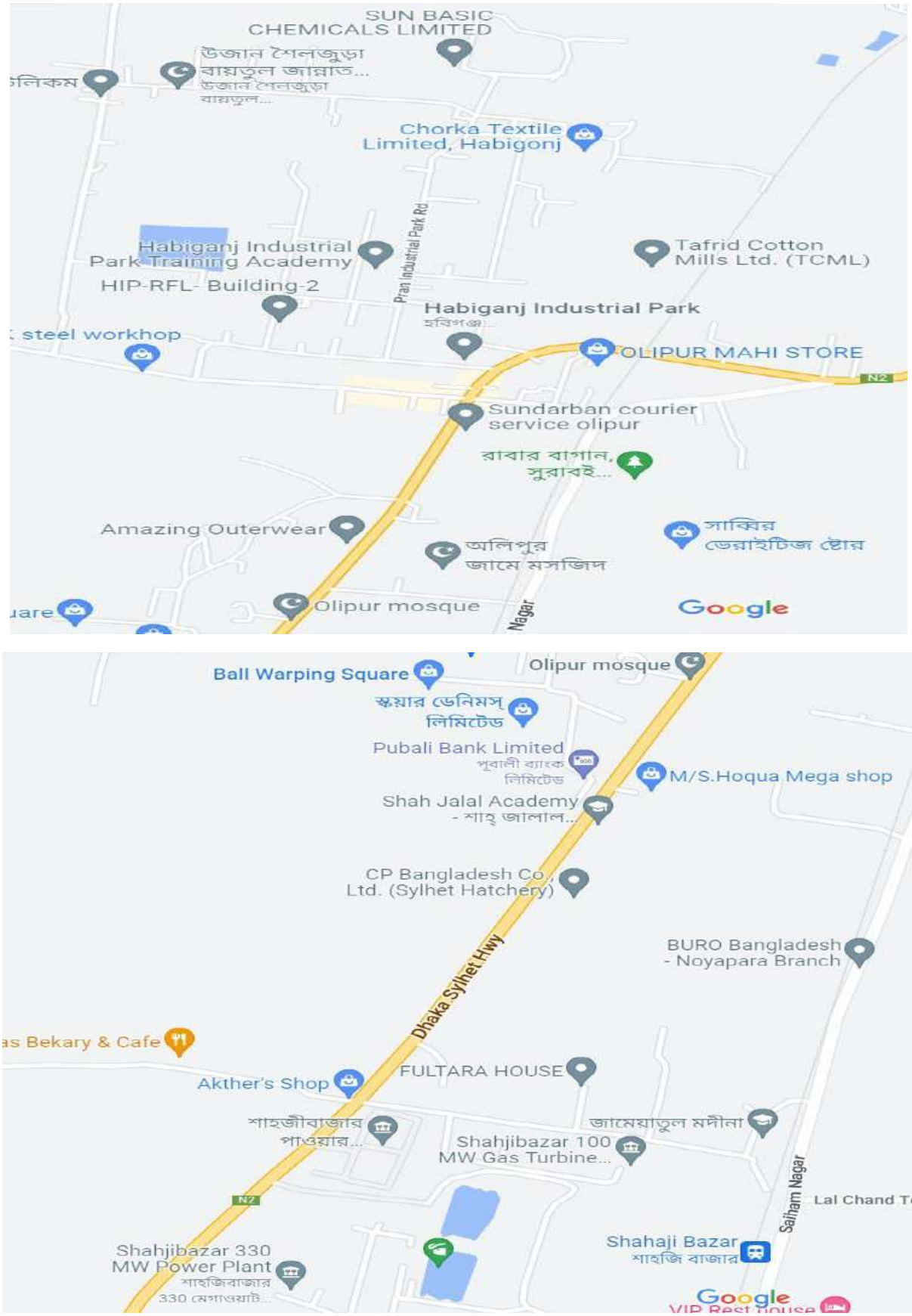


Bangladesh gas distribution network by franchise area

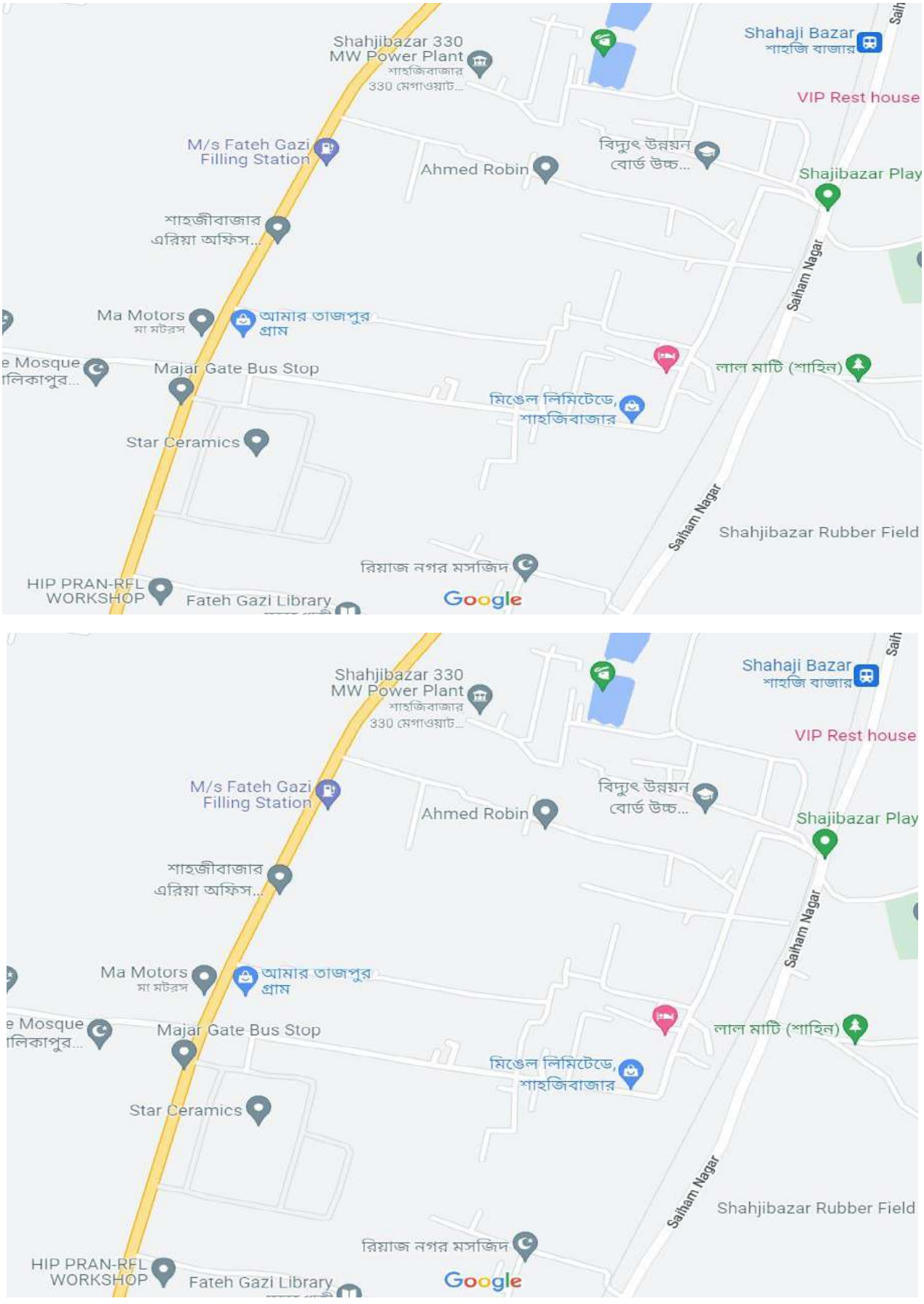
[https://www.gtcl.org.bd]



JGTDSL Franchise Area [http://www.jalalabadgas.org.bd]



Aerial View of Shahjibazar Industrial Area-1 [google maps]



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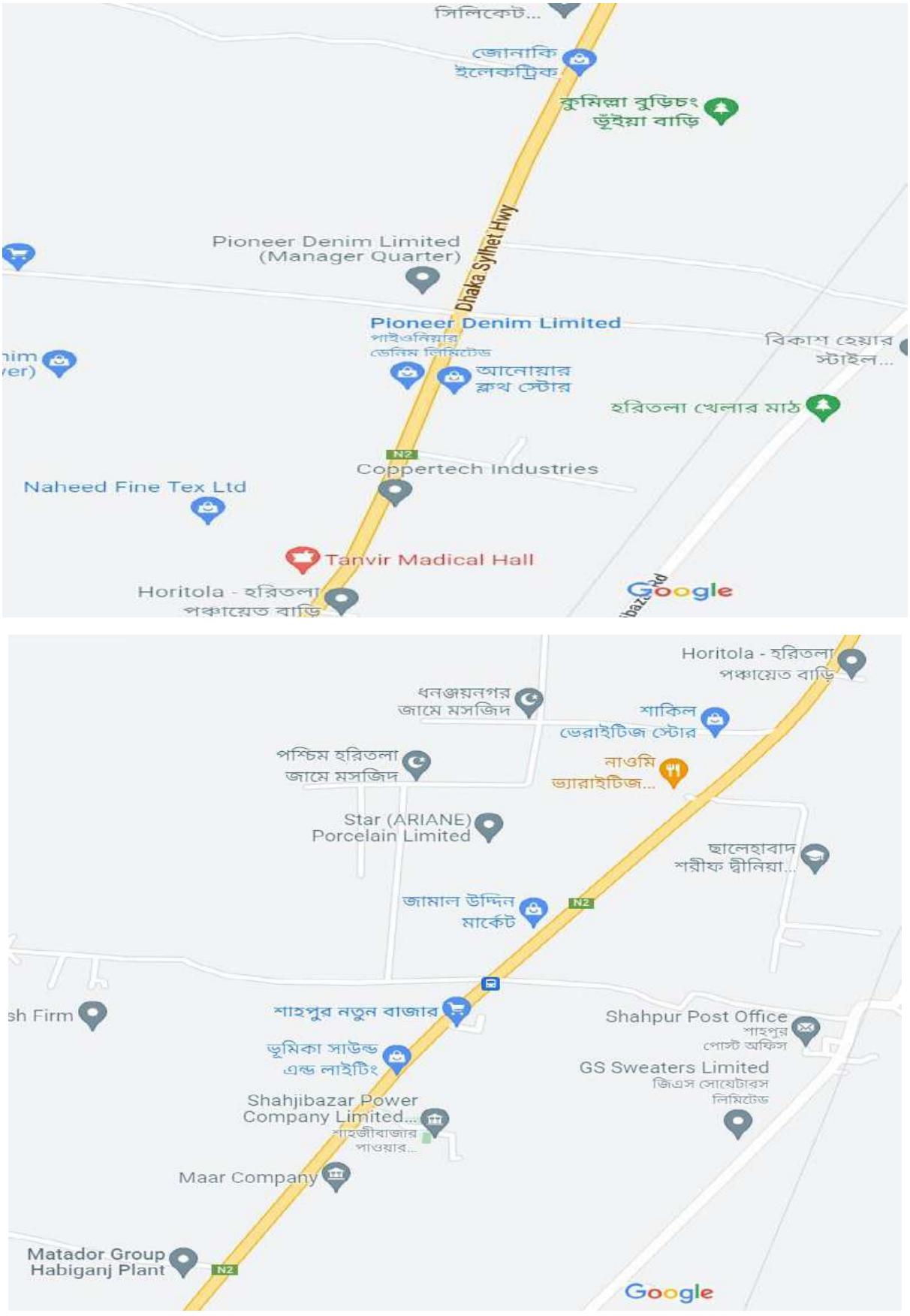
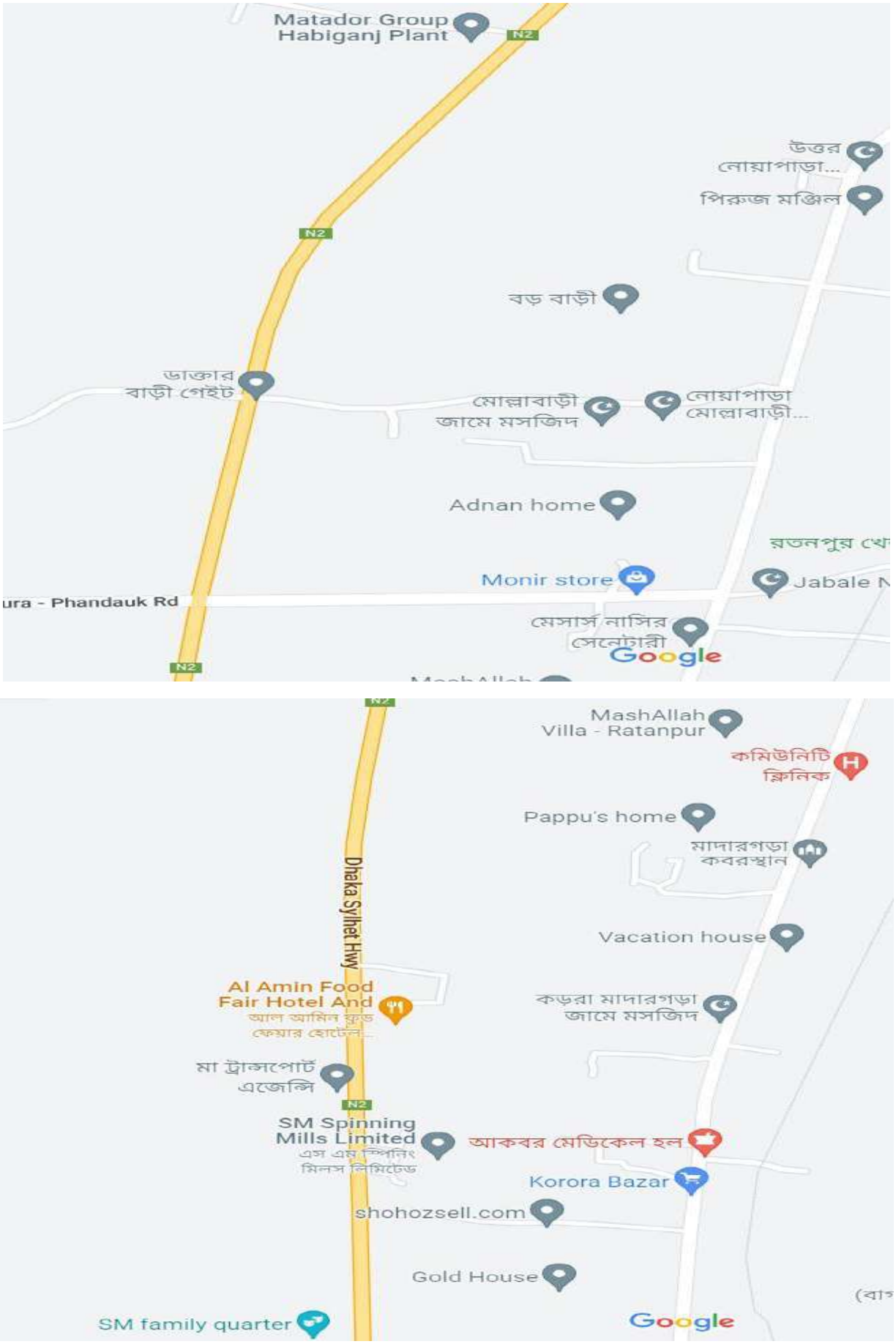
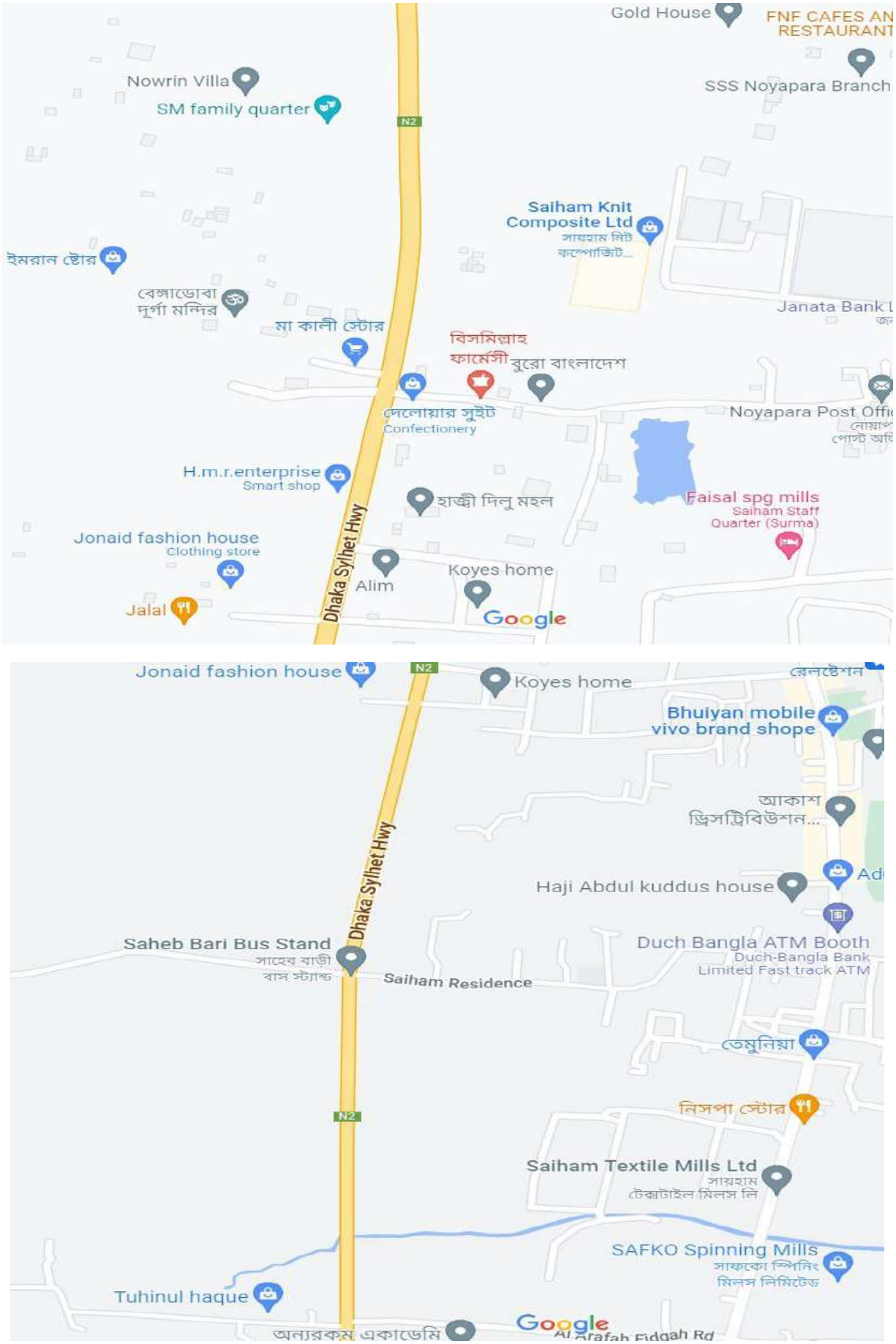


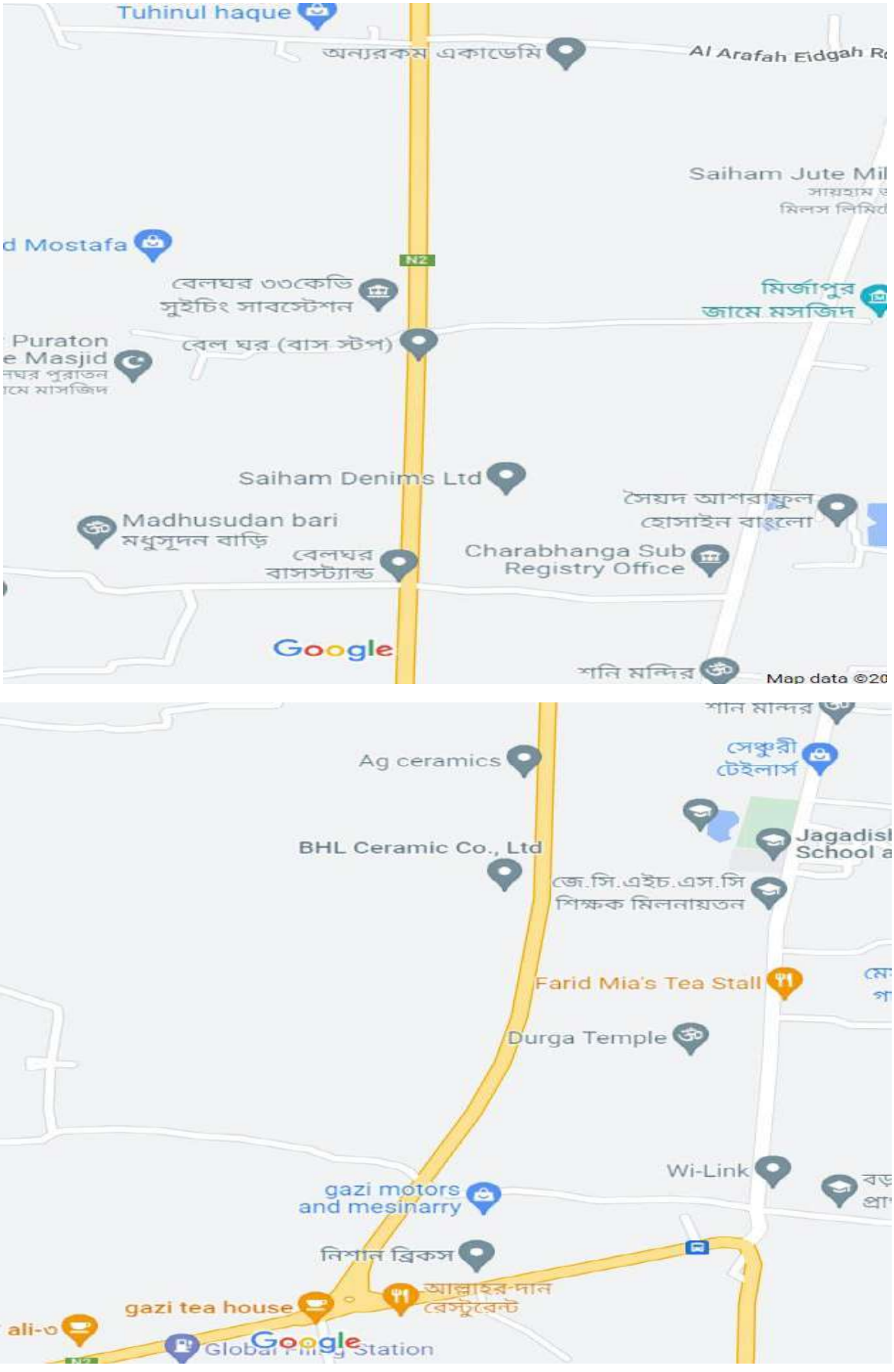
Aerial View of Shahjibazar Industrial Area-3 [google maps]



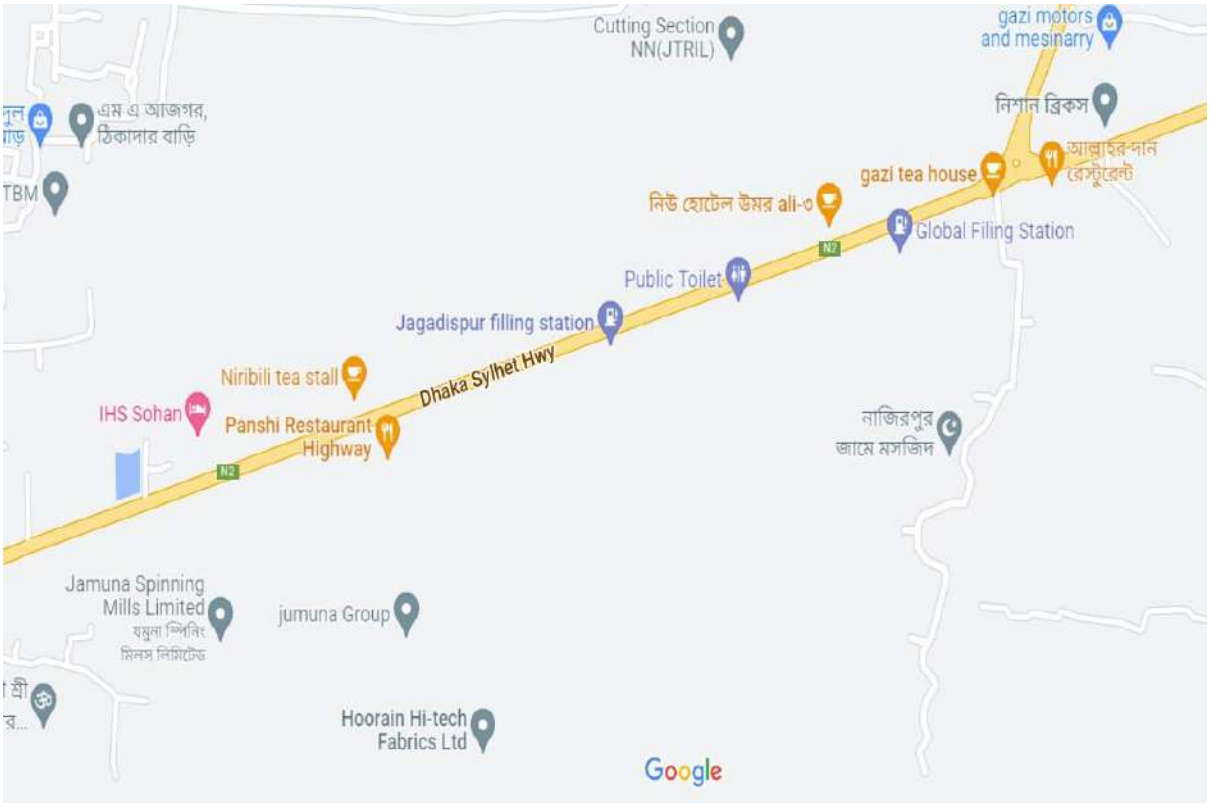
Aerial View of Shahjibazar Industrial Area-4 [google maps]



Aerial View of Shahjibazar Industrial Area-5 [google maps]



Aerial View of Shahjibazar Industrial Area-6 [google maps]



Aerial View of Shahjibazar Industrial Area-7 [google maps]

Estimated Cost

Case-2: Estimated cost for Existing 8in. Pipeline Tie-in with 1St Stage of JIP CMS

PART-A (MATERIAL COST):						
Item No.	**Description of the materials**		**Unit**	**Qty.**	**Unit Price (Tk)**	**Total Price (TK)**
i	ii		iii	iv	v	vi= (iv x vi)
1.0	**MS ERW Line pipe (API), 5L, Grade B**					
	1.1	8" DIA., Sch-40	Meter	2,500	19,088.00	47,720,000.00
2.0	**MS ERW Casing Pipe**					
	2.1	10"DIA.	Meter	60	10,411.00	624,660.00
3.0	**Isolating Valve**					
	3.1	8"DIA. X 150 RF Ball Valve	Nos.	1	197,983.00	197,983.00
4.0	**Weld-neck Flange: ANSI B16.5; ASTM A105.**					
	4.1	8"DIA. X ANSI 150RF	Nos.	2	6,158.00	12,316.00
5.0	**Gasket: ANSI B16.21 to use with ANSI B16.5 RF Flange.**					
	5.1	8"DIA. X ANSI 150RF Gasket	Nos.	6	1,055.00	6,330.00
6.0	**Tee: ANSI B16.9, ASTM A234 Gr. WPB, Butt-Welded**					
	6.1	8"DIA.×8"DIA.×8"DIA., Sch-Standard/40	Nos.	1	4,862.00	4,862.00
7.0	**Elbow: ANSI B16.9, ASTM A234 Gr. WPB, Butt-Welded**					
	7.1	8"DIA.×90º, Sch-Standard/40	Nos.	2	4,051.00	8,102.00
9.0	**END Cap**					
	9.1	8"DIA. End Cap, Sch-Standard/40	Nos.	1	1,275.00	1,275.00
10.0	**Insulating Joint**					
	10.3	8" DIA. x 150 class Insulating Joint	Nos.	1	151,163.000	151,163.00
11.0	**Stud Bolts with Nuts & Washers of various sizes as per des. req. (ANSI B16.5/ANSI B 18.2.2).**					
	11.1	3/4"DIA. x 4½"L (for 8”X150RF Flange)	Nos.	24	81.00	1,944.00
12.0	**Socket of various size. as per design req. (ASTM A105, 3000lb, NPT Female, ANSI B16.11).**					
	12.1	½"DIA. NPT	Nos.	3	188.00	564.00
	12.2	1"DIA. NPT	Nos.	3	368.00	1,104.00
13.0	**Hexagonal–Head Plug of various sizes as per design requirement (ASTM A105, 3000lb, NPT Male, ANSI B16.11).**					
	13.1	½"DIA. NPT	Nos.	3	163.00	489.00
	13.2	1"DIA. NPT	Nos.	3	480.00	1,440.00
14.0	**MS Nipple**					

	14.1	1/2"DIA. x 3 L Nipple	Nos.	3	375.00	1,125.00
	14.2	1"DIA. x 3 L Nipple	Nos.	2	657.00	1,314.00
15.0	**Niddle Valve**					
	15.1	½"DIA.	Nos.	3	1,637.000	4,911.00
16.0	**Pressure Gauge**					
	16.1	½"DIA. NPT Pressure Gauge (0-200) psig	Nos.	2	4,092.000	8,184.00
17.0	**Valve Pit Cover**					
	17.1	Valve pit cover for 8"DIA.× 150 RF Ball Valve	Nos.	1	29,745.000	29,745.00
18.0	**Thinsulator**					
	18.1	10"DIA.×8"DIA.	Nos.	8	2,436.000	19,488.00
19.0	**Casing End Seal**					
	19.1	10"DIA.×8"DIA.	Nos.	2	14,775.000	29,550.00
20.0	**Vent Pipe**					
	20.1	2"DIA. Vent Pipe	meter	30	912.000	27,360.00
21.0	**Tape and Primer:**					
	21.1	6″ X 400´ Tape (Black)	Rolls	20	8,510.00	170,200.00
	21.2	6″ X 400´ Tape (White)	Rolls	20	8,546.00	170,920.00
	21.3	Primer	Liter	200	906.00	181,200.00
Total Material Cost Estimated Price in Tk.=						**49,376,229.00**
PART-B (Pipeline Construction Cost (Laying, Welding, Radiography, Testing & Commissioning, Wrapping, Road Crossing etc.)):						
22.0	**8" Pipeline Construction Cost**					
	22.1	8" Pipeline Construction Cost	Meter	2,500	1,038.00	2,595,000.00
Total Construction Cost Estimated Price in Tk.=						**2,595,000.00**
Total Estimated Price in Tk.=						**51,971,229.00**
In Words: Tk. Five Crore Nineteen Lakh Seventy-One Thousand Two Hundred Twenty-Nine Only.						

Case-3: Estimated cost for 12in. parallel Pipeline Construction

PART-A (MATERIAL COST):						
Item No.	**Description of the materials**		**Unit**	**Total Qty.**	**Unit Price (Tk)**	**Total Price (TK)**
i	ii		iii	iv	v	vi= (iv x v)
1.0	**MS ERW Linepipe (API), 5L, Grade B**					
	1.1	12"DIA., Sch-40	Meter	15,000	10,425.00	156,375,000.00
2.0	**Isolating Valve**					
	2.1	12"DIA. X 150 RF Ball Valve	Nos.	3	444,000.00	1,332,000.00
3.0	**Weld-neck Flange: ANSI B16.5; ASTM A105.**					
	3.1	12"DIA. X ANSI 150RF	Nos.	6	12,320.00	73,920.00
4.0	**Gasket: ANSI B16.21 to use with ANSI B16.5 RF Flange.**					
	4.1	12"DIA. X ANSI 150RF Gasket	Nos.	12	515.00	6,180.00
5.0	**Tee: ANSI B16.9, ASTM A234 Gr. WPB, Butt-Welded**					
	5.1	12"DIA.×12"DIA.×8"DIA., Sch-Standard/40	Nos.	2	20,532.00	41,064.00
6.0	**Elbow: ANSI B16.9, ASTM A234 Gr. WPB, Butt-Welded**					
	6.1	8"DIA.×90º, Sch-Standard/40	Nos.	2	4,051.00	8,102.00
7.0	**END Cap**					
	7.1	12"DIA. End Cap, Sch-Standard/40	Nos.	2	18,163.00	36,326.00
8.0	**Stud Bolts with Nuts & Washers of various sizes as per des. req. (ANSI B16.5/ANSI B 18.2.2).**					
	8.1	7/8"DIA. x 4¾"L (for 12"X150RF Flange)	Nos.	72	225.00	16,200.00
9.0	**Socket of various size. as per design req. (ASTM A105, 3000lb, NPT Female, ANSI B16.11).**					
	9.1	½"DIA. NPT	Nos.	3	188.00	564.00
	9.2	1"DIA. NPT	Nos.	3	368.00	1,104.00
10.0	**Hexagonal–Head Plug of various sizes as per design requirement (ASTM A105, 3000lb, NPT Male, ANSI B16.11).**					
	10.1	½"DIA. NPT	Nos.	3	163.00	489.00
	10.2	1"DIA. NPT	Nos.	3	480.00	1,440.00
11.0	**MS Nipple**					
	11.1	1/2"DIA. x 3 L Nipple	Nos.	3	375.00	1,125.00
	11.2	1"DIA. x 3 L Nipple	Nos.	2	657.00	1,314.00
12.0	**Niddle Valve**					
	12.1	½"DIA.	Nos.	3	1,637.000	4,911.00
13.0	**Pressure Gauge**					
	13.1	½"DIA. NPT Pressure Gauge (0-200) psig	Nos.	2	4,092.000	8,184.00
14.0	**Valve Pit Cover**					
	14.1	Valve pit cover for 12DIA.× 150 RF Ball Valve	Nos.	3	45,000.000	135,000.00
15.0	**Tape and Primer:**					
	15.1	6″ X 400′ Tape (Black)	Rolls	120	8,510.00	1,021,200.00
	15.2	6″ X 400′ Tape (White)	Rolls	120	8,546.00	1,025,520.00

	15.3	Primer	Liter	1,000	906.00	906,000.00
					Total Material Cost Estimated Price in Tk.=	**160,995,643.00**
PART-B (Pipeline Construction Cost (Laying, Welding, Radiography, Testing & Commissioning, Wrapping, Road Crossing etc.)):						
16.0	**12" Pipeline Construction Cost**					
	16.1	12" Pipeline Construction Cost	Meter	15,000	1,617.00	24,255,000.00
					Total Construction Cost Estimated Price in Tk.=	**24,255,000.00**
					Total Estimated Price in Tk.=	**185,250,643.00**
In Words: Tk. Eighteen Crore Fifty-Two Lakh Fifty Thousand Six Hundred and Forty-Three Only.						

Case-4: Estimated cost for 16 in x 17.5 Km Pipeline Construction with 10 in existing inlet

PART-A (MATERIAL COST):						
Item No.	**Description of the materials**		**Unit**	**Total Qty.**	**Unit Price (Tk)**	**Total Price (TK)**
I	ii		iii	iv	v	vi= (iv x v)
1.0	**MS ERW Line pipe (API), 5L, Grade B**					
	1.1	16"DIA., Sch-40	Meter	17,500	15,160.00	265,300,000.00
	1.2	8"DIA., Sch-40	Meter	100	19,088.00	1,908,800.00
2.0	**Isolating Valve**					
	2.1	16"DIA. X 150 RF Ball Valve	Nos.	3	444,000.00	1,332,000.00
	2.2	8"DIA. X 150 RF Ball Valve	Nos.	1	197,983.00	197,983.00
3.0	**Weld-neck Flange: ANSI B16.5; ASTM A105.**					
	3.1	16"DIA. X ANSI 150RF	Nos.	6	12,320.00	73,920.00
	3.2	8"DIA. X ANSI 150RF	Nos.	2	6,158.00	12,316.00
4.0	**Gasket: ANSI B16.21 to use with ANSI B16.5 RF Flange.**					
	4.1	16"DIA. X ANSI 150RF Gasket	Nos.	12	570.00	6,840.00
	4.2	8"DIA. X ANSI 150RF Gasket	Nos.	2	1,055.00	2,110.00
5.0	**Tee: ANSI B16.9, ASTM A234 Gr. WPB, Butt-Welded**					
	5.1	16"DIA.×16"DIA.×16"DIA., Sch-Standard/40	Nos.	2	26,060.00	52,120.00
6.0	**Elbow: ANSI B16.9, ASTM A234 Gr. WPB, Butt-Welded**					
	6.1	8"DIA.×90º, Sch-Standard/40	Nos.	2	4,051.00	8,102.00
7.0	**END Cap**					
	7.1	16"DIA. End Cap, Sch-Standard/40	Nos.	2	49,278.00	98,556.00
8.0	**Stud Bolts with Nuts & Washers of vari. sizes as per des. req. (ANSI B16.5/ANSI B 18.2.2).**					
	8.1	1"DIA. x 5¼"L (for 16"X150RF Flange)	Nos.	96	313.00	30,048.00
	8.2	3/4"DIA. x 4½"L (for 8"X150RF Flange)	Nos.	16	81.00	1,296.00
9.0	**Socket of various size. as per design req. (ASTM A105, 3000lb, NPT Female, ANSI B16.11).**					
	9.1	½"DIA. NPT	Nos.	3	188.00	564.00
	9.2	1"DIA. NPT	Nos.	3	368.00	1,104.00
10.0	**Hexagonal–Head Plug of various sizes as per design requirement (ASTM A105, 3000lb, NPT Male, ANSI B16.11).**					
	10.1	½"DIA. NPT	Nos.	3	163.00	489.00
	10.2	1"DIA. NPT	Nos.	3	480.00	1,440.00
11.0	**MS Nipple**					
	11.1	1/2"DIA. x 3 L Nipple	Nos.	3	375.00	1,125.00
	11.2	1"DIA. x 3 L Nipple	Nos.	2	657.00	1,314.00
12.0	**Niddle Valve**					
	12.1	½"DIA.	Nos.	3	1,637.000	4,911.00
13.0	**Pressure Gauge**					
	13.1	½"DIA. NPT Pressure Gauge (0-200) psig	Nos.	2	4,092.000	8,184.00
14.0	**Valve Pit Cover**					
	14.1	Valve pit cover for 16DIA.× 150 RF Ball Valve	Nos.	3	45,000.000	135,000.00
15.0	**Tape and Primer:**					
	15.1	6″ X 400′ Tape (Black)	Rolls	140	8,510.00	1,191,400.00
	15.2	6″ X 400′ Tape (White)	Rolls	140	8,546.00	1,196,440.00

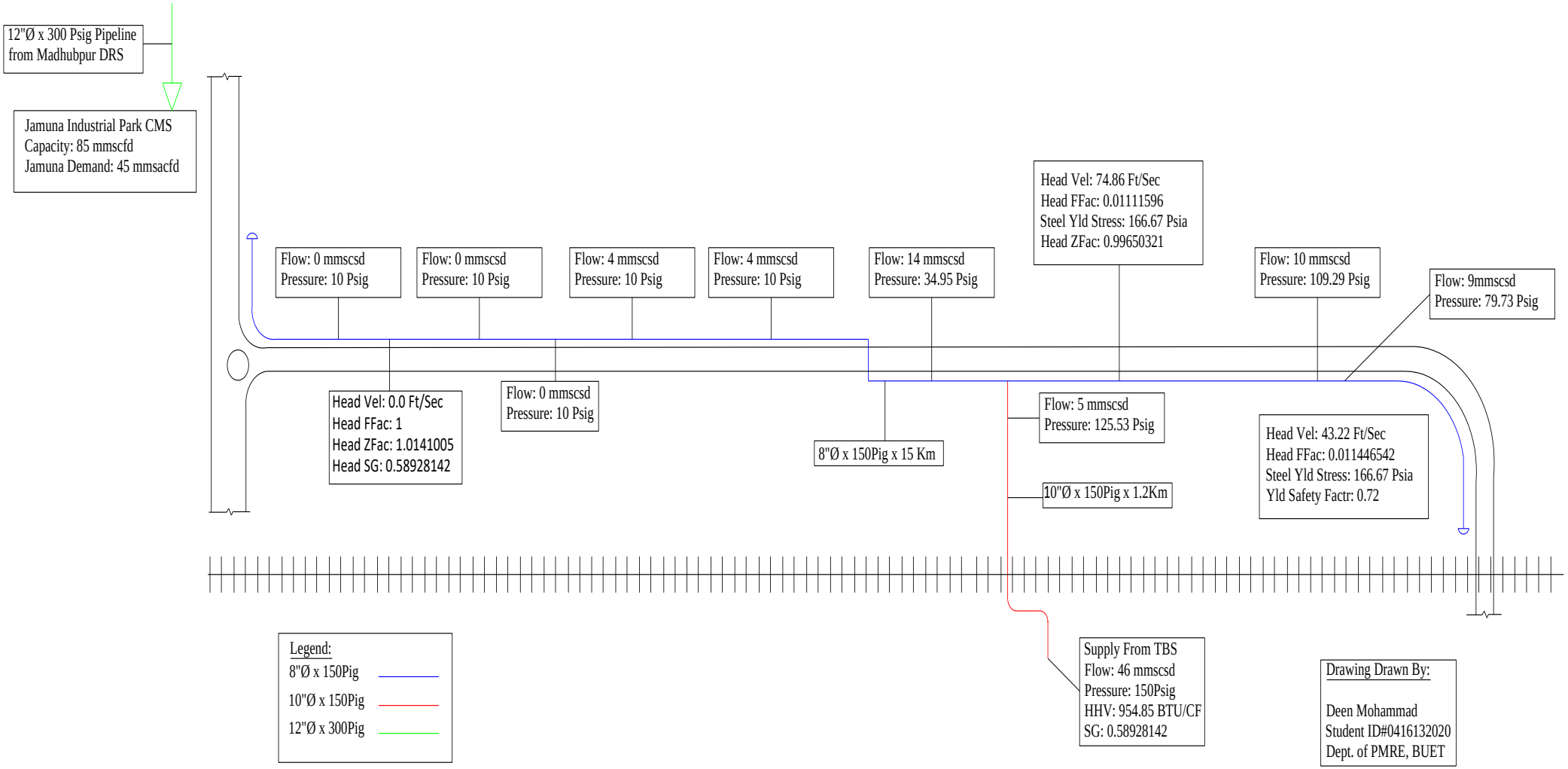
	15.3	Primer	Liter	1,100	906.00	996,600.00
Total Material Cost Estimated Price in Tk.=						**272,562,662.00**
PART-B (Pipeline Construction Cost (Laying, Welding, Radiography, Testing & Commissioning, Wrapping, Road Crossing etc.)):						
16.0	**16" Pipeline Construction Cost**					
	16.1	16" Pipeline Construction Cost	Meter	17500	2,356.00	41,230,000.00
	16.2	8" Pipeline Construction Cost	Meter	100	1,038.00	103,800.00
	16.3	Tie-in at various industrial connection	Nos.	50	100,000.00	5,000,000.00
	16.4	Existing 8in pipeline withdrawal Cost	Nos.	15000	347.00	5,205,000.00
Total Construction Cost Estimated Price in Tk.=						**51,538,800.00**
Total Estimated Price in Tk.=						**324,101,462.00**
In Words: Tk. Thirty-Two Crore Forty-one Lakh One Thousand Four Hundred and Sixty-Two Only.						

Case-5: Estimated cost for 16 in. x 18.7 Km Pipeline Construction

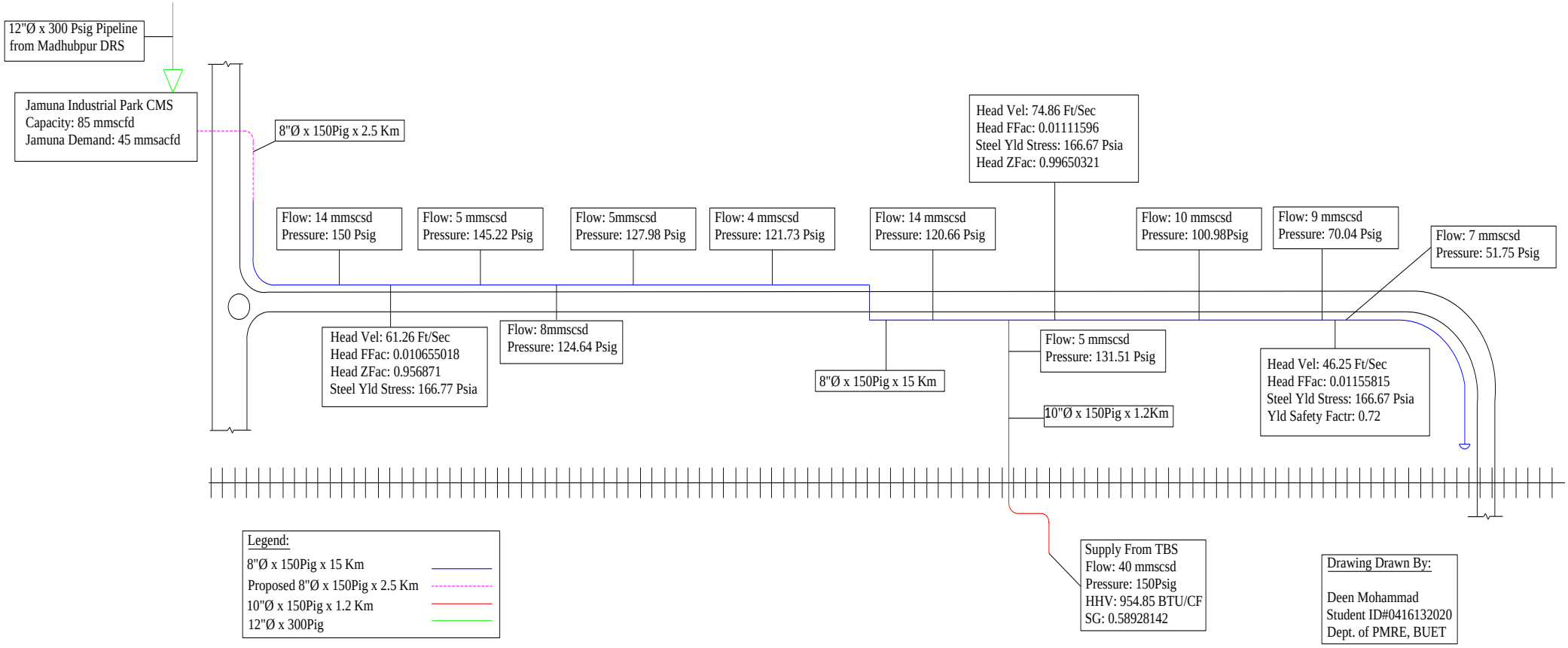
PART-A (MATERIAL COST) :						
Item No.	**Description of the materials**		**Unit**	**Total Qty.**	**Unit Price (Tk)**	**Total Price (TK)**
i	ii		iii	v	vi	vii= (v x vi)
1.0	**MS ERW Line pipe (API), 5L, Grade B**					
	1.1	16"DIA., Sch-40	Meter	18,700	15,160.00	283,492,000.00
	1.2	8"DIA., Sch-40	Meter	100	19,088.00	1,908,800.00
2.0	**Isolating Valve**					
	2.1	16"DIA. X 150 RF Ball Valve	Nos.	3	444,000.00	1,332,000.00
	2.2	8"DIA. X 150 RF Ball Valve	Nos.	1	197,983.00	197,983.00
3.0	**Weld-neck Flange: ANSI B16.5; ASTM A105.**					
	3.1	16"DIA. X ANSI 150RF	Nos.	6	12,320.00	73,920.00
	3.2	8"DIA. X ANSI 150RF	Nos.	2	6,158.00	12,316.00
4.0	**Gasket: ANSI B16.21 to use with ANSI B16.5 RF Flange.**					
	4.1	16"DIA. X ANSI 150RF Gasket	Nos.	12	570.00	6,840.00
	4.2	8"DIA. X ANSI 150RF Gasket	Nos.	2	1,055.00	2,110.00
5.0	**Tee: ANSI B16.9, ASTM A234 Gr. WPB, Butt-Welded**					
	5.1	16"DIA.×16"DIA.×16"DIA., Sch-Standard/40	Nos.	2	26,060.00	52,120.00
6.0	**Elbow: ANSI B16.9, ASTM A234 Gr. WPB, Butt-Welded**					
	6.1	8"DIA.×90º, Sch-Standard/40	Nos.	2	4,051.00	8,102.00
7.0	**END Cap**					
	7.1	16"DIA. End Cap, Sch-Standard/40	Nos.	2	49,278.00	98,556.00
8.0	**Stud Bolts with Nuts & Washers of vari. sizes as per des. req. (ANSI B16.5/ANSI B 18.2.2).**					
	8.1	1"DIA. x 5¼"L (for 16”X150RF Flange)	Nos.	96	313.00	30,048.00
	8.2	3/4"DIA. x 4½"L (for 8”X150RF Flange)	Nos.	16	81.00	1,296.00
9.0	**Socket of various size. as per design req. (ASTM A105, 3000lb, NPT Female, ANSI B16.11).**					
	9.1	½"DIA. NPT	Nos.	5	188.00	940.00
	9.2	1"DIA. NPT	Nos.	5	368.00	1,840.00
10.0	**Hexagonal–Head Plug of various sizes as per design requirement (ASTM A105, 3000lb, NPT Male, ANSI B16.11).**					
	10.1	½"DIA. NPT	Nos.	5	163.00	815.00
	10.2	1"DIA. NPT	Nos.	5	480.00	2,400.00
11.0	**MS Nipple**					
	11.1	1/2"DIA. x 3 L Nipple	Nos.	5	375.00	1,875.00
	11.2	1"DIA. x 3 L Nipple	Nos.	5	657.00	3,285.00
12.0	**Niddle Valve**					
	12.1	½"DIA.	Nos.	5	1,637.000	8,185.00
13.0	**Pressure Gauge**					
	13.1	½"DIA. NPT Pressure Gauge (0-200) psig	Nos.	5	4,092.000	20,460.00
14.0	**Valve Pit Cover**					
	14.1	Valve pit cover for 16DIA.× 150 RF Ball Valve	Nos.	3	45,000.000	135,000.00
15.0	**Tape and Primer:**					
	15.1	6″ X 400´ Tape (Black)	Rolls	150	8,510.00	1,276,500.00

	15.2	6″ X 400´ Tape (White)	Rolls	150	8,546.00	1,281,900.00
	15.3	Primer	Liter	1,200	906.00	1,087,200.00
Total Material Cost Estimated Price in Tk.=						**291,036,491.00**
PART-B (Pipeline Construction Cost (Laying, Welding, Radiography, Testing & Commissioning, Wrapping, Road Crossing etc.)):						
16.0	**16" Pipeline Construction Cost**					
	16.1	16" Pipeline Construction Cost	Meter	18700	2,356.00	44,057,200.00
	16.2	8" Pipeline Construction Cost	Meter	100	1,038.00	103,800.00
	16.3	Tie-in at various industrial connection	Nos.	50	100,000.00	5,000,000.00
	16.4	Existing 8 in pipeline withdrawal Cost	Nos.	15000	347.00	5,205,000.00
	16.5	Existing 10 in pipeline withdrawal Cost	Nos.	1500	463.00	694,500.00
Total Construction Cost Estimated Price in Tk.=						**55,060,500.00**
Total Estimated Price in Tk.=						**346,096,991.00**
In Words: Tk. Thirty-Four Crore Sixty Lakh Ninety-Six Thousand Nine Hundred Ninety-One Only.						

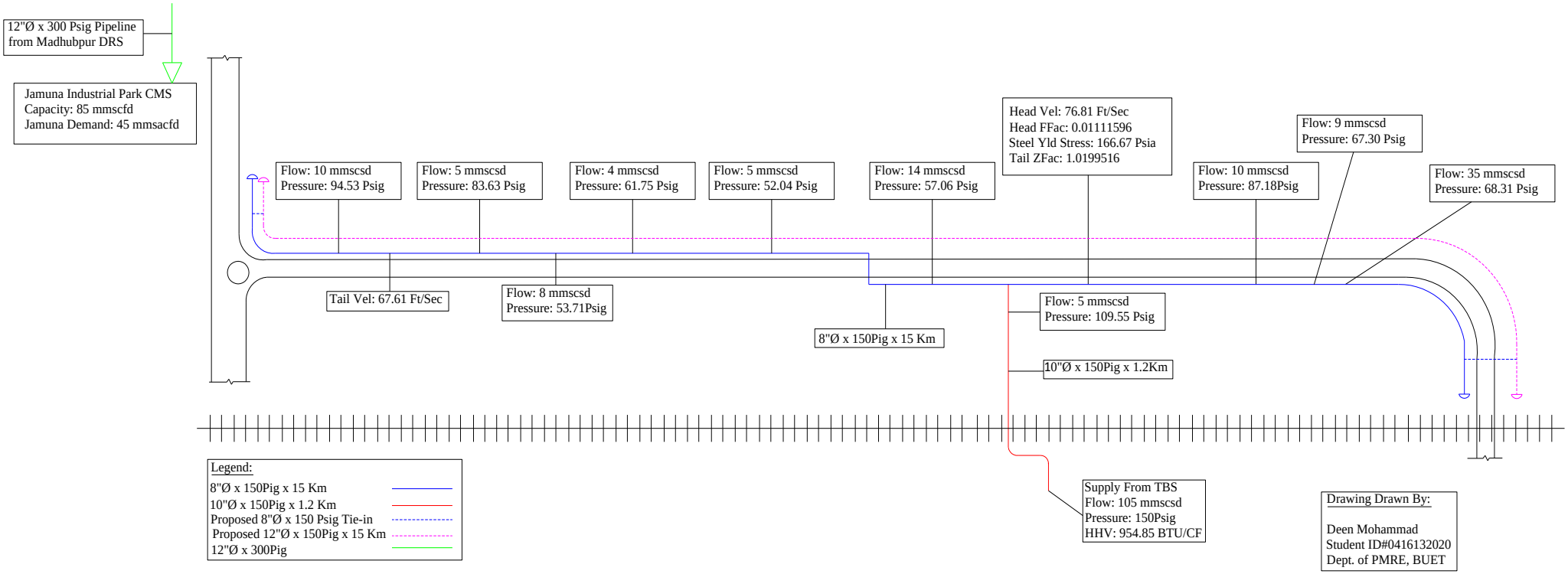
Title: Network Drawing for Existing 10"Ø x 1.2 Km - 8"Ø x 15 Km x150 Psig Local Transmission Pipeline for Shahjibazar Industrial Area.



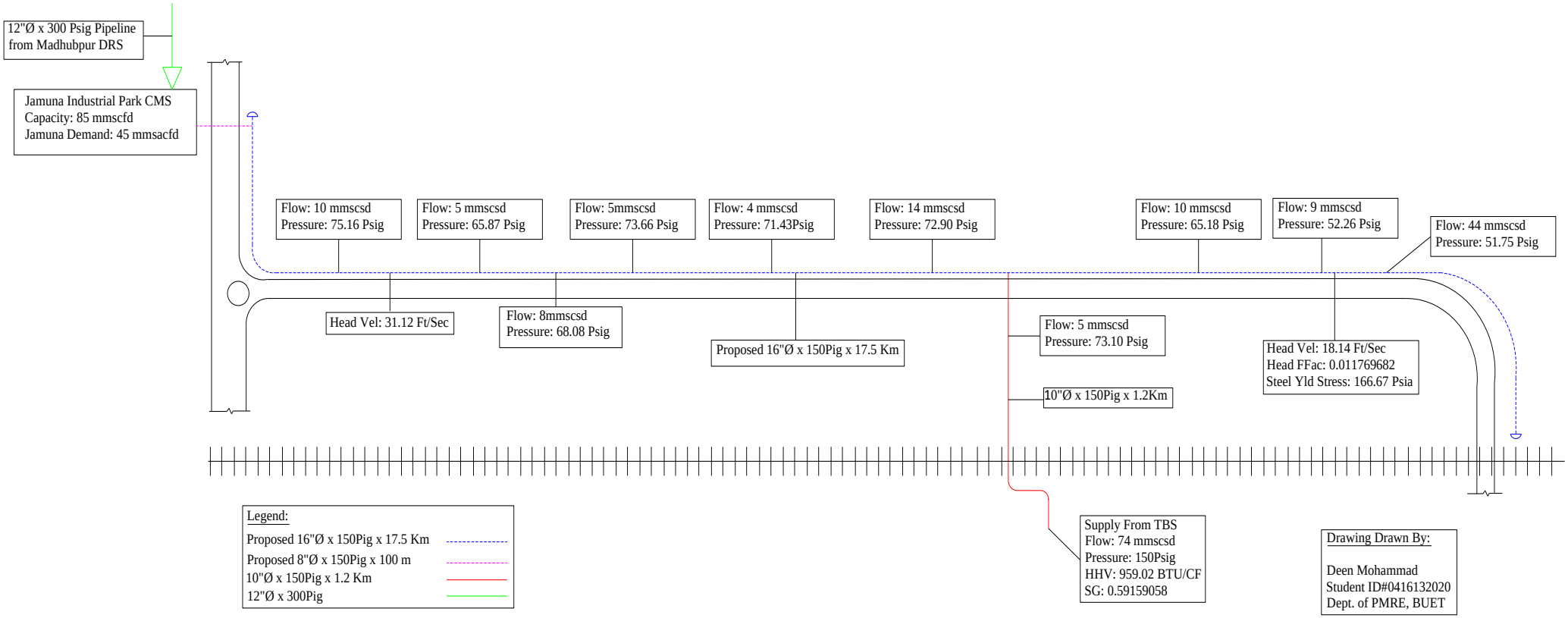
Title: Proposed Network Drawing for Tie-in of 1st stage of Jamuna Industrial Park CMS for supply of 40 mmscfd gas @150 Psig to Shahjibazar Industrial Area with Existing 10"Ø x 1.2 Km - 8"Ø x 15 Km x150 Psig Local Transmission P peline.



Title: Proposed Network Drawing for Existing 10"Ø x 1.2 Km - 8"Ø x 15 Km x150 Psig Transmission Pipeline with 12"Ø x15 Km x 150 Psig Parallel Balancing Pipeline to Existing 8"Ø x 15 Km x150 Psig Transmission Pipeline for Shahjibazar Industrial Area.



Title: Proposed Network Drawing for Existing 10"Ø x 1.2 Km Transmission Pipeline with new 16"Ø x17.5 Km x 150 Psig Pipeline and Tie-in with 1st Stage of Jamuna Industrial Park CMS for Shahjibazar Industrial Area.



Title: Proposed Network Drawing for new 16"Ø x18.7 Km x 150 Psig Pipeline and Tie-in with 1st Stage of Jamuna Industrial Park CMS for Shahjibazar Industrial Area.