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March 27, 2017

PROJECT DOCUMENT

OF

THE ASIAN INFRASTRUCTURE INVESTMENT BANK

The People's Republic of Bangladesh

Natural Gas Infrastructure and Efficiency Improvement Project

CURRENCY EQUIVALENTS

(Effective as of March 2, 2017)
Currency Unit = Taka (Tk)
US$ 1.00 = Tk 79.40

FISCAL YEAR

January 1 – December 31

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
ADF	Asian Development Fund
AIIB	Asian Infrastructure Investment Bank
BERC	Bangladesh Energy Regulatory Commission
BGFCL	Bangladesh Gas Fields Company Limited
DP	development partner
EIRR	economic internal rate of return
EMP	environmental management plan
EMRD	Energy and Mineral Resources Division
FIRR	financial internal rate of return
FSRU	floating storage and regasification unit
GDF	gas development fund
GDP	gross domestic product
GoB	Government of Bangladesh
GRC	grievance redress committee
GRM	grievance redress mechanism
GTCL	Gas Transmission Company Limited
IA	implementation agency
IEE	initial environmental examination
IFI	international financial institution
IMF	International Monetary Fund
IOC	international oil company
km	kilometer
LNG	liquefied natural gas
mmbtu	million British thermal unit
MMCFD	million cubic feet per day
ROW	right of way
Petrobangla	Bangladesh Oil, Gas and Mineral Corporation
PIU	project implementation unit
PSC	production sharing contract
PSIG	pounds per square inch gauge
SPS	safeguard policy statement
TCF	trillion cubic feet
WA	withdrawal application
WACC	weighted average cost of capital

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1. Project Summary Sheet

The People's Republic of Bangladesh
Natural Gas Infrastructure and Efficiency Improvement Project (the Project)

Project No.	000015
Borrower(s) Implementation Agency (IA)	People's Republic of Bangladesh Bangladesh Gas Fields Company Limited (BGFCL) and Gas Transmission Company Limited (GTCL).
Sector / Subsector	Energy / Natural Gas
Project Objectives/Brief Project Description	The objective of the Project is to improve efficiency in gas production and expand gas transmission pipeline capacity in Bangladesh. The Project will (i) install seven wellhead gas compressors in Titas Gas Field, and (ii) construct an approximately 181 kilometers, 36-inch gas transmission pipeline traversing Chittagong through Feni to Bakhrabad.
Project Implementation Period (Start Date and End Date)	Start Date: January 1, 2017 End Date: December 31, 2021
Expected Loan Closing Date	June 30, 2022
Project cost and Financing Plan	Project cost: US$453 million Financing plan: US$167 million from ADB (37%) US$60 million from AIIB (13%) US$226 million from domestic resources (50%).
AIIB Loan (Size and Terms)	US$60 million, with a 25-year term, including a grace period of 5 years, at the Bank's standard interest-rate for sovereign-backed loans with the corresponding weighted average maturity.
Co-financing (co-financier, Size and Terms)	ADB, US$ 167 million, with a 25-year term, including a grace period of 5 years, at annual rate determined in accordance with ADB's pricing policy.
Environmental and Social Category	Category A
Project Risk	High
Conditions for Effectiveness and Disbursement	1. Effectiveness Condition: Cross-effectiveness of ADB's Loan Agreement 2. Disbursement Conditions: (a) The Subsidiary Loan Agreements with the IAs have been executed and have become effective; and (b) The Borrower has submitted a draft revised gas pricing framework.
Key Covenants	1. The Borrower and IAs shall ensure that the preparation, design, construction, implementation, operation and decommissioning of the Project and all project facilities comply with, among others, all measures and requirements set forth in the legal agreements. 2. The Borrower shall provide counterpart funds for project implementation on time. 3. The Borrower shall use its best efforts to rationalize natural gas prices in Bangladesh.

	4. The Borrower shall ensure that the production and transmission companies receiving financing under the Project operate on full cost recovery basis during operating period of the project life. 5. The Borrower shall cause GTCL and BGFCL to achieve a debt service coverage ratio (net operating income divided by total debt service obligations) of at least 1.2x during the project implementation period, and maintain it throughout the entire operating period of the Project.
Policy Assurance	The VP Policy and Strategy confirms an overall assurance that the Bank is in compliance with the policies applicable to the Project.

President	JIN Liqun
Vice-President, CIO	D.J. Pandian
Director General	Supee Teravaninthorn
Manager	Ke Fang
Project Team Leader	Hongliang Yang, Senior Investment Operation Specialist
Team Members	Amiko Sudo, Office of the General Counsel Bin Wang, Senior Policy Officer Chongwu Sun, Senior Environmental Consultant Ian Nightingale, Procurement Advisor Jang Ping Thia, Senior Economist Kishlaya Misra, Operations Support Specialist Somnath Basu, Senior Social Development Specialist Thomas Walenta, Financial Officer Yan Li, Economic and Financial Consultant Yige Zhang, Project Assistant

2. Strategic Context

A. Country Context

1. Bangladesh is widely recognized to be one of the most vulnerable countries to natural disasters and climate change. Despite the challenges that it faces, Bangladesh has maintained an impressive track record, growing at 6% annually in the past decade. In 2014, with a population of about 160 million, Bangladesh's gross domestic product (GDP) per capita reached US$1,087.[1] According to the International Monetary Fund (IMF), Bangladesh has maintained a low risk of external public debt distress. Its macroeconomic performance has been strong despite facing recent global headwinds – inflation has eased, international reserves have risen, the public debt-to-GDP ratio has remained largely stable, and its medium-term economic outlook is expected to be positive marked by continuing stability and high growth.[2] However, moving the growth process forward, infrastructural deficiencies, particularly shortage of energy supply, continue to be a major impediment to Bangladesh's developmental efforts both in economic growth and in poverty reduction.

2. Bangladesh economy is heavily dependent on natural gas, which is the key indigenous source of energy. Natural gas accounts for around 75% of the commercial energy consumption in Bangladesh. Despite its importance, supply of natural gas in the country has not kept up with increasing demand. As of June 2016, out of a total recoverable reserve of 27.1 trillion cubic feet (TCF), cumulative production in the country was about 13.1 TCF. If no new gas fields are discovered, the remaining reserve of about 14 TCF can only sustain for about 12 years. Currently, the gas production is 2,700 million cubic feet per day (MMCFD) against gas demand of 3,150 MMCFD, indicating a daily shortage of 450 MMCFD. It was estimated that in 2015 around 800-1,000 megawatt generation capacity was not operational due to shortage of gas supply. The gas supply deficit is expected to further exacerbate in the wake of declining gas reserves and fast-rising gas demand that will eventually imperil Bangladesh's energy security and constrain the country's economic growth.

3. The Government of Bangladesh (GoB) has identified energy supply as a major constraint on GDP growth, and overall economic development. In the Seventh Five Year Plan (fiscal year 2015/16 to 2019/20), GoB aims to use a balanced approach between supply increase through new investments and demand management through policy interventions. With the support from international financial institutions, such as World Bank and Asian Development Bank (ADB), GoB has made plans to deploy utility-scale solar, wind, and biomass plants at selected places wherever possible. Per the GoB's sector development plan, about 10% of the total installed capacity will be renewable in 2020.[3] Energy supply from domestic sources will be complemented with energy trade, including for liquefied natural gas (LNG). The GoB's stated policy objectives are to make the gas sector financially viable, improve its efficiency and quality of supply, and increase private sector participation and investment. GoB has given continuing attention to the sector's overall development, through survey, exploration, exploitation, production, transmission, and distribution, and will allocate adequate resources to develop gas infrastructure. The proposed Project is designed to ease the country's major constraint on GDP growth by helping maintain the current level of gas production in one of the

[1] World Bank, 2014, World Development Indicators.

[2] IMF, 2016. Country Report No. 16/27: Press Release (No. 16/34) -Executive Board Concludes 2015 Article IV Consultation with Bangladesh. February 1, 2016.

[3] Bangladesh Power and Energy Sector Master Plan (PSMP2016).

country's largest gas fields (Component 1) and by facilitating the supply of LNG to complement domestic gas production (Component 2).

B. Sectoral and Institutional Context

4. **Supply constraint.** Notable improvements in gas production in Bangladesh have been made in the last decade. Natural gas production has increased from 1,744 MMCFD in 2009 to 2,700 MMCFD in 2015, with about 1,625 MMCFD (about 60%) produced from gas fields owned and operated by international oil companies (IOCs) and 1,075 MMCFD (about 40%) from gas fields owned by national gas companies. Some estimates show that production from operating gas fields will start depleting from 2021 onwards, and the gap between demand and supply will continue to widen. Considering the actual growth rate of average gas consumption in the last 10 years, the projected gas supply gap will be around 4,200 MMCFD in the year 2030.

5. **Programs to increase gas supply**. Bangladesh has not taken any extensive exploration for many years due to lack of public funds, and exploration in offshore blocks was stalled until recent years mainly due to unattractive production sharing contracts (PSCs). To combat the gas supply crisis, GoB recently took measures to accelerate gas exploration and production. For example, GoB established the gas development fund (GDF) in 2012 to support the upstream activities and undertake large scale exploration in onshore and offshore blocks.[4] Systematic appraisals were also initiated to prove additional gas reserves in discovered and producing gas fields using three-dimensional seismic survey. Moreover, several IOCs have been assigned offshore exploration rights and awarded new PSCs to complement the country's onshore exploration program.

6. Besides gas exploration activities, other programs have also been tried to increase gas supply by GoB. Above all, it has been trying to increase gas production from existing gas fields by installing gas compressors, which are to ensure continuous gas production from wells by lowering the abandonment pressure and maintaining the gas delivery pressure to the network. For example, three gas compressors financed by ADB were installed, two at Ashuganj and one at Elenga, to improve gas flows in the national gas transmission network. Prior to this, an IOC (Chevron) installed a compressor at Muchai under a PSC to improve gas supply from Bibiyana Gas Field. Similarly, Component 1 of the proposed Project is to install seven wellhead compressors (5 operating and 2 stand-by) in Titas Gas Field to maintain gas pressure and production at current level.

7. **Need to enhance natural gas transmission infrastructure**. Inadequate gas transmission infrastructure is another hurdle in Bangladesh's gas sector. Although about 920 kilometers (km) of gas transmission pipelines were constructed from 2010 to 2016, the present coverage of gas transmission network is not sufficient to serve key market areas in Bangladesh as most of the gas supply points are in the northeast and central regions of the country, while delivery points are in the central, south, and west. The ongoing ADB loans have enhanced the transmission capacity to some extent.[5] However, the Chittagong area is still suffering from shortage of gas supply due to full capacity attainment of the existing 24–inch Bakhrabad-Chittagong gas transmission pipeline.

[4] The fund size is currently US$900 million equivalent, all of which has been committed for utilization by 2021.
[5] ADB. 2010. Report and Recommendation of the President to the Board of Directors: Proposed Loans to the Peoples Republic of Bangladesh for Natural Gas Access Improvement Project. Manila.

8. The persisting gas shortage cannot be met solely by using domestic sources unless new gas fields are discovered and developed. GoB has taken steps to diversify the gas supply sources through imports by cross-border gas transmission pipeline and as LNG. A floating storage and regasification unit (FSRU) near Maheshkhali is now under construction. Upon completion by 2018, it will be able to accommodate the importation of about 500 MMCFD of natural gas. According to the GoB's sector development plan, the construction of this FSRU makes the first move, and other offshore and onshore LNG terminal projects will follow in the near future (Annex 2).[6] GoB is also considering the establishment of an energy security fund, which will be earmarked to support the import of LNG and liquefied petroleum gas.

9. To help GoB realize its sector development targets, it is essential to expand the gas transmission network to accommodate the upcoming diversified gas supply sources from imports and offshore discoveries into the national gas network. Since constructing a gas transmission pipeline normally takes much longer time than constructing a LNG terminal, it is therefore wise and preferable to start the construction of transmission pipeline two or three years earlier. Component 2 of the proposed Project is to construct a 181 km, 36-inch gas transmission pipeline traversing Chittagong through Feni to Bakhrabad. Upon completion, the pipeline will constitute a trunk transmission pipeline to transmit re-gasified LNG from south to central and west gas markets. Without the pipeline, importing LNG in large quantity will not be possible in Bangladesh.

10. **Sector institutions**. The gas sector is regulated and administered by GoB through the Energy and Mineral Resources Division (EMRD) of the Ministry of Power, Energy and Mineral Resources. The EMRD has the authority for policy formulation, appointment and transfer of key officials, investment decision, and sector regulation. Bangladesh Oil, Gas and Mineral Corporation (Petrobangla) is the coordinating authority under EMRD for gas sector companies. At present, the sector has one gas exploration and production company, two national gas companies in gas field development and production, one company in gas transmission, one company in processing and marketing liquefied petroleum gas, and six gas marketing companies. Petrobangla has also served as a supervisor and sole purchaser of IOC outputs. Among all the natural gas related companies/institutions in the country, the two important ones which are also implementation agencies (IAs) for the Project are the Bangladesh Gas Fields Company Limited (BGFCL), and the Gas Transmission Company Limited (GTCL).

11. BGFCL is the largest state-owned natural gas production company in the country and its operation is currently under supervision of Petrobangla. It derives its origin from Pakistan Shell Oil Company in 1956, and started gas production in 1968. After independence of Bangladesh and promulgation of the Petroleum Act (1974), the company became a state-owned company of Bangladesh and was renamed as Bangladesh Gas Fields Company Limited in 1975. It is currently a public limited company registered under the Companies Act (1994). Its Board of Directors, the highest decision-making body, comprises high level officials from concerned Ministries, Petrobangla, sister companies under Petrobangla and other organizations. The Managing Director is the Chief Executive of the company. Functions and responsibilities bestowed on the Managing Director are carried out through separate functional departments.

12. BGFCL contributed about 35% of total gas production of Bangladesh in 2014. At present, a maximum of 826 MMCFD is supplied to the national gas network from 38 wells of five producing fields out of its six fields. In 2014, 288 billion cubic feet gas and 178,788 barrels

[6] Bangladesh Power and Energy Sector Master Plan (PSMP2016).

condensate were produced as by-product from the company's gas wells. The total recoverable gas reserve of the six fields under the company is about 12.3 TCF, out of which 6.8 TCF or about 55.8% was recovered by June 30, 2014. BGFCL witnessed a healthy growth of about 10% annual growth rate in gross sales during the period of 2010–2015, while the net income grew at a rate of 33.8%, witnessing a major increment from 2014 to 2015. Overall, the average net profit margin and the return on capital employed across the five-years periods were found to be low at 6.3% and 8.9%, respectively. It is predicted that the revenues of BGFCL are expected to peak in next couple of years and subsequently decrease due to decline in production from its fields.

13. GTCL was established by GoB as a state-owned company under Petrobangla in December 1993, and started its commercial operation in March 1994. The objective of GTCL is to establish a balanced and reliable national gas transmission network with effective and unified control to ensure transportation of required gas for meeting the increasing gas demand in the country. Since its inception, GTCL has been playing a pivotal role in the country's economic growth by maintaining gas supply from gas fields to the distribution companies under Petrobangla. Like BGFCL, GTCL has a Board of Directors comprising high level officials from concerned Ministries, Petrobangla, and other organizations; and a Managing Director overseeing the company's daily operation through functional departments.

14. GTCL currently owns about 1,394 km of gas transmission pipeline of different diameters, and 193 km of condensate transmission pipeline. GTCL witnessed a healthy growth in revenues at approximately 7% from 2010 to 2015 in gross sales, in tune with the gas transportation volumes and maintained stable operating profit margins. As a natural monopoly utility, GTCL has a transmission tariff that is determined by the Bangladesh Energy Regulation Commission (BERC). Due to its high revenue earnings, BERC reduced GTCL's transmission tariff by 53% from 0.32 Taka/cubic meter (Tk/m^3) to 0.15 Tk/m^3 in 2015. If this reduction in transmission tariff were maintained, it would seriously affect the revenue stream of GTCL in the long run. GTCL, therefore, filed a petition to BERC for revision of transmission tariff to 0.36 Tk/m^3 in 2016. After several rounds of public hearing, BERC recently announced that the transmission tariff was restored to 0.2654 Tk/m^3, effective on March 1, 2017. It is expected that BERC will periodically revise tariff on a cost-plus basis to reflect the domestic inflation rate and possible cost increase.

15. **Development coordination**. Many development partners (DPs) are active in the Bangladesh gas sector, including: (i) multilateral institutions, such as ADB and the World Bank; and (ii) bilateral agencies, such as Japan International Cooperation Agency, Norway Agency for Development Cooperation, and United States Agency for International Development. Key areas received supports include: gas production, transmission pipeline, distribution network, gas sector reforms, capacity strengthening of sector entities, and assistance for regulatory commission. Table 1 summarizes major assistance programs provided by the DPs in the Bangladesh gas sector since 1993.

16. Given the critical role of the gas sector in promoting economic growth in Bangladesh, it is necessary for the DPs to continue their support, as the capacity of gas companies is not sufficiently developed to access international capital markets. The proposed Project is in line with Bangladesh's Seventh Five-Year Plan to ease energy crisis and accelerate economic growth. Some DP-financed projects previously experienced delays in achieving designed targets because of weak project implementation capacity. Lessons learned from these projects have been considered in the design of the proposed Project. ADB, as the lead co-financier of the

proposed Project, will provide training for the IAs in financial management, procurement, and reporting and monitoring to ensure timely project implementation.

Table 1: DPs' Assistances in Bangladesh Gas Sector

Development Partner	Project Name	Duration	Amount (million)		
			US$	JP ¥	UK £
1.	**Multilateral**				
ADB	Natural Gas Access Improvement	2010-2017	265.00		
	Gas Transmission and Development	2005-2016	230.00		
	Dhaka Clean Fuel	2003-2010	72.60		
	Third Natural Gas Development	1993-2005	107.00		
	Evaluation of Private Sector Investment Proposals for Oil and Gas Exploration and Development	1993	0.10		
	Preparation of a Gas System Development Plan	1993	0.57		
	Safety and Efficiency Improvements in the Gas Sector	1993	0.48		
	Gas Regulatory Authority	1997	0.60		
	Fourth Natural Gas Development	1997	0.60		
World Bank	Bakhrabad-Siddhirganj Pipeline	2008-2016	350.00		
	Design of Project Management Framework (gas entities)	2008-2010	0.80		
	Narsingdi-Demra Pipeline Gas Infrastructure Development (co-financing)	1995-1998	19.00		
2.	**Bilateral**				
Japan	Natural Gas Efficiency	2014-2017		23,598	
	Third Natural Gas Development (cofinancing)	1993-2005		1,050	
	Narsingdi-Demra Pipeline Gas Infrastructure Development (co-financing)	1995-1998		956	
	Construction of Meghna-Bakhrabad Pipeline	1997-2002		342	
Norway	Dhaka Clean Fuel (cofinancing)	2005-2010	9.30		
	Gas Transmission and Development	2005-2010	5.00		
UK	Narsingdi-Demra Pipeline Gas Infrastructure Development (co-financing)	1995-1998			19.00
US	Improved Capacity for Energy Access	2008-2011	7.70		

Source: ADB.

3. The Project

A. Rationale

17. The Project will help address two critical issues in energy sector in Bangladesh: (i) increase gas production through improving production efficiency in existing gas fields, and (ii) overcome the capacity limitation of the existing gas transmission pipeline and increase operational flexibility and supply reliability of the national gas transmission network. Upon completion, it is estimated that current level of wellhead gas pressure can be maintained and additional gas will be produced from Titas Gas Field. Also, natural gas transmission and delivery capacity will be expanded to 3,500 MMCFD from the current level of 2,700 MMCFD.

The Project is, therefore, expected to make substantial contributions to Bangladesh's economic growth, and thus is fully aligned with the Bank's mission, i.e., to support economic growth in Asia through infrastructure investments.

B. Objective

18. The objective of the Project is to improve efficiency in gas production in Titas Gas Field and to expand the capacity of gas transmission pipeline between Chittagong and Bakhrabad. The expected impact of the Project is increased energy sector contribution to sustainable economic growth in Bangladesh.

19. The Project's key performance indicators include:

- At outcome level
  - (i) average annual wellhead pressure drop reduced;
  - (ii) gas production sustained at 230 MMCFD[7]; and
  - (iii) natural gas transmission and delivery capacity expanded.
- At output level
  - (i) number of wellhead compressors installed;
  - (ii) wellhead gas delivery pressure maintained;
  - (iii) length of 36-inch gas transmission pipeline constructed; and
  - (iv) natural gas transmission and delivery capacity expanded.

20. Detailed information on the above-mentioned indicators is available in Annex 1.

C. Project Description and Components

21. The Project comprises of two components. Component 1 is to install seven wellhead compressors (5 operating and 2 stand-by) in Titas Gas Field to maintain wellhead gas pressure and production at current level. [8] Component 2 will finance the construction of a 181 km, 36-inch gas transmission pipeline to transmit additional gas to the national network.

22. Under Component 1, the Project is to help improve gas production efficiency to maximize recovery from Titas Gas Field, the largest producing gas field in the country, and to maintain current level of production at required delivery pressure to the gas transmission system. Titas Gas Field has been producing natural gas since 1968 and wellhead pressure has declined from 3,500 pounds per square inch gauge (PSIG) to an average of 1,250 PSIG. It is expected that the pressure may go down below the threshold of 1,000 PSIG by 2019. BGFCL plans to install gas wellhead compressors in Titas Gas Field to maintain gas pressure and production at current level.[9]

23. Under Component 2, a 181 km, 36-inch parallel gas transmission pipeline traversing Chittagong through Feni to Bakhrabad is to be constructed. Upon completion, the proposed pipeline will constitute a trunk transmission pipeline between Chittagong and Bakhrabad to

[7] Daily production of 525 MMCFD from Titas Gas Field would reduce to 230–235 MMCFD once the wellhead pressure declines below 1,200 psig, resulting in suspension of production from the wells. Upon completion of the project facilities, the production from the wells would be sustained during the project's operating life.
[8] Titas gas field is located in Brahmanbaria District, about 100 km northeast to Dhaka City.
[9] Japan International Cooperation Agency has also provided support in installing wellhead compressors in location C of Titas gas field and of Narsinghdi gas field.

transport re-gasified LNG to central and west gas markets. It will help overcome the capacity limitation of the existing 24-inch transmission line and complete a full looping of the original trunk gas pipeline, which is crucial for a dependable and reliable gas transmission network and increase operational flexibility and supply reliability. It will also include two city gate stations (i.e. site at which a local gas distribution company receives gas from the transmission system), sectionalizing valve stations, and interconnection provisions to the existing gas transmission network.

D. Cost and Financing

24. The Project is estimated to cost US$453.0 million including taxes, duties, contingencies, and financing charges during construction (see Table 2 below).

25. Upon GoB's request, the Bank will provide a loan of US$60 million to finance the Project, with a 25-year term, including a grace period of 5 years, at the Bank's standard interest-rate for sovereign-backed loans with the corresponding weighted average maturity.

26. GoB has also requested ADB to provide US$167 million (US$100 million from its ordinary capital resources and US$67 million equivalent from its Special Funds resources) to help finance the Project. ADB's loan will have a 25-year term, including a grace period of 5 years, at annual rate determined in accordance with ADB's pricing policy.

27. The Banks' loan and ADB loan will be used jointly to finance the cost items. Any shortfall in the funds required would be covered by either the government or the IAs themselves.

Table 2: Project Cost and Financing Plan (US$ million)

Item	Estimated Costs [a]	AIIB		ADB		GoB	
		Amount	%	Amount	%	Amount	%
A. Investment Cost [b]	389.0	54.0	13.9	152.0	39.1	183.0	47.0
1. Installation of wellhead compressors	113.0	24.0	21.2	67.0	59.3	22.0	19.5
2. Construction of a 181 km, 36-inch gas transmission pipeline	276.0	30.0	10.9	85.0	30.8	161.0	58.3
B. Contingencies [c]	25.0	2.0	8.0	7.0	28.0	16.0	64.0
C. Financing Charges During Construction [d]	39.0	4.0	10.3	8.0	20.5	27.0	69.2
Total (A+B+C+D)	**453.0**	**60.0**	**13.2**	**167.0**	**36.9**	**226.0**	**49.9**

Note: [a] Taxes and duties will be financed by government resources.
[b] In mid-2016 prices, including civil works, mechanical and equipment, project management consultants, environment and social impact mitigation, etc. Land acquisition and development will be financed by government.
[c] Including physical and price contingencies.
[d] Including interest during construction, commitment fee, and other charges.

E. Implementation Arrangements

28. The Bank's loan will be administered by ADB as lead co-financier pursuant to an arrangement between the Bank and ADB. Under the arrangement, ADB will supervise the project implementation, including supervision in respect of environmental and social,

procurement as well as financial management aspects. [10] The Project will be implemented as per the arrangements summarized in Table 3.

Table 3: Implementation Arrangements

Aspects	**Arrangements**
Implementation period	January 1, 2017 – December 31, 2021
Loan closing date	June 30, 2022
Management	
(i) Oversight body	Steering Committee consists of: Secretary, EMRD; Chairman, Petrobangla; Managing Directors, BGFCL and GTCL; ERD; Planning Commission; and other related Ministries/Divisions/Agencies.
(ii) Implementation agency (IA)	BGFCL for component 1 and GTCL for component 2
(iii) Project Implementation Unit (PIU)	One PIU will be established under each IA to carry out daily project administration activities. Each PIU will be headed by a project director and equipped with sufficient staff (16 staff for component 1 and 40 for component 2).
Procurement: goods, works and consulting services	All goods, works, and consulting services to be financed will be procured through open competitive bidding, following ADB's Procurement Guidelines (2015, as amended from time to time). Universal procurement will apply to all procurement packages to be financed by ADB and the Bank.
Environmental and Social Safeguards	EMPs and RPs prepared for the Project in accordance with ADB's safeguard policies will be implemented. PIU will supervise implementation of those plans, with support from external monitoring consultants.
Retroactive financing and/or advance contracting	Advance contracting and retroactive financing will be allowed. Retroactive financing will be applicable to the advance contracting packages for up to 20% of ADB's and the Bank's loan amounts for eligible expenditures including goods and consulting services, which may be incurred prior to loan effectiveness but not earlier than 12 months before the date of signing of the respective loan agreements.
Disbursement	The loan proceeds will be disbursed following ADB's Loan Disbursement Handbook (2015, as amended from time to time) and detailed arrangements agreed between the government, ADB and the Bank. Withdrawal applications will be submitted through ADB for approval. Upon approval, the Bank and ADB will disburse their respective portion of the loans.

ADB = Asian Development Bank, BGFCL = Bangladesh Gas Fields Company Ltd., EMP = environmental management plan, EMRD = Energy and Mineral Resources Division, GTCL = Gas Transmission Company Ltd., Petrobangla = Bangladesh Oil, Gas and Mineral Corporation, PIU = project implementation unit, RP = resettlement plan

29. **Procurement**. All procurement of goods, works and services will be undertaken in accordance with ADB's Procurement Guidelines (2015, as amended from time to time). Universal procurement will be applied to all procurement packages to be financed by the Bank's and ADB's loans. By allowing universal procurement the ADB's Procurement Guidelines can be considered as being materially consistent with the Bank's Articles of Agreement and the Bank's Procurement Policy and the Bank's Policy on Prohibited Practices. As the IAs have significant previous experience of implementing ADB funded projects, they are quite familiar with ADB's Procurement Guidelines and procedures. To further reduce the procurement related risk, measures to ensure timely and smooth project implementation have been included -

[10] The Services provided by ADB include: Environmental and Social Services, Procurement Services, Financial Management Services, Disbursement Services, and Sanctionable Practices and Investigative Services.

continuous training to project implementation staff will be provided by ADB to strengthen their procurement capacities, and master bidding documents will also be prepared for similar packages to expedite the procurement process.

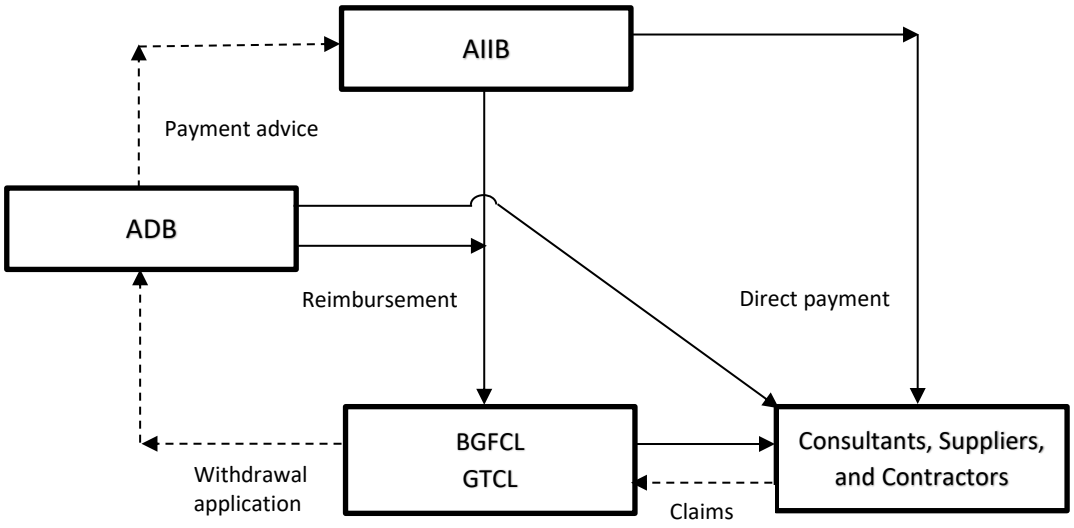
30. **Fund Flow Arrangements.** The proceeds of the Bank's and ADB's loans will be re-lent to the IAs under subsidiary loan agreements (SLAs) with terms and conditions acceptable to the Bank. GoB and IAs will ensure that all items of expenditures financed out of the proceeds of the loan to be used exclusively in carrying out the Project. GoB will exercise its rights under the SLAs in such manner as to protect its interests and those of the Bank and to accomplish the purposes of the Loan. The fund flow is illustrated in Figure 1.

31. **Disbursement**. The Bank's loan will be utilized and disbursed jointly with those financed by ADB for the procurement of goods, works and consulting services in all project components. Disbursement shall be made in accordance with ADB's Loan Disbursement Handbook (2015, as amended from time to time). BGFCL and GTCL (as designated by the Borrower) will prepare and submit the withdrawal applications (WAs) and supporting documents to ADB.

32. ADB and the Bank will finance eligible expenditures up to 100% of each WA received. BGFCL and GTCL will be responsible for maintaining contract ledger(s) including payments by ADB and the Bank. The IAs' staff will be required to undertake training on the applicable disbursement policies and procedures to help ensure efficient disbursement and fiduciary control.

33. To reduce the risk of price increase of the civil works and equipment and to avoid implementation delays, advance contracting and retroactive financing will be allowed. Retroactive Financing will be permitted for payments made for eligible expenditures made not more than twelve months prior to the expected signing date of the loan agreement, and for a maximum amount of US$12,000,000.

Figure 1: Fund Flow Arrangement



4. Project Assessment

A. Technical

34. Since the interventions supported under the Project are well established in Bangladesh, the technical risk of the Project is moderate. Technical due diligence focused on the review in terms of feasibility of technical solutions, investment plan, and operating cost structure. The IAs carried out the detailed designs for the project components respectively to address their specific needs. BGFCL intends to optimize natural gas production of Titas Gas Field. Installation of wellhead compressors will boost up wellhead pressure to maintain current levels of production from the wells to the gas transmission network and allow optimum condensate recovery from the raw gas and sustain production from the field for a longer period.

35. A gas compressor, like a pump, is a mechanical device that increases the pressure of gas by reducing its volume. The type of compressor which will be used is reciprocating. Under the Project, consultants will be engaged to prepare technical specification and basic engineering design for gas compressors and associated facilities. Detailed engineering design of the compressors and associated facilities will be prepared by the project contractors, and submitted to BGFCL and consultants for approval. The consultants will also supervise the contractor's work during the project implementation.

36. GTCL intends to increase gas supply in the national network and the Chittagong area through imported LNG or pipeline gas. The construction of the Chittagong-Bakhrabad pipeline will enable GTCL to transmit additional gas to the national network. The pipeline design was prepared based on international codes and practices and in compliance with Bangladesh Natural Gas Safety Rule (1991). Under the Project, the pipeline constructed will constitute loop transmission pipelines between Chittagong and Bakhrabad to central and west gas markets, and will help overcome the capacity limitation of the existing 24-inch pipeline and build up the line pack near the market area for peak shaving. It is crucial for a dependable and reliable gas transmission network and increase operational flexibility and supply reliability.

37. Under the Project, carbon steel pipes of varying sizes in diameter will be used for high pressure operation. The pipeline will be buried at a depth ranging from 1.9 to 2.7 meters depending on ground condition except for river crossings. River crossings will be done by horizontal directional drilling method at a depth of at least 10 to 15 meters below the deepest point of river bed without disturbing water flow stream or river shores. The longest segment of horizontal directional drilling under the Project is estimated to be around 350 meters, much shorter than the previous drilling segments implemented by GTCL under a prior ADB financing.[11] In addition to the pipeline, the Project also includes the installation of other elements, such as gas intake station, pig launching station, town border station, block valve station, and field devices supporting the remote operation of the gas network.

B. Economic and Financial

1) Economic Analysis

38. **Cost-and-benefit analysis and key assumptions**. A cost and benefit analysis was carried out for a period of 10 years for Component 1, and 20 years for Component 2, exclusive of a 3-year construction period in both cases. A social discount rate of 12.0% is used. All costs

[11] ADB, 2005. Report and Recommendation of the President to the Board of Directors on the Proposed Loans to the People's Republic of Bangladesh for the Gas Transmission and Development Project (No.: BAN 35242).

and benefits are estimated in constant 2016 prices with an average exchange rate of Tk79.00/US$. Economic prices of capital works and annual operation and maintenance are derived from the financial cost estimates with adjustments to allow for transfer payments and corrections for any market distortions – a shadow exchange rate factor (SERF) of 1.03 is applied to goods; a shadow wage rate of 0.75 to unskilled workers and no price distortion to wage of skill works. Investment costs include physical contingencies but exclude taxes, price contingencies, and financial charges during construction.

39. **Project economic benefits**. The primary economic benefit of the Project is savings from imported fuels and indigenous energy sources that gas supply enabled by the Project would displace. The Project will also result in reduction in greenhouse gas (GHG) emissions. The analysis is conducted from both the national and global perspectives. The national gain is the benefits of not having to use more expensive alternative fuels, while the global gain is the value of the avoided GHG emissions. Bangladesh will benefit from a proportion of these global benefits. A based case scenario assumes a long-run real price of US$50/barrel for crude oil and US$8/mmbtu for natural gas.

40. **Outcomes of the economic analysis**. In the base case, the Project has an economic internal rate of return (EIRR) of 19% from the national perspective and 25% with global environmental benefit. At the component level, Component 1 with global environment benefits yield a combined EIRR of 35%[12]; Component 2, without global environmental benefit, yield a net EIRR of 20%. Therefore, both components are economically viable (Table 4).

41. **Sensitivity analysis.** Given the high volatility in the global energy market, a sensitivity analysis is carried out to assess the impact of crude oil price changes on the prices of both natural gas and liquid fuel alternatives. As the impact of a rise in the crude price is greater on the latter, the economic returns to the Project rise with the assumed crude oil price. The analysis assesses a lower-price scenario of US$30/barrel and a higher-price scenario of US$70/barrel.

Table 4: Outcomes of the Economic Analysis – Base Case Scenario

Subproject	EIRR (%) Base Case	ENPV at 12% (US$ million)
1. Component 1		
Excluding global environmental benefit	18%	25
Including global environmental benefit	35%	125
2. Component 2	20%	180
3. Overall project		
Excluding global environmental benefit	19%	205
Including global environmental benefit	25%	305

42. A sensitivity analysis was carried out for both components using the afore-mentioned price scenarios along with (i) 20% overrun in capital; and (ii) 20% fall in demand. The results suggest that (i) both components have ample margin to withstand cost overrun and demand compression before the economic viability will be at risk; and (ii) with crude oil price fluctuations, a low crude price of US$30/barrel will bring the EIRR of Component 1 down from 35% to 26%, still well exceeding the hurdle rate of 12% whereas the EIRR of Component 2 will fall slightly below the hurdle rate. Although the oil market remains relatively volatile, from the

[12] It is important to note that the analysis assumes carbon price of US$35 per ton of CO_2 during appraisal while the current market trading price of carbon is US$10 per ton. These are two different concepts, one being the estimated cost to the global economy in the years under discussion; the other being the current spot market price for carbon trading, a value influenced by a multitude of factors, including policies, market dynamics, etc.

mid-2016 perspective a long-run crude value of as low as US$30/barrel in 2016 prices appears unlikely.

43. The economic analysis has worked with three alternative price scenarios for crude oil and energy prices, allowing a feedback between these, rather than with single point prices. If the crude price rises above US$50/barrel on a long-run basis, both components are unambiguously viable.

2) Financial Analysis

44. **Methodology and key assumptions.** The financial analysis is carried out for a period of 30 years with residual value.[13] All financial benefits and costs are expressed in constant prices. Financial benefits are derived from additional revenues generated by increased capacities. The financial internal rate of return (FIRR) is compared with the weighted average cost of capital (WACC) to ascertain financial viability. Cost streams used to determine the FIRR include capital costs, taxes and duties, and operation and maintenance costs.

45. The WACC is calculated in real terms, considering the cost of foreign currency (US$) denominated loans from international financial institutions (IFIs) such as the Bank, ADB, and ADF, and domestic currency borrowing from GoB. The rates of the foreign loans are linked to the London interbank offered rate (LIBOR) and will be repaid in 25 years, including a 5-year grace period. Domestic loans from GoB has an interest rate of 4% per annum according to state regulation. Cost of equity is at 11.75% per annum. Corporate tax rate stands at 35%. Inflation is assumed at 1.5% per annum in OECD countries and 5.9% per annum domestically. Based on the assumptions, the Project's overall WACC is estimated at 1.22% in real terms. For details, please refer to Annex 3.

46. **Project financial benefits**. For Component 1, the revenues from incremental gas and condensate sales are computed based on the incremental gas and condensate production estimated by the IA; For Component 2, transmission charges are based on the tariff determined by BERC and ADB's estimates. The gas wheeling charge is assumed at 0.2955 Tk/m^3, about 11% higher than the transmission tariff of 0.2654 Tk/m^3 announced recently by BERC. It is expected that BERC will periodically adjust the transmission tariff on a cost-plus basis to reflect domestic inflation rate and possible cost increase.

47. **Outcomes of the financial analysis**. The Project's overall investment yields a financial internal rate of return (FIRR) at 2.93% exceeding the Project's WACC of 1.22%. Thus, the Project is financially viable. At the component level, Component 1 yields a FIRR of 6.97% against a component WACC of 0.65%; and Component 2, a FIRR of 2.07% against a component WACC of 1.46%. All calculations are in real terms. Therefore, each project component is also financially viable.

Table 5: Outcomes of the Financial Analysis – Base Case

	FIRR (real)	WACC (real)	FNPV
Component 1	6.97%	0.65%	4,936
Component 2	2.07%	1.46%	2,234
Total	**2.93%**	**1.22%**	

[13] The BGFCL component's operating life is assumed at 12 years, considering the depletion of gas reserves.

48. Sensitivity analysis has been carried out to examine the sensitivity of the FIRR to changes in the key variables.

- Both components can withstand 10% capital cost overrun while maintaining financial viability. Component 1 still have ample room to absorb more uncertainties, while Component 2's margin is running thin approaching breakeven.

- With the relatively slim margin, the financial viability of Component 2 is highly sensitive to changes in tariff assumptions. Thus, the uncertainties relating to the starting level and the frequency of adjustment deserve some special attention. To break even, the starting tariff should be about 0.2675 Tk/m^3 while escalating every 4 years. In the base case where the starting tariff stands at 0.2955 Tk/m^3 while escalating every 4 years, the FIRR is 2.07%. If the frequency of tariff adjustment increases from every 4 years to every year, the FIRR will be 2.52%.

49. **Project-specific risks**. Project-specific risks typically include (i) a price increase of civil works and equipment, (ii) delays in implementation, and (iii) a lack of or delay in access to necessary counterpart funds. These risks are moderate since (i) cost estimates were based on recent tenders received, and advance procurement will lessen the time between loan effectiveness and disbursement; (ii) BGFCL and GTCL have previous experience implementing IFI-funded projects; and (iii) the government has committed to the timely release of counterpart funding, with the Project's budget already included in its annual development plan.

50. **External risks**. GTCL faces a tariff adjustment risk. Although GTCL is currently profitable, its long-term sustainability may be in jeopardy without adequate tariff increases. BGFCL, on the other hand, is exposed to the risk of reduced production. Over the medium term, production is expected to fall, which will constrain BGFCL's financial performance (please refer to Annex 3 for details). Risk of insufficient gas demand growth is low, as the country is already experiencing gas shortages.

C. Fiduciary and Governance

51. **Anticorruption**. The Project will be required to be implemented in a strict compliance with ADB's Anticorruption Policy (1998, as amended from time to time), which is consistent with the Bank's Policy on Prohibited Practices (2016). The Borrower and the IAs shall ensure that the anticorruption provisions are included in all bidding documents and contracts, including provisions specifying the right of ADB (as lead co-financier) to audit and examine the records and accounts of the IAs and all contractors, suppliers, consultants, and other service providers as they relate to the Project.

52. ADB will notify the Bank in a timely manner of information about any known credible and material allegation or indication of a sanctionable practice under its Anticorruption Policy in respect of the Project, and take the lead in any inquiry or investigations in accordance with its policies and procedures on sanctionable practices regarding whether to pursue an investigation or not.

53. **Financial Management**. Financial management assessments have been carried out for both IAs by ADB. Both IAs have previous experience in implementing externally funded projects. They have been the recipients of prior ADB financings and are conversant with ADB's project accounting procedures and requirements. The assessments indicated that financial management risks of both IAs are moderate. A financial management action plan has been

prepared recommending the IAs to further strengthen their internal audit and information systems. GoB and the IAs will ensure that proper accounts and records of use of loan proceeds are maintained and audited in a timely manner.

D. Environmental and Social

54. The Bank has decided to use ADB's Safeguard Policy Statement (SPS, 2009) since (i) it is consistent with the Bank's Articles of Agreement and materially consistent with the provisions of the Bank's Environmental and Social Policy and relevant Environmental and Social Standards; and (ii) the monitoring procedures that ADB has in place to ascertain compliance with ADB's SPS are appropriate for the Project. Under ADB's SPS, the Project has been assigned Category B for Environment, Category A for Involuntary Resettlement, and Category C for Indigenous Peoples. This categorization recognizes the need for in-depth review of environmental and social impacts and preparation of a detailed planning instrument to support involuntary resettlement and land acquisition. ADB found no Indigenous Peoples in the Project area. Under the Bank's Policy, the Project is assigned a Category A and required a similar environmental and social impact assessment and involuntary resettlement and land acquisition plan.

55. BGFCL and GTCL have prepared Initial Environmental Examinations (IEEs) of the respective components that include Titas Gas Field and the Right of Way (ROW) for the gas transmission line. The IEEs are based on the analysis of data collected through sampling, reviews of available reports, discussions with stakeholders, and field visits to the project area. They have considered the impacts associated with construction and the related and associated facilities, including occupational and safety hazards. The Environmental Management Plans (EMPs) included in the IEEs provide for the mitigation and monitoring of environmental and social impacts. The IEEs have been disclosed on ADB's website (https://www.adb.org/projects/45203-006/main#project-documents).

56. The Bangladesh Department of Environment will review and issue the required domestic environmental permits for the Project before the commencement of construction activities. If unanticipated environmental and social impacts are identified during project implementation, BGFCL and GTCL will update the IEEs and revise the EMPs accordingly. The updated IEEs and revised EMPs will need to be cleared by ADB. Environmental and social monitoring reports will be submitted to ADB and the Bank semiannually.

57. While the gas transmission pipeline route has been carefully designed to minimize involuntary resettlement and land acquisition, some resettlement and land acquisition will be required under the Project. The 36-inch gas pipeline will run for 181 km between Chittagong and Bakhrabad. The ROW for the pipeline is 8 meters (m) wide and approximately 148 hectares (ha) of private land will be permanently acquired for the pipeline and related facilities. The number of households affected by the Project is 1,382, totaling 5,693 people. Apart from the permanent land acquisition, 271 ha of land will be acquired temporarily for a 15 m ROW to be used only during construction (for equipment, vehicles, etc.). Commonly termed as "requisitioned land," these areas will be restored to their previous use once construction is completed.

58. Since mid-December 2015, several rounds of consultations have been held with stakeholders and project-affected communities. The draft Resettlement Plan has been prepared and was disclosed on ADB's website in August 2016 (https://www.adb.org/projects/45203-006/main#project-documents). Budgetary provisions are in place to compensate those affected,

including non-title holders, in a timely manner. Compensation for loss of crops and removal of trees has been included in the case of the temporarily requisitioned land. The draft Resettlement Plan will be finalized based on the final route alignment, preparation of the land acquisition plan, verification of ownership status of land and an additional census survey for those losing land based on the land acquisition plan. The implementation of the final version of the Resettlement Plan will be monitored and supervised by GTCL and an external monitoring agency, and monitoring reports will be submitted semi-annually to ADB and the Bank. As noted earlier, and based on the social assessment, no Indigenous Peoples are expected to be affected by the Project.

59. During the project appraisal, a field visit was conducted by the Bank to review the physical alignment of the transmission line with respect to the infringements with rural structures and settlements. It may be stated that both BGFCL and GTCL have well established procedures in place with due considerations to safeguard measures. With respect to the proposed Project, the local population was found to be supportive. Significantly, GTCL has taken measures to reduce the social impact of the Project and optimized infringements with local structures and habitations by realigning the transmission line. The safeguard risks associated with the Project are well under control and effectively managed by the IAs.

60. A comprehensive grievance redress mechanism (GRM) has been established and will function throughout implementation period of the Project. The objective of the GRM is to ensure a process of receiving and resolving complaint(s) promptly from persons that may be affected. Following the requirements of ADB's SPS, the GRM involves a process that is understandable, transparent, gender-responsive, culturally-appropriate, and easily accessible to affected persons without cost and retribution. Affected persons can seek redress of their grievance at three levels: (i) the PIU or the representative of the engineering, procurement and construction contractor during construction phase, (ii) the grievance redress committee (GRC), and (iii) the appropriate courts of domestic law. GRC will be responsible for resolving complaint(s) within 30 days from the date of receipt and will keep a record indicating the name of complainant and nature of complaint, status of resolving the complaint, decisions or actions undertaken, and the date when the decision is made. Records on grievances will be summarized and included in the environmental monitoring reports to be submitted by the IAs semi-annually to ADB and the Bank. The IAs will review the implementation of their respective GRMs regularly to assess their effectiveness of addressing grievances. The cost of implementing the GRMs will be a part of the project administration costs borne by the IAs.

E. Risks and Mitigation Measures

61. The Project has been assigned a high-risk rating, as it is classified as a Category A project for Involuntary Resettlement. Based on desk review and due diligence results, major project risks and risk management plan are summarized in Table 6.

Table 6: Summary of Risks and Risk Management Plan

Risk Description	Assessment	Risk Management Plan / Mitigation Measures
Governance, anticorruption, and financial management	Medium	DPs have jointly been supporting GoB in implementing governance reforms, strengthening public financial management, and developing capacity for planning, policy making, and procurement. GoB and the IAs will ensure that proper accounts and records of use of loan proceeds are maintained and audited in a timely manner.

Risk Description	Assessment	Risk Management Plan / Mitigation Measures
Weak capacity of procurement staff	Medium	ADB will provide a well-structured procurement training for IAs' staff to enhance their capabilities.
Project implementation may be affected by the need for approval of the IEEs and issue of environmental permits.	Medium	The IAs will work closely with the Department of Environment to obtain approval of the IEEs and issue of the environmental permits.
Project implementation may be affected by a lengthy process of land acquisition and requisition.	High	GTCL identified land acquisition requirements and submitted a land acquisition proposal for government approval. Adequate budget provisions for land acquisition and resettlement compensation have been made.
Import of LNG or pipeline gas supply does not materialize, affecting full use of the proposed transmission pipeline in the short term.	Medium	Petrobangla has signed the FSRU terminal use agreement with the concerned private investor. Negotiations on LNG supply agreement are ongoing and discussions on pipeline gas supply are underway.
Non-cost reflective gas price and tariffs impact the Project's financial viability and IA's sustainability.	Medium	GoB is revising the gas pricing framework that will enable market-oriented pricing considering LNG and cross border import. A disbursement condition requiring submission of the revised gas pricing framework will be included in the loan agreement.

ADB = Asian Development Bank, DP = development partner, FSRU = floating storage and regasification unit, GTCL = Gas Transmission Company Ltd., IA = implementation agency, LNG = liquefied natural gas.

ANNEX 1: RESULTS FRAMEWORK AND MONITORING

Project Objective Indicator	Unit	Baseline 2016	Target Values					Data Collection and Reporting		
			2017	2018	2019	2020	2021	Frequency	Data Collection Instruments	Responsibility for Data Collection
Average annual wellhead pressure drop reduced to 50-60 PSIG	PSIG	90	90	80	70	60	50-60	Annually	Annual reports	BGFCL
Gas production sustained at 230 MMCFD[14]	MMCFD	230	230	230	230	230	230	Annually	Annual reports	BGFCL
Natural gas transmission and delivery capacity expanded	MMCFD	2,700	2,700	2,700	2,700	2,700	3,500	Annually	Annual reports	GTCL
Project Output Indicators										
Number of wellhead gas compressors	Number	0	0	0	2	4	7	Semi-annually	Project implementation report	BGFCL
Wellhead gas delivery pressure maintained at 1,250 PSIG	PSIG	1,250	1,250	1,250	1,250	1,250	1,250	Semi-annually	Project implementation report	BGFCL
Length of 36-inch gas transmission pipeline	kilometers	0	0	50	120	161	181	Semi-annually	Project implementation report	GTCL
36-inch gas transmission pipeline built and capacity realized	MMCFD	0	0	0	0	0	800	Semi-annually	Project implementation report	GTCL

BGFCL = Bangladesh Gas Fields Company Limited, GTCL = Gas Transmission Company Limited, MMCFD = million cubic feet per day, PSIG = pounds per square inch gauge

[14] Daily production of 525 MMCFD from Titas Gas Field would reduce to 230–235 MMCFD once the wellhead pressure declines below 1,200 psig, resulting in suspension of production from the wells. Upon completion of the project facilities, the production from the wells would be sustained during the project's operating life.

ANNEX 2: DETAILED PROJECT DESCRIPTION

1. Bangladesh economy is heavily dependent on natural gas, which accounts for around 75% of the commercial energy consumption in Bangladesh. Currently, the gas production in Bangladesh is 2,700 million cubic feet per day (MMCFD) against gas demand of 3,150 MMCFD, indicating a daily shortage of 450 MMCFD. It was estimated that in 2015 around 800-1,000 megawatt generation capacity was not operational due to shortage of gas supply. The gas supply deficit is expected to further exacerbate in the wake of declining gas reserves and fast-rising gas demand that will eventually imperil Bangladesh's energy security and constrain the country's economic growth.

2. The proposed Project will address two critical issues in the energy sector in Bangladesh: (i) increase gas production through improving production efficiency in existing gas fields, and (ii) help overcome the capacity limitation of the existing gas transmission pipeline and increase operational flexibility and supply reliability of the national gas transmission network. Correspondingly, the proposed Project comprises of two components: (i) installation of seven wellhead compressors (5 operating and 2 stand-by) in Titas Gas Field to maintain wellhead gas pressure and production at the current level; and (ii) construction of a 181 km, 36-inch gas transmission pipeline to transmit additional gas to the national network. Bangladesh Gas Fields Company Limited (BGFCL) will be the implementing agency (IA) of component 1, and Gas Transmission Company Limited (GTCL) will be the IA of component 2. Both IAs have in-house capacity for planning, design, operation, and maintenance of gas production and transmission systems. The location of the project components is shown in Figure A2.1.

A. Component 1: Wellhead Compressor

3. Titas Gas Field is located in Brahmanbaria district, about 100 kilometers (km) north-east of Dhaka City. It started gas production from 1968. Its recoverable gas reserve is estimated at 7,582 billion cubic feet, and daily gas production is 520 million cubic feet per day (MMCFD). As of December 2015, the total production of Titas Gas Field was 4,083 billion cubic feet. Initial wellhead pressure of the Titas field was 2,800-3,200 pounds per square inch (psig). Wellhead pressure of the producing wells of Titas Gas Field has decreased gradually at an average rate of 90 psig per year due to extraction of gas over a long time. Gas flow from the wells under the Project cannot be continued after 2 - 3 years at the sales line at gas pressure of 980 ± 20 psig. As such, it is necessary to install wellhead gas compressors before the gas process plants for maintaining the design pressure from the raw gas and also for continuation of gas flow from the field.

4. **Scope.** Under the Project, seven wellhead gas compressors having a capacity of 60 MMCFD each will be installed in the gas field together with associated equipment and facilities to increase wellhead pressure of producing wells and sustain the current production of natural gas. Out of the 7 wellhead gas compressors, 5 will be installed for operation and 2 will be stand-by. The compressors will have a suction pressure of 600 – 650 psig and a delivery pressure of 1,200 – 1,500 psig. There will be provision for installing second stage compressors to ensure gas production at reduced suction pressure of 200 psig to 300 psig. The scope will also include operating and standby generators, auxiliary equipment, control room and related civil works.

Figure A2.1: Location of the Project Components

5. The compressors and ancillary facilities will be installed at BGFCL's own premises, which is a restricted area and prohibited from public entry, and no land acquisition will be needed. About 6,000 square meter open developed land is available for the Project.

6. **Description of Gas Compressor**. A gas compressor, like a pump, is a mechanical device that increases the pressure of gas by reducing its volume. The type of compressor that will be used is reciprocating. Under the Project, consultants will be engaged to prepare technical specification and basic engineering design for gas compressors and associated facilities; and conduct reservoir study, environmental study, and preparation of tender documents. Detailed engineering design of the compressors and associated facilities will be prepared by the winning project contractor, and submitted to BGFCL and consultant for approval. The consultants will also supervise the contractor's work during the project implementation.

7. Reciprocating compressors, like the rotary sliding vane and helical lobe screw machines, are positive displacement compressors. This means that gas is compressed by trapping a charge of gas and then reducing the confining space, causing a build-up in pressure. The reciprocating compressors, more commonly called "piston compressors," compress gas by use of a piston, cylinder, and valve arrangement.

8. Rotary motion provided at the compressor shaft is converted to reciprocating (linear) motion by use of a crankshaft, crosshead, and a connecting rod between the two. One end of the connecting rod is secured by the crankpin to the crankshaft, and the other by crosshead pin to the cross head which, as the crankshaft turns, reciprocates in a linear motion. Intake (suction) and discharge valves are in the top and bottom of the cylinder. Sometimes they may be in the cylinder barrel. These are basically check valves, permitting gas to flow in one direction only.

9. The movement of the piston to the top of the cylinder creates a partial vacuum in the lower end of the cylinder; the pressure differential between intake pressure and this vacuum across the intake valve then causes the valves to open, allowing gas to flow into the cylinder from the intake line. On the return stroke, when the pressure in the cylinder exceeds the pressure in the discharge line, the discharge valve opens, permitting gas at that pressure to be discharged from the cylinder into the discharge or system line. This action, when on one side of the piston only, is called "single-acting" compression; when on both sides of the piston, it is called "double-acting" compression.

10. In common with all positive displacement compressors, the reciprocating compressor is classified as a "constant-volume variable pressure" machine. For most applications, they are the most efficient built today. They can be fitted with capacity control devices to closely maintain their efficiency at partial loads (reduced capacity output). They can be built to handle almost any commercial gas, provided corrosion problems in some extreme cases can be solved. Gas cylinders are generally lubricated. Because of the reciprocating pistons and other parts, as well as some unbalanced rotating parts, inertia forces are set up that tend to shake the unit. It is necessary to provide a mounting that will stabilize the installation.

11. Reciprocating compressors are the most widely used of all compression equipment and provide the widest range of sizes and types. Ratings vary from fractions to more than 20,000 horsepower per unit. Pressures range from low vacuum (at intake) to special process compressors for 65,000 psig or higher.

B. Component 2: Gas Transmission Pipeline

12. The Chittagong area, the country's major industrial growth center, has been suffering from shortage of gas supply due to full capacity attainment of the Bakhrabad-Chittagong pipeline. As the existing Bakhrabad-Chittagong pipeline has reached saturation, and due to the need to accommodate the planned diversified sources from imports and offshore discoveries into the national gas network, it would become necessary to construct a gas transmission pipeline traversing Chittagong through Feni to Bakhrabad. The proposed pipeline under the Project will constitute loop transmission pipelines between Chittagong and Bakhrabad to central and west gas markets, and will help overcome the capacity limitation of the existing 24-inch pipeline and build up the line pack near the market area for peak shaving. It is crucial for a dependable and reliable gas transmission network.

13. **Scope.** Component 2 includes the construction of a 181 km, 36-inch gas transmission pipeline from Salimpur (Chittagong) to Bakhrabad with associated valve stations, pig launchers and receivers, town border stations including the provision for installing compressors at Fauzdarhat and Feni. Carbon steel pipes of varying sizes from 5.08 centimeters (cm) to 106.68 cm in diameter will be used for high pressure operation. The pipeline will be buried at a depth of 1.9 meter to 2.7 meter depending on ground condition except for river crossings. River crossings will be done by horizontal directional drilling method at a depth of at least 10 meter to 15 meter below the deepest point of river bed without disturbing water flow stream or river shores.

14. Gas pipeline networks are composed of several components of equipment that operate together to move gas from location to location. The proposed Project includes the following main elements.

15. **Salimpur (Chittagong) gas intake point and pig launching station**: LNG will be received at the floating storage and re-gasification unit (FSRU) that is expected to become operational in 2018. After receiving LNG, it will be re-gasified for onward transmission to Selimpur Valve Station (i.e. the injection point for the Project). At Fauzdarhat (Chillimpur), pig launching facilities will be installed for cleaning and commissioning of the pipeline and subsequent periodic on-stream pigging for cleaning as well as integrity testing of the pipeline. In general, re-gasified LNG has very little or no condensate compared to other sources.

16. **Compressor stations**: Capacity of a gas pipeline depends on diameter, length and differential pressure of the flowing gas. For a long pipeline, compressors are installed at an interval of 60 miles–70 miles for transmitting required quantity of gas at a desired pressure at delivery point. Under the Project, no compressor stations will be constructed along the pipeline at the onset of the Project. However, provision has been kept to install future compressor stations at Salimpur and between Chandpur and Feni.

17. **Town border station (TBS)**: Partial Delivery Station – Town border stations (TBS) will be constructed at Barabkunda and Bizra to meet the gas demand of these areas. TBSs are small-scale pressure reducing and gas metering stations with associated facilities including gas-heating provision.

18. **Block valve station**. These are the first line of protection for pipelines. With these valves, the operator can isolate any segment of the line to perform some specific maintenance

work or isolate a rupture or leak. Block valve stations are usually located every 30–50 km, depending on the site condition. Overall the location of these stations depends exclusively on the nature of the product being transported, the trajectory of the pipeline and/or the operational conditions of the line. Nine block valve stations will be installed on the Chittagong-Bakhrabad gas transmission pipeline.

19. **Pipeline operation**. When a pipeline is built, it will also include the installation of the field devices supporting the remote operation of these networks. Field devices are basically instrumentation, such as data gathering units and communication systems. The field instrumentation includes flow, pressure and temperature gauges and transmitters, as well as other devices to measure the relevant data required to operate. These field instruments are installed along the pipeline on some specific locations, such as injection or delivery stations, compressor stations and block valve stations.

20. The information measured by these field instruments are then gathered in local remote terminal units (RTU) that transfer the field data to a main control room in real time using communication systems, such as satellite channels, micro wave links or cellular phone connections. The supervisory control and data acquisition (SCADA) system at the main control room then receives all the field data and presents them to the pipeline operator through a set of screens or SCADA interface, showing the main operational conditions of the pipeline. The operator can monitor the conditions of the line, as well as remotely manipulate compressors, valves, deliveries, etc. sending operational commands (open/close valves, turn on/off compressors, change set points, etc.) through the SCADA system or through other means to the field.

C. Associated Facilities

21. The imported LNG will land at Maheshkhali, and after re-gasification will be transmitted through pipeline to Anwara. At Anwara, a city gate station (CGS) will be built to supply gas to the Chittagong 300-psig-ring main to cater to the demand of Chittagong region. A new 42-inch, 30-km pipeline is planned to be constructed from Anwara to Faujdarhat to transport balance gas into the national network after meeting the demand in Chittagong.

22. The construction of both the Maheshkhali-Anwara and the Anwara-Faujdarhat pipelines is expected to be completed in 2017 and the FSRU is expected to be completed in 2018. The LNG terminal, together with the Maheshkhali-Anwara and the Anwara-Faujdarhat transmission pipelines, are considered as associated facilities to the Chittagong-Bakhrabad transmission pipeline under the Project. Figure A2.2 illustrates the arrangements for gas supply of the proposed Project.

23. A custody transfer metering station (CTMS) is being installed at Maheshkhali for supplying LNG to the Maheshkhali-Anwara pipeline. The CTMS will also cater to future LNG supply at Maheshkhali from other sources. A CGS will be installed at Anwara and a regulating and metering station (RMS) will be installed at Salimpur where the gas will be fed into the Chittagong-Bakhrabad pipeline. The existing intermediate compressor station (ICS) in operation at Feni will facilitate transmission of gas at the required pressure for distribution among consumers enroute to Bakhrabad. If necessary, another ICS may be installed in the future.

D. LNG Outlook in Bangladesh

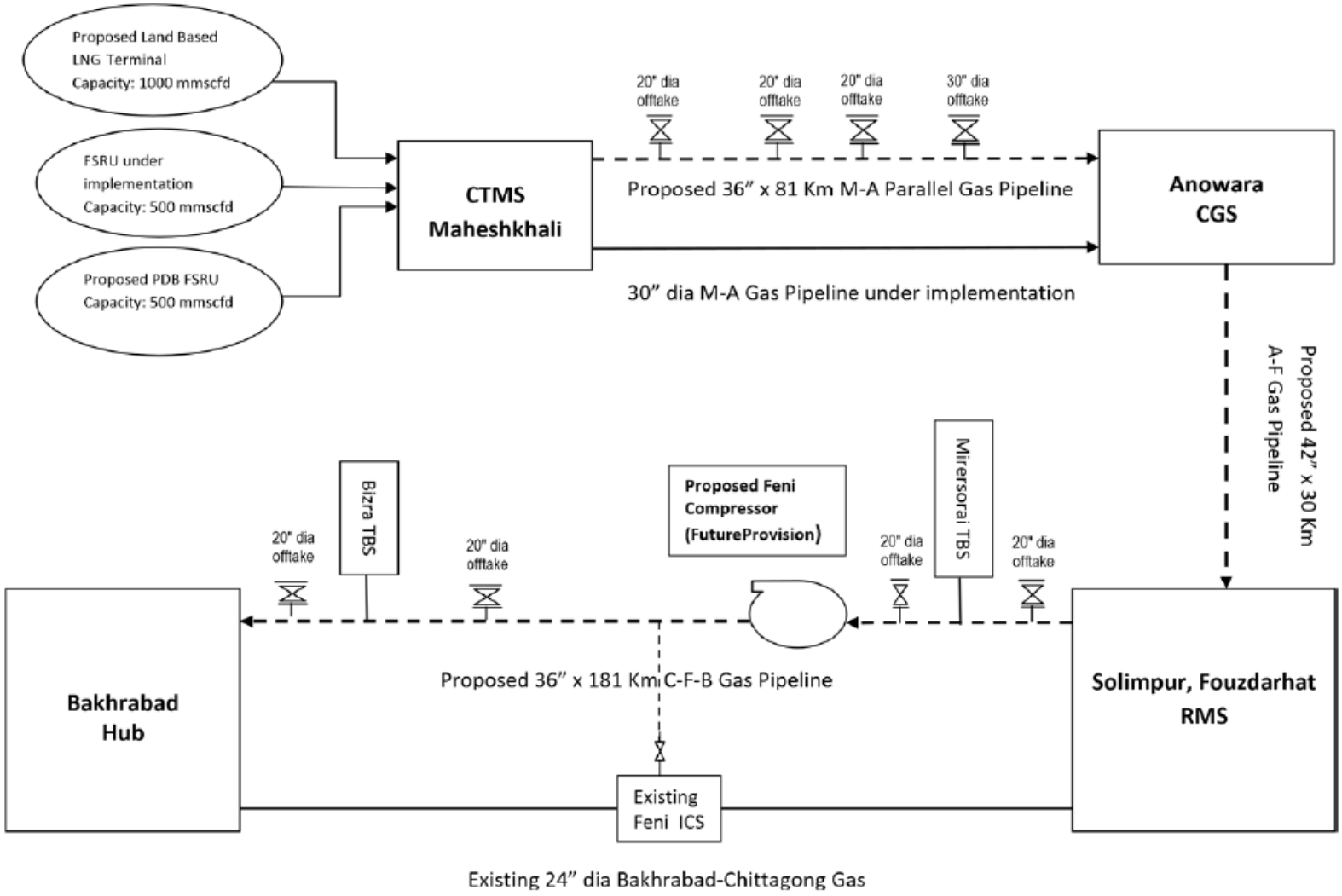
24. LNG has been identified as an integral part for energy security in Bangladesh. In 2016, Petrobangla and Excelerate Energy reached an agreement on terms for the development and operation of Bangladesh's first LNG import terminal. The agreement includes the provision of a FSRU under a 15-year long term charter, as well as the design and construction of the facility near Moheshkhali Island in the Bay of Bengal. The terminal will provide much needed natural gas to the country's major economic hub, Chittagong. The facility will include the installation of a subsea buoy system anchored offshore. The buoy system will act as both the mooring mechanism for the FSRU and as the conduit through which natural gas is delivered to shore through a subsea pipeline. The FSRU will have 138,000 cubic meters of LNG storage capacity and a base regasification capacity of 500 MMCFD.

25. The FSRU by Petrobangla made the first move, and other terminals will follow. Per Bangladesh's Power and Energy Sector Master Plan (PSMP 2016), gas demand by 2041 will be approximately 5,900 MMCFD, out of which 4,000 MMCFD will be supplied through 8 LNG terminals (Table A2.1).

Table A2.1: LNG Terminal Development Plans

No.	Fiscal Year	Type of Terminal	Capacity (MMCFD)	Remarks
1	2018	FSRU	500	Ongoing project by Petrobangla, located in Moheshkhali
2	2023	FSRU	500	To be planned
3	2027	Land-based	500	Moheshkhali and/or Payra
4	2029	Land-based	500	Moheshkhali and/or Payra
5	2036	Land-based	500	Moheshkhali and/or Payra
6	2039	Land-based	500	Moheshkhali and/or Payra
7	2040	Land-based	500	To be planned
8	2041	Land-based	500	To be planned
		Total	4,000	

Figure A2.2 Diagram of Gas Supply of the Proposed Project (source: GTCL)



ANNEX 3: ECONOMIC AND FINANCIAL ANALYSIS

1. This annex comprises three parts: (i) the economic analysis of the project investments; (ii) the financial analysis of the project investments; and (iii) the financial assessment of the implementing agencies.

2. The proposed Project comprises of two components: (i) installation of seven wellhead compressors (5 operating and 2 stand-by) in Titas Gas Field to maintain wellhead gas pressure and production at the current level; and (ii) construction of a 181 km, 36-inch gas transmission pipeline to transmit additional gas to the national network. Component 1 will be implemented by the Bangladesh Gas Fields Company Limited (BGFCL), while Component 2 will be implemented by the Gas Transmission Company Limited (GTCL).

I. Economic analysis

1) Sector overview

3. Natural gas accounts for three quarters of Bangladesh's total commercial energy consumption. Nearly a half of the country's total recoverable reserve of 27.12 trillion cubic feet (TCF) has been produced thus far. The remaining can only last about 12 more years of domestic production. In recent years, gas consumption has been curbed due to supply constraints. During the period of 2009-14, gas consumption grew at an average annual rate around 4.6%, down from an average rate of 6.4% during the period of 2001-09.

4. Production from existing gas fields will start depleting from 2021 onwards, and the gap between supply and demand will continue to widen, putting serious strains on power generation and industrial production.[15] Should the situation persist, it may eventually imperil energy security and constrain national economic growth. Other gas supply sources from imports either through an inter-country transmission pipeline or as liquefied natural gas (LNG) are planned to partially bridge the shortfall. To maintain uninterrupted gas supply, natural gas companies have been undertaking augmentations of gas production from their existing fields. Since January 2009, 706 Million cubic feet per day (MMCFD) of gas production capacity has been added through new wells, workovers, or capacity enhancements.

5. On the transmission side, the infrastructure coverage is inadequate to service the country's key market areas, as most gas supply points are in the northeast and central regions, while delivery points are in the central, south, and west. There is an urgent need to expand transmission networks.

6. The proposed Project is a crucial step toward bridging the widening supply shortfall following the rapid output decline from the domestic gas fields. The Project comprises two components:

- **Component 1 – Installation of wellhead compressors**. This component will install wellhead gas compressors with associated facilities at Titas Gas Field to increase and sustain wellhead gas delivery pressure to maintain the current gas-production level to the gas transmission pipeline system.

[15] In 2015, 800–1,000 megawatt generation capacity was not operational because of inadequate gas supplies.

- **Component 2 – Construction of Transmission pipeline**. This component will allow the transmission of gas to major consumption centers and will construct a 181-kilometer, 36-inch gas transmission pipeline traversing Chittagong through Feni to Bakhrabad.

7. The magnitude of the supply shortfall is significant. The additional supply resulting from investments under the Project is expected to only serve to offset LNG imports and the use of alternative liquid fuels, and is not expected to meet the increasing demand.

2) Methodology and key assumptions

8. **Least-cost analysis**. For Component 1, there is no practical alternative other than the one proposed to sustain supply from an existing gas field, thus the component is considered a least-cost solution. The transmission investment proposed under Component 2 is a part of the national least-cost development plan for the gas transmission and distribution network based on system design and optimization using simulation outputs.

9. Cost-and-benefit analysis. A cost and benefit analysis was carried out over a period of 10 years for Component 1, and 20 years for Component 2, exclusive of a 3-year construction period in both cases. A social discount rate of 12.0% is used. All costs and benefits are estimated in constant 2016 prices with an average exchange rate of Tk79.00/US$. Economic prices of capital works and annual operation and maintenance are derived from the financial cost estimates with adjustments to allow for transfer payments and corrections for any market distortions – a shadow exchange rate factor (SERF) of 1.03 is applied to goods; a shadow wage rate of 0.75 to unskilled workers and no price distortion to wage of skilled workers. Investment costs include physical contingencies but exclude taxes, price contingencies, and financial charges during construction.

10. Project economic benefits. The primary economic benefit of the Project is savings from imported fuels and indigenous energy sources that gas supply enabled by the Project would displace. Moreover, the Project will also result in reduction in greenhouse gas (GHG) emissions.

- ***Savings on imported fuels.*** To calculate the value of displacing imported fuels and indigenous energy sources, the analysis estimates the long-run import parity price between crude oil and natural gas based on the existing relationship between the import prices of LNG and crude oil considering margins for regasification, transportation and distribution.

- ***Savings on indigenous energy sources.*** The fuel substitution values for gas are calculated based on the economic prices for the alternative fuels converted into gas equivalent values. To quantify the fuel substitution that the subproject would create, the expected mix of alternative fuels that would be used by each consumer category were estimated.

- ***Reduced GHG emissions*.** Component 1 will also result in global environmental benefit through reductions in GHG emissions from using dirtier alternative fuels. The replacement of alternative fuels by natural gas results in the reduction of carbon dioxide

(CO_2) emission by 703,522 tons per year during 2021–2031. The avoided GHG emission is valued at US$35/ton of CO_2.

11. The analysis is conducted from both the national and global perspectives. The national gain is the benefit of not having to use more expensive alternative fuels, while the global gain is the value of the avoided GHG emissions. Bangladesh will benefit from a proportion of these global benefits.

12. The base case scenario assumes a long-run real price of US$50/barrel for crude oil and US$8/mmbtu for natural gas. The base-case price for natural gas is about 30% lower than the estimated long-run cost of natural gas used in a recent gas project in Bangladesh, but closer to the recent cost, insurance, and freight import cost of LNG to Japan.

13. **Sensitivity analysis**. Given the high volatility in the global energy market, a sensitivity analysis is carried out to assess the impact of crude oil price changes on the prices of both natural gas and liquid fuel alternatives. As the impact of a rise in the crude price is greater on the latter, the economic returns to the Project rise with the assumed crude oil price. The analysis assesses a lower-price scenario of US$30/barrel and a higher-price scenario of US$70/barrel.

14. **Outcomes of the economic analysis**. In the base case, the Project has an economic internal rate of return (EIRR) of 19% from the national perspective and 25% with global environmental benefit. At the component level, Component 1 with global environment benefits yield a combined EIRR of 35%[16]; and Component 2, without global environmental benefit, yield a net EIRR of 20%. Therefore, both components are economically viable.

Table A3.1: Outcomes of the Economic Analysis – Base-case Scenario

Subproject	EIRR (%) Base Case	ENPV at 12% (US$ million)
1. Component 1		
Excluding global environmental benefit	18%	25
Including global environmental benefit	35 %	125
2. Component 2	20 %	180
3. Overall project		
Excluding global environmental benefit	19%	205
Including global environmental benefit	25%	305

15. **Sensitivity Analysis**. A sensitivity analysis was carried out for both components using the afore-mentioned price scenarios along with (i) 20% overrun in capital; and (ii) 20% fall in demand. The results suggest that (i) both components have ample margin to withstand cost overrun and demand compression before the economic viability will be at risk; (ii) with crude oil price fluctuations, a low crude price of US$30/barrel will bring the EIRR of Component 1 down from 35% to 26%, still well exceeding the hurdle rate of 12% whereas the EIRR of Component 2 will fall slightly below the hurdle rate. Although the oil market remains relatively volatile, from the mid-2016 perspective a long-run crude value of as low as US$30/barrel in 2016 prices appears unlikely. The results are shown in Table A3.2.

[16] It is important to note that the analysis assumes carbon price of US$35 per ton of CO2 during appraisal while the current market trading price of carbon is US$10 per ton. These are two different concepts, one being the estimated cost to the global economy in the years under discussion; the other being the current spot market price for carbon trading, a value influenced by a multitude of factors, including policies, market dynamics, etc.

Table A3.2: EIRR Sensitivity to Capital Cost, Demand and Crude Oil Price

	Component 1		Component 2
	Excluding GHG	Including GHG	
Base case	18%	35%	20%
Capital cost +20%	14%	30%	18%
Demand -20%	13%	28%	7%
Crude oil price @ $70/barrel	24%	39%	24%
Crude oil price @ $30/barrel	4%	22%	11%

3) Conclusion

16. The analysis has worked with three alternative price scenarios for crude oil and energy prices, allowing a feedback between these, rather than with single point prices. If the crude price rises above US$50/barrel on a long-run basis, both components are unambiguously viable.

II. Financial analysis

1) Methodology and key assumptions

17. The financial analysis is carried out over 30 years with residual value.[17] All financial benefits and costs are expressed in constant prices. Financial benefits are derived from additional revenues generated by increased capacities. The financial internal rate of return (FIRR) is compared with the weighted average cost of capital (WACC) to ascertain financial viability. Cost streams used to determine the FIRR include capital costs, taxes and duties, and operation and maintenance costs.

18. **WACC** is calculated in real terms, considering the cost of foreign currency (US dollar) denominated loans from international financial institutions (IFIs) such as the Bank, ADB and ADF, and domestic currency borrowing from the government of Bangladesh. The rates of the foreign loans are linked to the London interbank offered rate (LIBOR) and will be repaid in 25 years, including a 5-year grace period. Domestic loans from the government has an interest rate of 4% per annum per state regulation. Cost of equity is at 11.75% per annum. Corporate tax rate stands at 35%. Inflation is assumed at 1.5% per annum in OECD countries and 5.9% per annum domestically. Based on the assumptions, the Project's overall WACC is estimated at 1.22% in real terms (Table A3.3).

Table A3.3 (a): Weighted Average Cost of Capital (Overall Project)

	Financing mix			WACC	
	IFIs (2.47%)	GoB loans (4.00%)	Equity (11.75%)	Nominal	Real
Component 1 (Tk million)	8,429	1,100	1,101	2.76%	0.65%
Component 2 (Tk million)	10,472	8,285	6,505	5.52%	1.46%
Total (Tk million)	**18,901**	**9,384**	**7,606**	**4.01%**	**1.22%**

[17] The BGFCL component's operating life is assumed at 12 years, considering the depletion of gas reserves.

Table A3.3 (b): Weighted Average Cost of Capital (By components)

	Component 1			Component 2		
	Foreign Loans	Government Loan	Equity	Foreign Loans	Government Loan	Equity
Amount (TK million)	8,429	1,100	1,100	10,472	8,285	6,505
Weight	79%	10%	10%	41%	33%	26%
Nominal cost	2.47%	4.00%	11.75%	2.47%	4.00%	11.75%
Tax rate	35%	35%	-	35%	35%	-
Tax-adjusted cost	1.60%	2.60%	11.75%	1.60%	2.60%	11.75%
Weighted cost nominal	1.27%	0.27%	1.22%	0.66%	0.85%	3.02%
Nominal WACC	**2.76%**			**5.52%**		
Inflation	1.50%	5.90%	5.90%	1.50%	5.90%	5.90%
Real cost	0.10%	-3.12%	5.52%	0.10%	-3.12%	5.52%
Minimum rate (>=0)	0.10%	0.00%	5.52%	0.10%	0.00%	5.52%
Weight cost real	0.08%	0.00%	0.57%	0.04%	0.00%	1.42%
Real WACC	**0.65%**			**1.46%**		

19. **Project financial benefits**. For Component 1, the revenues from incremental gas and condensate sales are computed based on the incremental gas and condensate production estimated by the Bangladesh Gas Fields Company Limited (BGFCL). For Component 2, transmission charges are based on the tariff determined by the Bangladesh Energy Regulatory Commission (BERC) and ADB's estimates. The gas wheeling charge is assumed at 0.2955 Tk/m^3, about 11% higher than the transmission tariff of 0.2654 Tk/m^3 which was recently announced by BERC. It is expected that BERC will periodically adjust the transmission tariff on a cost-plus basis to reflect domestic inflation rate and possible cost increase.

20. **Outcomes of the financial analysis**. The Project's overall investment yields a financial internal rate of return (FIRR) at 2.93%, exceeding the Project's WACC of 1.22%. Thus, the Project is financially viable. At the component level, Component 1 yields a FIRR of 6.97% against a component WACC of 0.65%; and Component 2, a FIRR of 2.07% against a component WACC of 1.46%. All calculations are in real terms. Therefore, each project component is also financially viable.

Table A3.4: Outcomes of the financial analysis – Base case

	FIRR (real)	WACC (real)	FNPV
Component 1	6.97%	0.65%	4,936
Component 2	2.07%	1.46%	2,234
Total	**2.93%**	**1.22%**	

21. **Sensitivity Analysis.** Sensitivity analysis has been carried out to examine the sensitivity of the FIRR to changes in the key variables.

- Both components can withstand 10% capital cost overrun while maintaining financial viability. Component 1 still have ample room to absorb more uncertainties, and component 2's margin is running thin approaching breakeven.

Table A3.5: FIRR sensitivity to Capital and Operating Expenses

	Component 1	Component 2
Base case	6.97%	2.07%
Capital expenses +10%	5.56%	1.50%
Capital expenses - 10%	8.60%	2.72%
Operating expenses +10%	6.97%	1.82%
Operating expenses -10%	6.98%	2.32%

- With the relatively slim margin, the financial viability of Component 2 is highly sensitive to changes in tariff assumptions. Thus, the uncertainties relating to the starting level and the frequency of adjustment deserve some special attention. To break even, the starting tariff should be around 0.2675 Tk/m^3 while escalating every 4 years. In the base case where the starting tariff stands at 0.2955 Tk/m^3 while escalating every 4 years, the FIRR is 2.07%. If the frequency of tariff adjustment increases from every 4 years to every year, the FIRR will be 2.52%.

Table A3.6: Component 2 FIRR Sensitivity to Tariff Variations

	Component 2 FIRR
Base case – tariff starting at 0.2955 escalating every 4 years	2.07%
Worst case – tariff starting at 0.1565 staying constant	-12.21%
Breakeven – tariff starting at 0.2675 escalating every 4 years	1.35%
Optimistic case – tariff starting at 0.2955 escalating every year	2.52%

22. **Project-specific risks**. Project-specific risks typically include (i) an increase in the price of civil works and equipment, (ii) delays in implementation, and (iii) a lack of or delay in access to necessary counterpart funds. These risks are moderate since (i) cost estimates were based on recent tenders received, and advance procurement will lessen the time between loan effectiveness and disbursement; (ii) BGFCL and GTCL have previous experience implementing IFI-funded projects; and (iii) the government has committed to the timely release of counterpart funding, with the project budget already included in its annual development plan.

23. **External risks**. GTCL has a tariff adjustment risk. Although GTCL is currently profitable, its long-term sustainability may be in jeopardy without adequate tariff increases. If the transmission tariff could be adjusted periodically on a cost-plus basis to reflect domestic inflation and possible cost increase, GTCL would generate sufficient cash for debt servicing and funding the projected capital expenditure. BGFCL, on the other hand, is exposed to the risk of reduced production. Over the medium term, production is expected to fall, which will constrain BGFCL's financial performance (see next section for detail). Risk of insufficient demand growth is low, as the country is already experiencing gas shortages.

III. Financial performance of the implementing agencies

1) Bangladesh Gas Fields Company Limited

24. **Historical financial performance**. BGFCL is the country's largest state-owned natural gas production company contributing about 35% of the country's total gas production in 2014.

BGFCL owns six gas fields, five of which have been maintaining continuous production with a combined throughput of 826 million m3 per day. In FY 2013-14, BGFCL produced 288 billion cubic feet of gas and 178,788 barrels of condensate as by-product from 38 wells in those five fields. The company's six fields have a combined recoverable gas reserve of approximately 12.3 trillion cubic feet, of which 6.8 trillion cubic feet or about 55.8% had been recovered by June 2014.

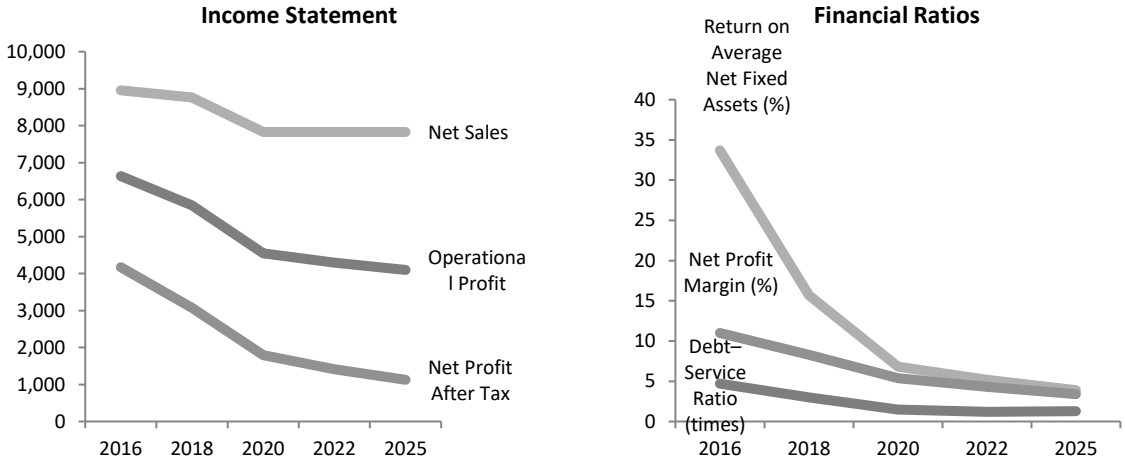
25. During the period of 2010-15, BGFCL experience healthy growth with gross sales growing at an average annual rate around 10.0%. Except for 2012 when the company suffered a loss due to a large outgo of tax payments, BGFCL had had stable albeit modest operation margins around 6.3% and return on capital around 8.9%. In FY 2014-15, the company's net income increased by 33.8%. The company has had healthy asset utilization and internal cash generation evidenced by relatively high return on net fixed assets around 15% and self-financing ratio around 30%. On the balance sheet, BGFCL is lean on debt with a debt-to-asset ratio under 15% during the period of 2010–2015, well under the advised threshold of 30% for production companies. The company also showed a strong position in equity and reserves.

26. **Projected financial performance.** With productions from its gas fields falling, BGFCL's revenues are expected to decline after reaching their peak in 2017. Net income is expected to experience a steep fall with rising costs of operations. Going forward, with these adverse factors at play, BGFCL will see thinning margin, lower returns on assets and on capital, and may indeed experience losses. To combat the declining trend, the company will need to substantially expand its asset base over the coming years. To finance these investments, the company will also see rising debt-to-asset ratio to the upper 20% from current levels around 15%. Along with the declining income, the company's cash flows from operations will also decline although remain sufficient to meet debt-servicing requirements.

Table A3.7: Bangladesh Gas Fields Company Limited, Projected Financial Performance

Year Ending 30 June	**2016 E**	**2018 E**	**2020 E**	**2022 E**	**2025 E**
Gas Sales (MMCM)	12,661	12,629	11,398	11,398	11,398
Gas Wellhead Margin	2.80	2.80	2.80	2.80	2.80
Income Statement	Tk m	Tk m	Tk m	Tk m	Tk m
Gross Sales	38,038	37,225	33,256	33,256	33,256
Net Sales	8,955	8,763	7,829	7,829	7,829
Operational Profit	6,635	5,849	4,545	4,299	4,098
Net Profit Before Tax	5,959	4,392	2,559	2,024	1,610
Net Profit After Tax	4,171	3,074	1,791	1,417	1,127
Financial Ratios					
Return on Average Net Fixed Assets (%)	33.7	15.7	6.8	5.2	3.9
Debt–Service Ratio (times)	4.7	3.0	1.5	1.2	1.3
Self-Financing Ratio (%), 3-yr avg	0.0	42.5	27.2	20.6	26.6
Gross Profit Margin (%)	17.4	15.7	13.7	12.9	12.3
Net Profit Margin (%)	11.0	8.3	5.4	4.3	3.4
Debt Financing (%)	13.3	17.8	21.3	18.8	16.1

Figure A3.1: Bangladesh Gas Fields Company Limited, Projected Financial Performance



2) Gas Transmission Company Limited

27. Historical financial performance. Registered as a public limited company on 14 December 1993 under the Companies Act, GTCL is the owner and operator of the country's natural gas transmission network. During the period of 2010-15, the company experienced healthy revenue growth averaging around 7% per annum while maintaining stable operating margins. In the meantime, GTCL had also seen higher growth in non-operating income along with lower interest expenses. Thus, its net income grew at a faster pace around10.3% per annum; margin grew from an already stellar 66.0% in 2010 to 76.0% in 2015. The high margin was in part due to the interest income from the investment activities.

28. During the period of 2010-15, GTCL had also undergone large investment programs doubling it net fixed assets doubled from 2010 levels. The return on net fixed assets remained high above 14% albeit falling slightly with the expansion of the asset base. With rising cash flows from operations, the company's debt service coverage ratio also increased steadily from 3.8x in 2010 to 6.2x in 2015, well above the expected threshold of 1.2x. Similarly, the company's self-financing ratio had maintained above the recommend 30%. With large capital outlays in recent years, the company's debt-to-asset ratio had risen from about 30% in 2010 to a slightly worrisome 50% in 2015. In general, GTCL had showed consistently strong financial performance during the period of 2010-15.

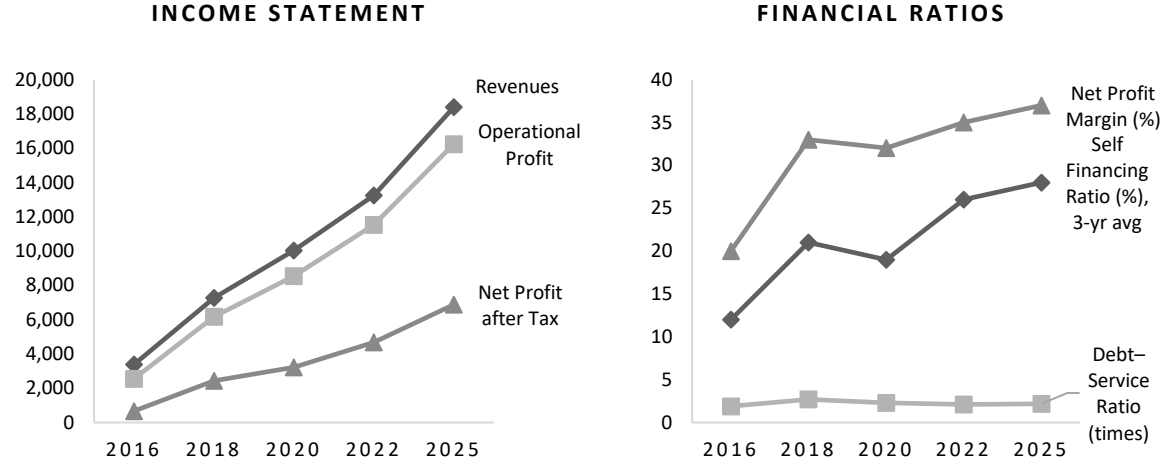
29. **Projected financial performance**. Going forward, GTCL will likely maintain a healthy and stable output growth rate of 6% per annum. One major uncertainty that foreshadows the company's financial outlook is on the transmission tariff, which will be determined by BERC, the sector regulator. In 2015 following the sharp fall in crude oil price, BERC halved transmission tariff from Tk0.32/m^3 to Tk0.15/m^3. GTCL's revenue stream would be adversely affected by this change if it would remain for a long term. The company filed a petition to revise the wheeling charge to a higher level in 2016. After several rounds of public hearings, BERC recently announced that the transmission tariff was restored to 0.2654 Tk/m^3, effective on March 1, 2017. It is assumed that BERC will revise the tariff periodically, and at least every 3 years to adjust for domestic inflation to ensure the transmission tariff remain above cost recovery. It is further expected that GTCL will continue to invest in system expansion in the coming period between 2016 and 2022. If the transmission tariff can be adjusted to keep up with domestic inflation at least every 3 years, GTCL should have sufficient cash flow from operations to meet debt service requirements. In such a scenario, funding for

the envisaged capital expenditure may not pose a problem.

Table A3.8: Gas Transmission Company Limited, Projected Financial Performance

Year Ending 30 June	2016 E	2018 E	2020 E	2022 E	2025 E
Gas Transported (MMCM)	21,086	24,300	28,004	30,874	35,740
Wheeling Charge (Tk/m3)	0.16	0.30	0.35	0.43	0.51
Income Statement	Tk m	Tk m	Tk m	Tk m	Tk m
Total Revenues	3,388	7,277	10,026	13,250	18,390
Operational Profit	2,557	6,168	8,547	11,531	16,240
Net Profit Before Tax	1,032	3,749	4,941	7,190	10,578
After Tax Profit	671	2,437	3,211	4,673	6,876
Financial Ratios					
Return on Average Net Fixed Assets (%)	0.0	3.7	4.0	5.2	6.6
Debt–Service Ratio (times)	1.9	2.7	2.3	2.1	2.2
Self-financing Ratio (%), 3-yr avg	12	21	19	26	28
Net Profit Margin (%)	20	33	32	35	37
Debt Financing (%)	52	51	51	49	46

Figure A3.2: Gas Transmission Company Limited, Projected Financial Performance



ANNEX 4: SOVEREIGN CREDIT FACT SHEET

A. Recent Economic Development

1. Bangladesh registered robust growth averaging 6.3 percent per annum during 2011-2015, and became a low-middle-income country when its per capita income reached US$1,314 in 2015. Real GDP growth remained above 6 percent in 2015 based on prudent policies under Extended Credit Facility (ECF) arrangement with the International Monetary Fund(IMF). On the back of a good rice harvest in 2014 and declining global prices, food price inflation decelerated, easing headline inflation. After two years of surpluses, the current account balance (CAB) swung into a moderate deficit in FY2015 on account of subdued exports. IMF projects real GDP growth at 6.3 percent in FY2016, supported by higher public sector wages and public investment[18].

B. Economic Indicators

Table A4.1: Selected Macroeconomic Economic indicators (2014-2018)

Economic Indicators	FY14	FY15*	FY16*	FY17*	FY18*
National income and prices (change %)					
Real GDP	6.1	6.5	6.3	6.8	7.0
CPI inflation (change %, end of year)	6.9	5.9	7.0	7.0	6.4
Central government operations (% of GDP)					
Central government balance	-3.1	-3.9	-4.4	-4.3	-4.1
External debt (% of GDP)	17.6	16.7	16.8	16.7	16.4
Public debt (% of GDP)	35.3	34.6	35.8	36.4	36.9
Money and credit					
Broad money (M2, % annual change)	16.1	12.4	13.5	14.7	--
Foreign direct investment (% of GDP)	0.8	0.9	0.9	1.0	1.0
Gross reserves (months of imports)	5.3	5.8	5.8	5.7	5.5
Current account balance (% of GDP)	0.8	-0.8	-1.3	-1.4	-1.6
Exchange rate (taka/US$, end period)	77.6	77.8			

Note: * denotes projected figures. Source: IMF Country Report No. 16/27, January 2016.

C. Economic Outlook and Risks

2. Looking ahead, Bangladesh's medium term growth is projected to accelerate to 7 percent on the back of a ramp-up in public investment, supported by the new value added tax(VAT), as well as the recovery in private investment which is itself supported by the easing of regulatory and infrastructure bottlenecks. Inflation is expected to edge up because higher public sector wages and a one-off effect from the introduction of the new VAT. On the back of investment-led growth, the current account deficit is projected to widen to about 2 percent of GDP over the medium term, with international reserves remaining adequate. Political and financial-fiscal shocks are the main risks to the outlook. On the external side, a protracted slowdown in the European Union (Bangladesh's main export destination) could hurt exports.

3. On debt outlook, Bangladesh remains at a low risk of external public debt distress. Total public debt is also on a sustainable path if the new value added tax comes into effect in full, but

[18] International Monetary Fund (IMF), 2016. Country Report No.16/27—2015 Article IV Consultation—Press Release; Staff Report; and Statement by the Executive Director for Bangladesh, January, 2016

the public debt trajectory would become unsustainable if the absence of a permanent boost to revenues.[19]

[19] International Monetary Fund (IMF), 2016. Staff Report for 2015 Article IV Consultation—Debt Sustainability Analysis Update for Bangladesh, January, 2016.