ASSESSMENT OF GAS DEMAND, SUPPLY, AND TRANSMISSION SYSTEM CAPABILITY TO ENSURE SUSTAINABLE GAS SUPPLY TO THE PROPOSED RUPSHA 800-MEGAWATT COMBINED CYCLE POWER PLANT

I. INTRODUCTION

1. The Asian Development Bank (ADB) is considering providing a loan to Northwest Power Generation Company Limited (NWPGCL) to construct an 800 megawatt (MW) combined cycle gas-fired power plant at Rupsha, Khulna. NWPGCL initially planned to construct the power plant based on imported regasified liquid natural gas (R-LNG) from India through a pipeline. NWPGCL was in negotiation with an Indian private sector firm for supply of 125 million cubic feet per day (MMCFD) R-LNG for the power plant initially, with provision for supply of another 125 MMCFD R-LNG in future. Negotiation with the Indian firm failed due to procedural lag on the Indian side.

2. Following that, NWPGCL approached Bangladesh Oil, Gas and Mineral Corporation (Petrobangla) for supplying required gas for the power plant. Petrobangla has agreed in principle to supply gas to the proposed plant subject to (i) availability of additional gas through the existing transmission system, and (ii) further development of the transmission system to ensure supply of gas to the power plant on a sustainable basis

3. An analysis was done to ascertain availability of gas for Rupsha power plant under various scenarios in short and long run.

II. GAS SECTOR DEMAND AND SUPPLY SCENARIO

4. Though exploration for oil and gas commenced since 1908, the first discovery of natural gas was in Sylhet in 1955. In the 1960s, some major gas fields were discovered in Sylhet and Comilla region. Natural gas use commenced in 1960 with supply of gas to a cement plant in Sylhet, followed by supply to a 100,000-metric ton per year urea fertilizer plant also in Sylhet. After discovery of Titas gas field in Comilla in 1962, which is closer to Dhaka, the then government decided to implement a project to supply gas to Dhaka City for other commercial purposes and build gas-based fertilizer and power plants at Ashuganj and Ghorasal, nearby the gas transmission route. Until that time, imported oil and coal were the primary commercial energy sources. Following independence of Bangladesh in 1971 and oil shock of 1973, importance of exploiting natural gas reserves was felt and significant development activities took place. At present, most of the cities and towns of eastern region of the country are covered with gas distribution networks. After construction of Jamuna Multipurpose Bridge, gas transmission and distribution networks have been extended to some power stations and townships in the western region up to Khulna in the southwest.

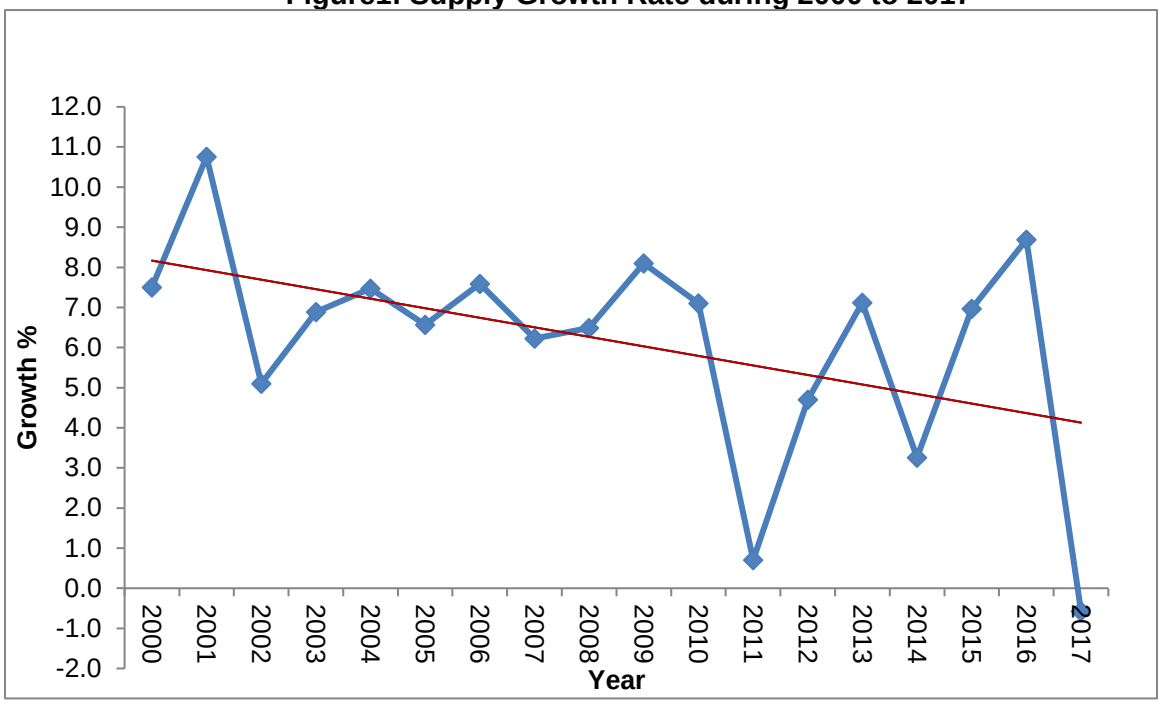
5. Natural gas accounts for around 75% of Bangladesh's total commercial energy consumption. Notable improvements have taken place in the last decade. Natural gas production has increased from 1,744 MMCFD in 2009 to 2,700 MMCFD in 2015, with about 1,625 MMCFD (60%) produced from gas fields owned and operated by international oil companies (IOCs) and 1,075 MMCFD (40%) from gas fields owned by national gas companies (NGCs). However, production from some fields has declined and the current production level is around 2,680 MMCFD.

6. **Gas reserve**. Since 1955, 26 gas fields were discovered. Reputed international consultants assessed gas reserve in these fields from time to time. Reserve assessment data

are given in Attachment 1. Out of a total recoverable reserve of 27.12 trillion cubic feet (TCF), cumulative production as of June 2017 was 14.73 TCF (Attachment 2). If fully exploited, the remaining reserve of about 12.39 TCF can meet gas demand at best for 10 more years, with a modest demand growth rate of 5% per year.

7. **Gas supply.** Production from gas fields increased from 332 billion cubic feet (BCF) in 2000 to 975 BCF in 2016 and reduced to 969 BCF in 2017. Average supply growth rate varied from –0.6% to 10.8 percent during 2000 to 2017 (Figure 1). The gas deficit will further exacerbate, given the declining reserves and fast-rising gas demand.

Figure1: Supply Growth Rate during 2000 to 2017



Source: Petrobangla.

8. In 2017, production from gas fields operated by IOCs peaked to 580 BCF against production of 389 BCF by NGCs. IOCs commenced operation in 1998 and now accounts for about 60% of total production. Share of IOC production during 2012 to 2017 is given in Table 1.

Table 1: IOC Share in Natural Gas Production

Financial Year	Production, BCF								% Share	
	NGC				IOC				NGC	IOC
	BGFCL	SGFL	BAPEX	Total	CAIRN	Chevron	Tullow	Total		
2012	278.5	55.4	19.3	353.2	4.0	350.0	36.6	390.6	47.5	52.5
2013	274.4	56.3	31.8	362.5	5.8	400.5	31.7	438.1	45.3	54.7
2014	288.0	53.3	40.1	381.4	0.3	401.2	37.5	439.0	46.5	53.5
2015	297.7	54.1	39.8	391.5	-	462.1	38.6	500.6	43.9	56.1
2016	298.3	53.9	38.2	390.4	-	541.2	36.8	577.9	40.3	59.7
2017	301.3	51.3	36.7	389.3	-	545.4	34.5	579.9	40.2	59.8

BAPEX = Bangladesh Production and Exploration Company Limited, BCF = billion cubic feet, BGFCL= Bangladesh Gas Fields Company Limited, IOC = international oil company, MMCF = million cubic feet, NGC = national gas company, SGFL = Sylhet Gas Fields Limited.
Source: Petrobangla.

9. The gas supply constraint causes lower power generation, reduced industrial production, low supply efficiency, and major economic disruption.[1] This may eventually imperil energy security and constrain national economic growth. Other gas supply sources may be imports, either through an inter-country transmission pipeline or as liquefied natural gas (LNG), are planned to partially meet the demand. Large-scale exploration in onshore and offshore areas for further discovery, systematic appraisal and development of discovered and producing gas fields to prove additional gas and import of gas will be necessary to ensure gas supply sustainability.

10. **Production augmentation.** Augmentation of gas production from existing fields is being undertaken by NGCs to maintain uninterrupted gas supply. Since January 2009, 706 MMCFD of gas production capacity has been added through new wells, workovers, or capacity enhancements. The Government of Bangladesh in 2012 established the Gas Development Fund (GDF) primarily to support the upstream activities and allow NGCs to be self-reliant to expedite the development.[2] The GDF's $900 million in resources finances onshore exploration, gas field development, seismic surveys, and transmission pipeline construction for delivery from gas fields to the nearest transmission network. An additional 400 MMCFD may be produced when the production augmentation programs under the Seventh Five Year Plan, FY2016–FY2020 are implemented.[3] The government is also creating an energy security fund.[4] The resource cost introduced by the government in FY2015 on natural gas produced in country will constitute this fund, estimated at $333 million equivalent, and its proceeds may be used to support the import of LNG and liquefied petroleum gas, construction of LNG terminals, and investments in foreign countries to achieve energy security in Bangladesh.

11. **Projected gas supply**. Given the above scenario, supply projection has been done with a focus on imported gas. Production from onshore fields, progress in setting up of terminals for LNG import, progress in purchasing LNG by Petrobangla and plans for expediting exploration in onshore and offshore, have been considered. Supply is projected to peak at 5,831 MMCFD in 2027 from the current level of 2,680. LNG import is projected to reach 3,000 and 3,250 MMCFD in 2027 and 2029, respectively. Details of supply projection are given in Attachment 3.

12. **Projected demand and supply gap.** Gas sector demand growth rate during 2004 to 2017 are given in Attachment 4. There was a sharp increase in demand in industrial, captive generation and compressed natural gas for use in transport sector during 2004 to 2010. Captive power generation is primarily in industrial sector as unreliable grid power was a major problem for industries.

13. Gas demand projection has been prepared based on past growth pattern and assumptions of growth in various sectors that are listed in Attachment 5. Demand will be dominated by power and industrial sectors. During 2009 to 2017, 8,900 MW generation capacity was added to the grid, of which over 5,000 MW is gas or gas and diesel based. Power Division of Ministry of Power, Energy and Mineral Resources has drawn up a power generation plan

[1] In 2015, 800–1,000-megawatt generation capacity was not operational because of inadequate gas supplies. This problem still prevails.

[2] The Gas Development Fund will consist of the proceeds, averaging 11.22%, from the revised consumer-level prices approved by the Bangladesh Energy Regulatory Commission in 2009.

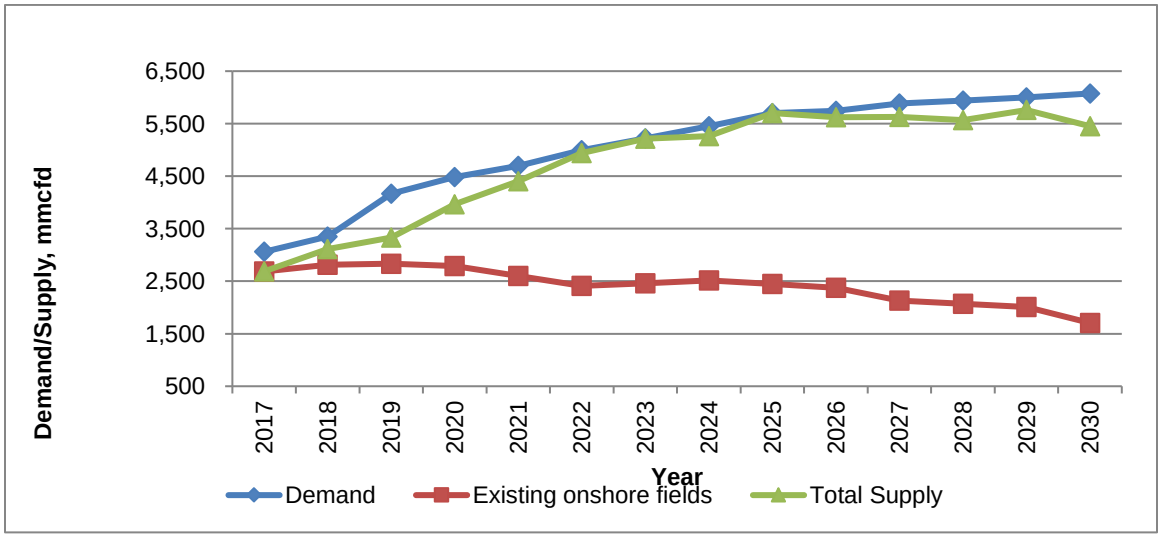
[3] Government of Bangladesh, Planning Commission, Ministry of Planning. 2015. *Seventh Five Year Plan (FY2016-FY2020)*. Dhaka.

[4] The energy security fund will consist of the resource cost (of Tk1.01 per cubic meter) as determined by the Bangladesh Energy Regulatory Commission in 2015.

based on recommendation in Power System Master Plan 2016[5] for implementation during 2018 to 2026 that includes plants based on gas, diesel/gas and coal as fuel. Power plants having capacity of 13,771 MW are under construction of which over 4,000 MW is gas and gas, or diesel fuel based. Thirty power plants having a total capacity of 5,092 MW (gas based 2074 MW) are under process for implementation. Nineteen projects having capacity of 20,732 MW (gas and LNG based 9,000 MW of which 7,200 MW LNG based plants will be located at Payra and Maheshkhali) have been planned for completion by 2026. List of under construction, under process and planned gas projects are given in Attachment 6. While projecting gas demand from gas grid for power generation, demand from gas-based power plants was considered.

14. Gas demand is projected to double in 2030 to 6075 MMCFD from current level of 3,060 MMCFD (that includes unmet demand of connected consumers to the tune of about 400 MMCFD). 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 3,650 MMCFD in the year 2030. Demand supply gap up to 2022, can be met by accelerating supply of 1,000 MMCFD LNG through contracted floating storage and regasification units (FSRUs) and contracting new FSRUs or develop land-based LNG storage and regasification facilities immediately. Discovery of new gas fields, proving additional reserve in producing gas fields, secondary recovery from existing fields and import of gas (LNG or piped gas) will be required to eliminate the demand-supply gap beyond 2025. Demand supply gap is shown in Figure 2.

Figure 2: Demand and Supply Gap



Source: Consultant's estimate

III. STEPS FOR ENHANCEMENT OF GAS SUPPLY

15. **Offshore exploration**. Gas exploration and production in Bangladesh have not kept pace with demand growth because of policy complexity and the absence of advanced technology. The long lead time from exploration to production and the unfavorable terms of the production sharing contract (PSC) have impacted the exploitation of gas resources by IOCs, while NGCs have not done extensive exploration for many years due to a shortage of public

[5] Government of Bangladesh, Power Division, Ministry of Power Energy and Mineral Resources. 2016. *Power System Master Plan 2016.* Dhaka.

resources and inadequate planning. The government signed one PSC for two deep-sea blocks with Conoco Phillips in June 2011. After doing the seismic survey in their assigned blocks, the company sought to revise the PSC terms, which were declined by the government. However, the government has signed two PSCs with IOCs since 2012, and a few more are under discussion.

16. **Supply augmentation from producing fields.** Bangladesh Gas Fields Company Limited introduced wellhead compressor in depleting Bakhrabad gas field in March 2007 and sustained production till to date. Well head pressure of Titas gas field (the largest gas field) producing since 1968 is depleting fast, Bangladesh Gas Fields Company Limited has taken plan to install wellhead compressors under ADB and Japan International Cooperation Company financing to sustain production at 600 MMCFD. Without wellhead compressors, production from the subject wells shall had to be suspended. Chevron, operator of Bibiana gas field has also planned to install wellhead compressors to sustain production from the field at a higher level. Appropriate secondary recovery technology should be applied to maximize gas recovery from all producing gas fields.

17. **Onshore exploration.** In the last few years, Bangladesh Petroleum Exploration and Production Company Limited (BAPEX) have achieved considerable success in oil and gas exploration and development onshore. During 2011–2015, BAPEX drilled five exploratory wells and discovered three gas fields, which are currently under production. The government recently allocated additional onshore areas for exploration to BAPEX. Other NGCs, namely Bangladesh Gas Fields Company Limited and Sylhet Gas Fields Company Limited, may also undertake exploration activities using their own resources. BAPEX is also conducting an ambitious exploration using the GDF and other resources and engaging international drilling contractors and oil and gas companies and may undertake joint venture initiatives with IOCs. After drilling and work over are completed, an additional 460 MMCFD of gas may be brought into production. BAPEX has discovered another gas field in Bhola and estimates reserve at .6 trillion cubic feet.

18. **Gas import**: The government and private sector stakeholders are exploring the import of LNG as well as pipeline gas from neighboring countries to alleviate gas reserve constraint and augment gas supply through the transmission network. The government has taken steps to accelerate LNG import and commenced development of LNG import terminals through private sector.

19. **Infrastructure for LNG import.** The country's first FSRU for imported LNG is under construction by Excelerate, USA near Maheshkhali on a build–own–operate–transfer basis for 15 years. It will have capacity to handle about 500 MMCFD of gas (equivalent to 3.75 million tons of LNG) annually and would be operational by April 2018. Excelerate was selected through a solicited process. The FSRU is targeted for commissioning in April 2018.

20. Apart of the above, the government has signed memorandum of understandings (MOUs) with a number of interested parties for construction of FSRU and land-based storage and regasification units. A map showing the location of FSRUs that will in operation within 2–3 years and planned gas transmissions lines are shown in the map in Attachment 7. Status of the FSRUs and land-based LNG terminals is given below:

(a) FSRU by SUMMIT LNG Terminal Co. Ltd.

(i) Proposed site is Maheshkhali;
(ii) Capacity of the plant is 3.75 metric tons per annum equivalent to 500 MMCFD;
(iii) Terminal use agreement (TUA) signed;
(iv) Geo ocean has been engaged as engineering procurement construction contractor;
(v) Targeted commissioning in October 2018;
(vi) SUMMIT is a local firm and is quite active in energy business. SUMMIT built first barge-mounted oil fired 110 MW independent power producers power plants at Khulna in late 1990s. Currently owns several IPP power plants with capacity of over 1,000 MW; and
(vii) SUMMIT has signed an O&M contract with Excelerate, USA for operation of the FSRU.

(b) FSRU by Reliance Power Ltd., India

(i) Proposed site is Kutubdia Island;
(ii) Capacity of the plant is 3.75 metric tons per annum equivalent to 500 MMCFD;
(iii) Non-binding memorandum of understanding signed on 10 April 2017;
(iv) TUA initialed on 30 November 2017;
(v) Targeted completion in mid-2019; and
(vi) Reliance Power plans to construct 2,200 MW combined cycle power plant at various locations. The first unit having 750 MW capacity is planned for construction at Meghnaghat for which the power purchase agreement (PPA) has also been signed with Bangladesh Power Development Board on 30 November 2017.

(c) Fixed Jetty Based offshore FSRU by Hongkong Shanghai Manjala Power ltd. (HSMPL)

(i) Proposed site is Kutubdia Island;
(ii) Capacity of the plant is 3.75 metric tons per annum equivalent to 500 MMCFD;
(iii) Non-binding MOU signed on 24 November 2016;
(iv) Petronas, Malaysia and Global LNG are partners of HSMPL;
(v) Site suitability is being examined by ILF, Germany;
(vi) Term sheet signed on 16 October 2017; and
(vii) Target completion in March 2020.

(d) Land based Petronet LNG Limited. India (PPL)

(i) Proposed site is Kutubdia Island;
(ii) Capacity of the plant is 7.5 metric tons per annum equivalent to 1,000 MMCFD;
(iii) Non-binding MOU signed on 29 December 2016;
(iv) Non-binding heads of understanding signed on 8 April 2017;
(v) Feasibility study completed by Petronet;
(vi) Term sheet for TUA is under discussion; and

(vii) Targeted completion in December 2021.

(e) Land Based China Huangqiu Contracting and Engineering Corp. (HQC)

(i) Proposed site is Moheshkhali;
(ii) Capacity of the plant is 7.5 metric tons per annum equivalent to 1,000 MMCFD;
(iii) Non-binding MOU signed on 20 November 2016;
(iv) Feasibility study nearing completion (likely by January2021)
(v) Formal proposal to be submitted; and
(vi) Even if all remaining steps taken in time it will take 3–4 years for completion.

21. A feasibility study for constructing land-based LNG 1,000 MMCFD terminals at Kutubdia (in addition to on-going developments iii and iv above) and Payra (where, a new sea port is under construction) is underway. Feasibility study will be completed in August 2018. Petrobangla has already shortlisted five firms for construction of land-based terminals, and a request for proposal will be issued once the feasibility study is completed.

22. Petrobangla has issued expression of interest (EOI) for construction of a 1,000 MMCFD (7.5 mpta) FSRU at Payra.

23. Petrobangla is also considering proposals for small-scale LNG import and initialed gas purchase and sales agreement with Trafigura, Singapore and Gunvor, Singapore. Regasified LNG is planned for supplying to the 350 pounds per square inch gauge (PSIG) ring main around Chittagong. Jetties of Chittagong Urea Fertilizer Limited and Karnafully Fertilizer Company Limited will be used for handling small-scale LNG vessels.

24. The government is already in dialogue with Indian Oil Company for import of piped gas for power stations at Khulna, through possible cross-border interconnections. The government is also examining the possibility of securing natural gas from the ADB-supported Turkmenistan-Afghanistan-Pakistan-India transmission pipeline.

25. **LNG import**. Government has decided to have control over purchase of LNG and Petrobangla has been assigned to identify sources and enter into agreement with parties with government concurrence.

26. Petrobangla has already signed a contract with RAS Gas of Qatar on 25 September 2017 for import of 2.5 mpta LNG (around 333 MMCFD). Delivery at Excelerate's FSRU will be synchronized with commissioning of FSRU. Petrobangla also has signed MOUs with Pertamina, Indonesia and Oman Trading, Oman for supply of LNG on long term basis.

27. Petrobangla asked for EOI for spot purchase of LNG and received EOIs on 17 August 2017. Petrobangla has shortlisted 30 firms. Master sales and purchase agreement will be sent to selected firms for spot purchase of LNG. Meanwhile, a few more MOUs have been signed with interested firms for spot purchase of LNG.

28. **Pricing of LNG in international market.** LNG price is always linked to oil price and subject to variation. According to Federal Energy Regulatory Commission USA, estimated world LNG estimated landing prices per million British Thermal Unit (MMBTU) in November 2017 varied from $7.29 to $9.55 in Europe, $2.96 to $7.91 in North America, $9.09 to $9.35 in South

America and $9.52 to $9.55 in Asia. In 2010, landed LNG price in Japan was $10.2/MMBTU. Petrobangla has received an offer recently for LNG at $11.3/MMBTU. Rising trend in oil prices is likely to increase LNG prices further.

29. **Upgrade of gas transmission infrastructure for transportation of imported gas.** To ensure smooth transportation of re-gasified LNG, Gas Transmission Company Limited (GTCL) has initiated several projects, some of which are already under various stages of implementation. Status of the pipeline construction projects, some of which are not directly related to the supply of gas to Rupsha power plant, is given below and shown in the map (Attachment 7):

(i) **Maheshkhali-Anwara Pipeline**. GTCL has nearly completed construction of 91-kilometer (km), 30-inch diameter pipeline with associated facilities to transport R-LNG from Excelerate's FSRU at Maheshkhali to the gas transmission network. Capacity of the line is 500 MMCFD.

(ii) **Anwara-Fauzdarhat Pipeline.** 42-inch pipeline is under construction with government financing. This line is needed to deliver gas to Chittagong area through Fauzdarhat city gate station and to Bakhrabad-Chittagong 24-inch existing line. GTCL ordered for all required materials. GTCL has awarded the EPC contract for Karnafully river crossing. Local contractors have been engaged for pipeline construction. GTCL is hopeful of completing all works to commission the line by April 2018.

(iii) **Chittagong-Bakhrabad Parallel Pipeline.** A 36-inch parallel line is under construction with ADB financing. Pipeline and associated facilities are likely to be completed on schedule in 2019. All materials for the pipeline have been ordered. Local contractors are being engaged. This line will be needed for transporting LNG based gas beyond 500 MMCFD.

(iv) **Maheshkhali-Anwara Parallel Pipeline.** A 42-inch, 79-km parallel line is also under construction with government financing. This is needed to transport R-LNG beyond 500 MMCFD from Maheshkhali to existing transmission system. GTCL has already ordered for pipes and all other materials. Activities for engaging local contractors for construction of pipeline and EPC contractor for river crossings are also in progress to complete the pipeline by December 2018. Land availability by December 2017 will ensure completion as per schedule.

(v) GTCL has submitted a preliminary development project proposal (PDPP) to the government for construction of 175 km, 30-inch pipeline from Langlabandh near Dhaka to Khulna that will pass through the Padma bridge at an estimated cost of $350 million. The bridge contractor will construct the pipeline along the bridge. The proposal is aimed to supply natural gas in the energy starved Southwest regions of the country for establishment of gas-based power plants, fertilizer, industrial and commercial unit for improvement of poverty level, livelihood and overall economic development of the region. Target completion date is December 2021. Once constructed, gas supply constraint will be removed and ensure sustainable supply of required amount of gas to the Rupsha plant.

(vi) Another 36-inch, 175 km pipeline from Payra to Khulna is also under consideration for construction to transmit R-LNG from Payra where a 1,000 MMCFD FSRU is planned for construction (see para 21).

30. Construction of Chittagong-Bakhrabad 36-inch line and Maheshkhali-Anwara 42-inch parallel line will enable the transportation of up to 1,500-2,000 MMCFD, depending on the demand in Chittagong, re-gasified LNG meeting desired pressure level across the transmission system.

IV. AVAILABILITY OF ADEQUATE GAS FOR RUPSHA 800 MW POWER PLANT

31. **Supply limitations**. Khulna, the location of the power plant, is the farthest point from all sources of gas supply in the country, both existing and planned. The transmission pipeline has recently been extended up to Khulna. The pipeline along with the existing supply infrastructure upstream is adequate to supply gas to both the existing 225 MW Khulna power plant and the proposed 800 MW Rupsha plant, in the event of availability of additional gas. At present, gas demand from connected consumers in other areas is well above supply from producing gas fields and there is no possibility of supplying gas even to the exiting Khulna 255 MW plant, which is presently operating on diesel.

32. In 2017, a joint committee was formed with officials of Petrobangla, Gas Transmission Company Limited (GTCL) and NWPGCL for finding suitable option and additional gas infrastructure needed to ensure supplying required quantity gas to Rupsha plant. Detailed gas system analysis was conducted with number of scenarios. Findings were (i) gas cannot be supplied to the power plant at this stage in spite of having pipeline capacity for not having enough gas production even to meet demand of already connected consumers; (ii) gas supply to Titas franchise area through Elenga should be from upstream of compressor to limit flow though compressor at 500 MMCFD that will enable gas availability up to 200 MMCFD at Khulna CGS; (iii) even if 1,500 MMCFD R-LNG is ensured supply to Khulna CGS will be limited to 200 MMCFD due to flow limitation of compressors at Elenga; and (iv) required amount of gas supply for all consumers at Khulna can only be ensured by constructing the proposed 30-inch Langlbandh-Gopalganj-Elenga pipeline.

33. There are two limitations in the gas transmission line already constructed to Khulna that will limit supply of adequate gas to Khulna to serve the two power plants. The first bottleneck is the undersized 20-inch diameter Bheramara-Khulna transmission line, which will not be able to supply more than 200 MMCFD of gas even if adequate gas is available. The other limitation is the capacity of the compressor station at Elenga having a maximum capacity of 500 MMCFD. To overcome these limitations, GTCL has planned to construct the Langalbandh-Mawa-Khulna 30-inch diameter pipeline (see para. 29(v)). The government has also planned to import LNG through Payra and a 36-inch diameter pipeline from Payra to Khulna, to ensure long term supply of required gas in the southwestern region of the country.

34. **Network Simulation**, Gas transmission network simulation was done with all supply options to examine availability of gas in Khulna in short and long run. The results are summarized in Table 2.

Table 2: Summary of Gas Transmission Network Simulation

Simulation Options (Demand-Supply Projection Year)	Peak Transmission Capability, MMCFD	Gas Availability at Khulna, MMCFD	Limitations	Remarks
Before LNG Supply (2017)	2,938	182	On completion of Dhanua Elenga 30-inch loop and subject to availability of gas over current production level.	Pressure at Khulna-500 PSIG. No need for operation of Compressor at Elenga
Supply of 500 MMCFD LNG at Maheshkhali (2018)	3,248	197	On completion of Dhanua Elenga 30-inch loop. On completion of Anwara-Fauzdarhat 42-inch line.	Pressure at Khulna-500 PSIG. No need for operation of compressors at Ashuganj. Compressor at Elenga in operation.
Supply of 1,000 MMCFD LNG at Maheshkhali (2019)	3,702	208	Construction of Maheshkhali-Anwara 42-inch line. Construction of a new 30-inch line from Kutumbapur to Meghnaghat power plant to isolate load of power stations	Pressure at Khulna-500 PSIG. No need for operation of compressors at Ashuganj. Compressor at Elenga in operation.
Supply of 1,500 MMCFD LNG at Maheshkhali (2019)	3,638	177	Flow from Titas field limited to 426 MMCFD. Special arrangement should be made to evacuate full production of 600 MMCFD from Titas field.	Pressure at Khulna-500 PSIG. Compressor (West) at Ashuganj in operation. No need for operation of compressor at Elenga.
Construction of 30-inch Langalbandh-Mawa-Gopalganj-Khulna 30-inch line. Supply of 1,500 MMCFD LNG at Maheshkhali (2019)	3,763	275	Demand met through Langlabandh-Mawa-Gopalganj-Khulna (116 MMCFD) and Bheramara-Khulna line (159 MMCFD).	Pressure at Khulna-400 PSIG. Compressor (West) at Ashuganj in operation. No need for operation of compressor at Elenga.
Supply of 750 MMCFD LNG at Payra (2021)	4,463	Unlimited amount. *Assumed 300 MMCFD for simulation.*	On completion of Payra - Khulna 36-inch line.	Pressure at Khulna-800 PSIG. Compressor (West) at Ashuganj in operation. No need for operation of compressor at Elenga.
Supply of 125 MMCFD from India to Khulna (2021)	4,600	Unlimited amount	On completion of Payra-Khulna 36-inch line and Indian border to Khulna line.	Subject to Finalization of deal with Indian Oil Company

LNG = liquefied natural gas, MMCFD = million cubic feet per day, PSIG = pound per square in gauge.

V. LNG-BASED GAS TARIFF

35. Import of high cost of LNG compared to low priced domestic gas will have significant impacts on end use tariff. The government is considering various options to come up with a bearable tariff structure to minimize impact on the consumers. In 2012, AECOM New Zealand Limited, engaged by the World Bank, developed a pricing framework for LNG blended gas for Petrobangla. An interministerial committee was formed in October 2015 to determine the price of gas, blending domestic production with R-LNG. The committee submitted its recommendation to the Energy and Mineral Resources Division of the Ministry of Power, Energy, and Mineral Resources in June 2016. The committee outlined several options for government consideration.

36. According to an estimate, based on IOC and national oil companies gas production ratio of 66:34 and blending of 1,000 MMCFD R-LNG with 2,700 MMCFD domestically produced gas, average selling price will increase from $1.89/MMBTU to $4.04/MMBTU.

37. At present, 55% of end use gas price is taken by the government in the form of supplementary duty on domestically produced gas by NGCs and 15% value added taxes (VAT) on end use prices. The government has decided to abolish supplementary duty and impose only 15% VAT on end use price for R-LNG blended gas. This will minimize impact of high cost of LNG on end use price.

Attachment 1

Comparison of Recoverable Gas Reserve (GIIP Proven+Probable)
Estimated by Different Agencies (1991-2015)

Figures in Bcf

Sl No.	Gas Field	Year of Discovery	Petrobangla - RPS Energy	Gustavson-HCU	HCU-NPD	Publication of Petrobangla 1/	Gasunie Netherlands	IKM Canada	Welldrill UK
			2010	2010	2003	1997	1992	1991-92	1991
	Producing								
1	Bakhrabad	1969	1,232	1,387	1,049	870	874	867	1,340
2	Bangura	2004	522	621					
3	Beani Bazar	1981	203	137	170	110	114	167	126
4	Begumganj	1977	70	33	33	20	15		18
5	Bibiyana	1998	5,754	4,532	2,401				
6	Fenchuganj	1988	381	329	283	210	210		230
7	Habiganj	1963	2,633	2,787	3,852	1,900	1,908	1,895	2,764
8	Jalalabad	1989	1,184	1,128	837	900	900		730
9	Kailashtilla	1962	2,760	2,880	1,904	2,530	2,523	2,276	3,190
10	Meghna	1990	70	101	119	100	103	82	96
11	Moulavi Bazar	1997	428	494	360				
12	Narshingdi	1990	277	345	215	130	116	79	118
13	Rashidpur	1960	2,433	3,134	1,401	1,310	1,557	1,309	2,100
14	Saldanadi	1996	279	275	116	140			
15	Semutang	1969	318	318	150	100	98		112
16	Shahbazpur	1995	390	261	466	330			
17	Srikail	2012	161						
18	Sundulpur	2011	35						
19	Sylhet/Haripur	1955	319	408	479	270	266		286
20	Titas	1962	6,367	7,582	5,128	2,100	499	2,100	3,754
	Non Producing								
21	Rupganj	2014	34						
22	Kutubdia	1977	46	46	46	470	468		585
	Production Suspended								
23	Chattak	1959	474	474	474	1,140	1,140		1,100
24	Feni	1981	125	130	130	210	79		16
25	Kamta	1981	50	50	50	200	195		215
26	Sangu (Depleted)	1996	578	771	848	850			
	Total in Bcf		**27,121**	**28,223**	**20,511**	**13,890**	**11,066**	**8,775**	**16,780**
	Total in Tcf		**27.1**	**28.2**	**20.5**	**13.9**	**11.1**	**8.8**	**16.8**

* Exploration Opportunities in Bangladesh was published by Petrobangla in 1997 during PSC bidding round.

Source: Petrobangla

Attachment 2

Gas Reserve and Production

(As of 30 June 2017)

Operator Company	Gas Field	Discovery		Reserve Estimated by		GIIP	Recoverable P1+P2	P1	P2	Cum Prod. up to 30 June 2017	Remaining P1+P2 Reserve
		Discovered by	Year of Discovery	Company	Year	Bcf	Bcf	Bcf	Bcf	Bcf	Bcf
BGFCL	Titas	PSOC	1962	RPS Energy	2009	8,148.9	6,367.0	5,384.0	983.0	4,323.5	2,043.5
	Bakhrabad	PSOC	1969	RPS Energy	2009	1,701.0	1,231.5	1,052.9	178.6	809.8	421.7
	Habiganj	PSOC	1963	RPS Energy	2009	3,684.0	2,633.0	2,238.0	395.0	2,313.1	319.9
	Narshingdi	Petrobangla	1990	RPS Energy	2009	369.0	276.8	218.0	58.8	186.0	90.8
	Meghna	Petrobangla	1990	RPS Energy	2009	122.1	69.9	52.5	17.4	63.6	6.3
SGFL	Sylhet	PPL	1955	RPS Energy	2009	370.0	318.9	256.5	62.4	212.6	106.3
	Kailashtila	PSOC	1962	RPS Energy	2009	3,610.0	2,760.0	2,390.0	370.0	659.4	2,100.6
	Rashidpur	PSOC	1960	RPS Energy	2009	3,650.0	2,433.0	1,060.0	1,373.0	595.9	1,837.1
	Beanibazar	Petrobangla	1981	RPS Energy	2009	230.7	203.0	150.0	53.0	97.1	105.9
BAPEX	Salda Nadi	Petrobangla	1996	RPS Energy	2009	379.9	279.0	79.0	200.0	88.5	190.5
	Fenchuganj	Petrobangla	1988	RPS Energy	2009	553.0	381.0	229.0	152.0	152.3	228.7
	Shahbazpur	Petrobangla	1995	Petrobangla	2011	677.0	390.0	322.0	68.0	32.3	357.7
	Semutang	OGDC	1969	RPS Energy	2009	653.8	317.7	151.0	166.7	12.4	305.3
	Sundalpur-Shahzadpur	Petrobangla	2011	BAPEX	2012	62.2	35.1			10.0	25.1
	Srikail	Petrobangla	2012	BAPEX	2012	240.0	161.0			61.9	99.1
	Begumganj	Petrobangla	1977	BAPEX	2014	100.0	70.0			0.9	69.1
	Rupganj	Petrobangla	2014	BAPEX	2014	48.0	33.6			0.4	33.2
	A: Total Petrobangla					**24,599.6**	**17,960.5**	**13,582.9**	**4,077.9**	**9,619.7**	**8,340.8**
Chevron	Jalalabad	Scimitar	1989	D&M	1999	1,491.0	1,184.0	823.0	361.0	1,094.2	89.8
	Maulavibazar	Oxy/Unocal	1997	UNOCAL	2003	1,053.0	428.0	405.0	23.0	296.4	131.6
	Bibiyana	Oxy/Unocal	1998	D&M	2008	8,350.0	5,754.0	4,415.0	1,339.0	2,747.6	3,006.4
Kris	Bangura	Tullow	2004	Tullow	2011	1,198.0	522.0	379.0	143.0	376.8	145.2
OVL	Kutubdia(Offshore)		1977	HCU	2003	65.0	45.5			-	45.5
	B: Total IOCs - 1:					**12,157.0**	**7,933.5**	**6,022.0**	405.0	**4,515.0**	**3,418.5**
Cairn	Sangu	Cairn	1996	Cairn/Shell	2010	899.6	577.8			487.9	89.9
Niko	Chattak	PPL	1959	HCU	2000	1,039.0	474.0			26.5	447.5
BGFCL	Kamta	Petrobangla	1981	Niko/BAPEX	2000	71.8	50.3			21.1	29.2
Niko	Feni	Petrobangla	1981	NIKO/BAPEX	2000	185.2	125.0			62.4	62.6
	C. Total (Production Suspended Fields)					**2,195.6**	**1,227.1**	**-**	**-**	**597.9**	**629.2**
	Grand Total (Petrobangla+IOCs)					**38,952.2**	**27,121.1**	**19,604.9**	**4,482.9**	**14,732.6**	**12,388.5**

2P= proven (P_1)+probable (P_2); bcf = billion cubic feet; BAPEX = Bangladesh Petroleum Exploration Company Limited; BGFCL = Bangladesh Gas Fields Company Limited; GIIP = gas initially in place; HCU = Hydrocarbon Unit; IOC = International Oil Company; OGDC = Oil and Gas Development Corporation; PPL = Pakistan Petroleum Limited; PSOC = Pakistan Shell Oil Company Limited; SGFL = Sylhet Gas Fields Company limited

Source: Petrobangla and Hydrocarbon Unit

Attachment 3

Projected Gas Production/Supply

(MMCFD)

Company	Gas Field	2017 Actual	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BGFCL	Titas	635	620	590	570	510	450	450	450	450	450	450	450	450	300
	Bakhrabad	83	38	35	28	23	30	30	50	80	80	70	70	50	50
	Habiganj	220	225	225	220	200	100	70	70	50	40	30	30	20	10
	Narshingdi	27	28	28	25	24	23	20	20	20	20	20	20	20	20
	Meghna	13	10	10	10	9	9	5							
	*Kamta														
SGFL	Sylhet	75	78	77	75	74	73	72	25	25	25	20	20	20	20
	Kailashtila	64	85	120	120	115	110	140	140	160	160	200	200	200	250
	Rashidpur	54	60	55	65	85	80	100	150	200	250	250	250	250	200
	Beanibazar	9	9	9	8	8	8	8	8	8	6	6	5	5	5
BAPEX	Salda Nadi	74	18	16	13	12	12	12	10	10	10	10	10	10	10
	Fenchuganj	13	35	30	30	28	28	45	45	40	40	35	35	30	30
	Shahbajpur	36	45	45	45	50	50	60	60	70	70	70	70	70	70
	Semutang	1	4	3	15	15	15	30	30	20	20	20	10	10	10
	Sundalpur-Shahzadpur		3	8	8	8	8	8	6	6	6	5	5	5	
	Srikail	34	35	55	50	50	45	40	40	30	30	20	20	20	10
	Begumganj		8	10	25	20	15	15	15	15	10	10	10	20	5
	Rupganj		8	8	8	7	7	7	6	6	6	5	5	5	5
	From New Discovery				50	80	100	100	100	100	100	100	100	100	100
	A: Total Petrobangla	1,048	1,139	1,264	1,305	1,258	1,103	1,152	1,225	1,290	1,323	1,321	1,310	1,285	1,095
IOCs	Jalalabad	261	250	200	200	200	200	200	200	180	180	150	120	100	80
Chevron	Maulavibazar	84	60	55	50	50	50	50	40	40	40	40	30	30	30
	Bibiyana	1,250	1,250	1,200	1,200	1,100	1,100	1,100	1,100	1,000	1,000	900	700	700	600
Kris	Bangura	94	115	115	85	70	60	60	50	40	30	20	10	5	
OVL	Kutubdia(Offshore)														
Niko	*Feni														
	*Chattak(West)														
	B: Total IOCs 1:	1,639	1,675	1,570	1,535	1,420	1,410	1,410	1,390	1,260	1,250	1,110	860	835	710
	From New Discovery (Shallow Offshore)								100	200	200	200	200	200	200
	From New Discovery (Deep Offshore)									100	200	200	200	200	200
	C: Total IOCs 2								100	300	400	400	400	400	400
	Total IOCs (B+C)	1,639	1,675	1,570	1,535	1,420	1,410	1,410	1,490	1,560	1,650	1,510	1,260	1,235	1,110
	D: Total (Petrobangla+IOCs)	2,687	2,814	2,834	2,840	2,678	2,513	2,562	2,715	2,850	2,973	2,831	2,570	2,520	2,205
	E: LNG Import (Petrobangla)		300	500	1,000	1,500	2,000	2,000	2,000	2,500	2,500	2,750	2,750	3,000	3,000
	F: LNG/Piped gas import at Khulna				125	125	125	250	250	250	250	250	250	250	250
	G: LNG Import (BPDB)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	H: Total LNG		300	500	1,125	1,625	2,125	2,250	2,250	2,750	2,750	3,000	3,000	3,250	3,250
	Grand Total (Petrobangla+IOCs+LNG)	2,687	3,114	3,334	3,965	4,303	4,638	4,812	4,965	5,600	5,723	5,831	5,570	5,770	5,455

*If BAPEX will be allowed by the govt. to develop Chattak (West), Feni and Kamta Gas Field.

Note: a) Not considered any gas reserve or further production from Sangu Gas Field because of the field has been depleted.
b) Expected that 170 MMcfd gas production will be coming from new discovery within 2019 by BAPEX
c) In addition, 200 MMcfd will be through drilling of development wells and 90 MMcfd by workover at Titas and Shahbazpur Gas Fields.

Source: Consultant's estimate.

Gas Sector Demand growth during FY2004 to FY2017

(in MMCF)

Fiscal Year (FY)	Power		Fertilizer		Others 1/														Own use/ condensate collection	Total	
					Industry		Captive Power		Seasonal/ Brick Fields		Commercial		Tea Estates		CNG		Domestic		Sub-Total			Annual	
	Annual		Annual		Annual		Annual		Annual		Annual		Annual		Annual		Annual		Annual				
	Demand	Growth	Demand	Growth	Demand	Growth	Demand	Growth	Demand	Growth%	Demand	Growth	Demand	Growth	Demand	Growth	Demand	Growth	Demand	Growth		Demand	Growth%
2004	199,320		92,803		54,620		37,608		224		5,649		964		2,282		58,024		159,369			451,492	
		5.8		1.3		11.6		19.1		-100.0		2.0		-1.9		88.7		7.6		12.4			7.2
2005	210,948		93,986		60,929		44,785		-		5,761		946		4,305		62,413		179,139			484,073	
		6.4		-5.2		19.5		25.6				4.0		-8.0		82.6		4.7		16.7			8.0
2006	224,394		89,086		72,813		56,240		-		5,994		870		7,859		65,316		209,093			522,573	
		-1.5		4.9		17.6		22.8				4.4		-4.8		66.5		7.0		17.1			7.0
2007	221,139		93,472		85,614		69,076		-		6,257		829		13,088		69,891		244,754			559,365	
		5.9		-15.8		14.1		23.1				11.7		2.2		84.8		4.7		17.6			7.4
2008	234,283		78,667		97,710		85,028		-		6,991		847		24,182		73,155		287,913			600,863	
		9.6		-4.9		10.4		15.2				10.5		-27.4		33.1		3.4		11.8			8.8
2009	256,843		74,832		107,858		97,972		-		7,722		615		32,180		75,678		322,025			653,700	
		10.2		-13.5		8.8		13.6				3.9		29.6		13.4		7.9		10.4			7.6
2010	283,146		64,719		117,350		111,253		-		8,019		797		36,493		81,670		355,583			703,447	
		-3.3		-3.0		1.3		6.6				3.3		-4.6		10.6		4.7		4.7			0.8
2011	273,809		62,764		118,872		118,605		-		8,282		760		40,360		85,472		372,352			708,925	
		10.5		-6.6		5.9		2.9				1.2		0.3		-6.8		2.7		2.7			4.9
2012	302,513		58,597		125,859		122,103		-		8,379		762		37,599		87,762		382,465			743,575	
		8.7		2.3		6.6		11.6				1.3		5.2		8.6		3.9		7.7			7.7
2013	328,845		59,952		134,204		136,285		-		8,485		802		40,814		91,178		411,769			800,566	
		2.6		-10.3		2.0		4.6				1.3		0.7		-2.5		10.4		4.3			2.5
2014	337,374		53,770		136,835		142,562		-		8,598		808		39,778		100,704		429,284			820,428	
		5.1		-0.6		8.0		5.3				5.6		0.5		7.9		17.4		9.2			6.9
2015	354,736		53,466		147,721		150,052				9,076		812		42,907		118,198		468,767			876,970	
		12.7		-1.6		5.6		6.4				-1.2		13.0		8.3		19.7		9.5			10.1
2016	399,621		52,619		155,985		159,693				8,970		918		46,474		141,471		513,511			965,751	
		1.0		-9.7		3.6		-0.1				-3.5		7.7		1.1		9.2		3.6			1.8
2017	403,576		47,498		161,529		159,552				8,652		989		46,969		154,431		532,122			983,197	

1/- System loss adjusted figures

Source: Petrobangla

Appendix 4

Gas Demand Projection

Sector	Actual	Projected												
	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Power	1,327	1,519	1,951	2,105	2,154	2,283	2,381	2,484	2,592	2,499	2,410	2,324	2,242	2,163
Fertilizer	130	147	262	274	274	274	274	274	274	281	281	281	281	281
Non-bulk														
Industry	487	512	600	659	725	797	844	895	951	1,027	1,129	1,186	1,245	1,307
Captive Power	481	506	642	705	775	851	899	951	1,005	1,035	1,139	1,196	1,256	1,318
Domestic	465	492	530	547	564	582	600	619	639	652	665	678	692	706
Commercial	26	27	28	28	29	30	30	31	32	33	33	34	35	35
CNG	142	145	154	162	170	178	187	197	207	213	224	235	246	259
Tea & Seasonal	3	3	3	3	4	4	4	4	4	5	5	5	5	6
Sub-Total	1,604	1,684	1,956	2,105	2,265	2,441	2,565	2,697	2,838	2,964	3,195	3,334	3,479	3,631
Total	**3,060**	**3,350**	**4,169**	**4,483**	**4,693**	**4,998**	**5,220**	**5,455**	**5,705**	**5,744**	**5,886**	**5,939**	**6,002**	**6,075**

Note:

1 Gas demand of committed gas based power plantsassumed to be met during 2019 and 2020. Power sector gas demand to go down by 4% annualy from 2026 onward with commissiong of coal based nuclear power plants and increased import of power from neighboring countries

2 Industial growth rate - 5-10%

3 Captive generation growth rate- 3-10%.

4 Domestic consumption growth rate- 2-3%

5 Commercial consumption to grow by 2% from 2019 onward.

6 CNG consumption to grow by 3-5%.

7 2% growth rate is considered for tea sector.

Source: Consultant estimate.

Gas Based Power Plants to be Commissioned/ Implemented during 2018–2026

Table A6.1. Status of Under Construction Gas Based Power Plants

Power Station Owner	Contract signed on	Capacity, MW	Fuel	Target Completion Date	Remarks
A. Public Sector					
Ghorasal 365 MW CCPP (BPDB)	26/05/2013	363	Gas	January 18	
Sirajganj 225 MW CCPP (2nd Unit) (NWPGCL)	20/03/2017	220	Gas/Diesel	January 18	Additional gas needed
Siddhirganj 335 MW CCPP (EGCB)	28/05/2012	335	Gas	GT: January 18 ST: June 18	Additional gas needed
Sirajganj 225 MW CCPP (3rd Unit) (NWPGCL)	01/07/2015	220	Gas/Diesel	GT: March 18 ST: September 18	Additional gas needed
Bibiana 800 MW CCPP (3rd Unit)	26/12/2012	400	Gas	GT: June 18 ST: December 18	Additional gas needed
Bibiana South 383 MW CCPP (BPDB)	15/12/2014	383	Gas	GT: January 20 ST: December 20	Additional gas needed
Ghorasal (Unit 4 Repowering) (BPDB)	06/06/2016	206	Gas	May 19	No additional gas needed
Ghorasal (Unit 3 Repowering) (BPDB)	12 /01/2014	206	Gas	June 19	No additional gas needed
Upgradation of Sylhet 150 MW plant to 225 MW CCPP (BPDB)	26/11/2016	87	Gas	June 19	No additional gas needed
Shahjibazar 100 MW GT (BPDB)	21/12/17	100	Gas	June 19	Additional gas needed
Khulna 330 MW CCPP (BPDB)	17/11/16	336	Gas/Diesel	ST: Jun 20 GT: Dec 20	Additional gas needed
Bheramara 360 MW CCPP (NWPGCL)	16/03/14	360	Gas/Diesel	ST: Test Run Commissioned GT: Jan 18	Additional gas needed.
B. Private Sector					
Kodda 149 MW (Summit & Alliance)	12/04/17	149	Gas/Diesel	Aug 18	Additional gas needed
Sirajganj 400 ± 10 MW CCPP (Symcorp, Singapore/NWPGCL)	03/08/16	414	Gas/Diesel	GT: Jan 19 ST: May 19	NWPGCL has 29% share. Additional gas needed
Bhola 220 MW CCPP (Sapurji Palanji, India)	29/08/17	220	Gas	December 19	Additional gas needed. Based on gas field at Bhola. No gas needed from grid.
Kushiara 163 MW CCPP (Kushiara Power)	20/08/15	163	Gas	January 18	Additional gas needed

BPDB = Bangladesh Power Development Board, CCPP = combined cycle power plant, GT = gas turbine, MW = megawatt, NWPGCL = Northwest Power Generation Company Limited, ST = steam turbine.

Table A6.2. Status of Under Process Gas Based Power Plants

Power Station (Owner)	Capacity, MW	Fuel	Target Completion Date	Remarks
A. Public Sector				
Upgradation of Baghabari 100 MW plant to 150 MW CCPP (BPDB)	50	Gas	June 21	Bid under evaluation. No additional gas needed
Upgradation of Shahjibazar 70 MW plant to 105 MW CCPP (BPDB)	35	Gas	June 21	Bid under evaluation. No additional gas needed
Ghorasal Unit 6 Repowering	206	Gas	June 22	No additional gas needed
Ashuganj (East) 400 MW CCPP	400	Gas	January 21	Bid under evaluation. Additional gas needed
B. Private Sector				
Fenchuganj 50 MW PP	50	Gas	June 20	Approved by the government. Additional gas needed
Meghnaghat 750 MW CCPP (Reliance Power, India	750	Gas	June 21	LOI issued on 26 July 2017. Additional gas needed
Meghnaghat 583 MW CCPP	583	Gas	June 21	LOI issued on 27 November 2017. Additional gas needed

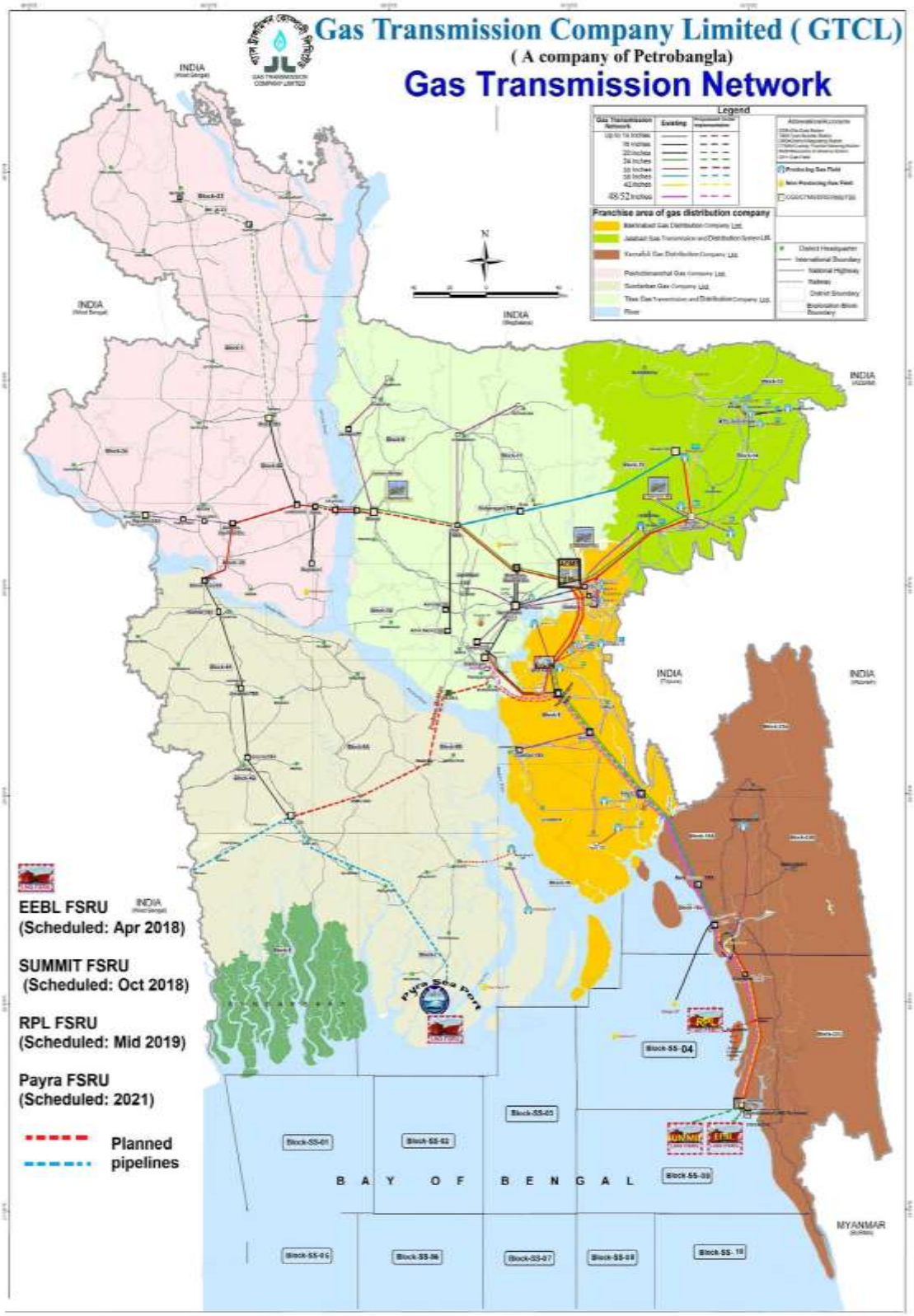
BPDB = Bangladesh Power Development Board, CCPP = combined cycle power plant, MW = megawatt.
Source: Ministry Power, Energy and Mineral Resources.

Table A6.3. Status of Planned Gas Based Power Plants

Power Station (Owner)	Capacity, MW	Fuel	Target Completion Date	Remarks
Rupsha 800 MW CCPP (NWPGCL)	800	LNG	June 22	Proposed to be financed by ADB. Additional gas needed.
Payra 3x1,200 MW CCPP (NWPGCL/GCL)	3,600	LNG	June 20 June 21 June 22	MOU signed between NWPGCL and Siemens. Additional gas needed.
Barisal 225 MW CCPP (BPDB)	225	Gas and diesel	December 21	Preliminary activities ongoing Additional gas needed.

BPDB = Bangladesh Power Development Board, CCPP = combined cycle power plant, LNG = liquefied natural gas, MOU = memorandum of understanding, MW = megawatt, NWPGCL = Northwest Power Generation Company Limited.
Source: Ministry Power, Energy and Mineral Resources.

Figure. Planned FSRUs and Associated Gas Transmission Lines



Source: Gas Transmission Company Limited.