ADB TA-8839 BAN: Study on Energy Security (48277-004)

Draft Final Report on Energy Security – Cover Note

29 June 2016

pwc

List of Abbreviations

ADB	Asian Development Bank
Apr	April
BAN	Bangladesh
BBIN	Bangladesh, Bhutan, India, and Nepal
BDT	Bangladeshi Taka
BERC	Bangladesh Energy Regulatory Commission
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
CBET	Cross Border Energy Trade
CNG	Compressed natural gas
Dec	December
E&P	Exploration & Production
EGCB	Electricity Generation Company of Bangladesh
EPZ	Export Processing Zone
Est.	Estimated
EZ	Economic Zones
Feb	February
FiT	Feed-in-Tariff
FSRU	Floating Storage Regasification Unit
FY	Financial Year
GDP	Gross Domestic Product
GoB	Government of Bangladesh
GTCL	Gas Transmission Company Limited
GRID	Government Reforms and Infrastructure Development Sub-Business Unit of PricewaterhouseCoopers Private Limited
GSMP	Gas Sector Master Plan of Bangladesh
HFO	Heavy Furnace Oil
IOC	Internal Oil Companies
Jan	January
JICA	Japan International Cooperation Agency
JV	Joint Venture
kWh	kilowatt hour
LNG	Liquefied natural gas
LPG	Liquid petroleum gas
MMSCFD	Million standard cubic feet of gas per day
MMTPA	Million metric tonnes per annum
MT	Million tonnes
MW	Mega Watt

NOC	National Oil Companies
NWPGCL	North West Power Generation Company Limited of Bangladesh
PPA	Power Purchase Agreement
PGCB	Power Grid Company of Bangladesh Ltd
PLND	Planned
PPP	Public Private Partnership
PSMP	Power Sector Master Plan of Bangladesh
PROJ	Projected
PwC	PricewaterhouseCoopers Private Limited, India
R&D	Research and Development
RE	Renewable Energy
RLNG	Re-gasified liquefied natural gas
SARD	South Asia Department of Asian Development Bank
SAARC	South Asian Association for Regional Cooperation
SARI/Energy	South Asia Initiative for Energy
SASEC	South Asia Subregional Economic Cooperation
SBM	Single Buoy Mooring
SREDA	Sustainable and Renewable Energy Development Authority, Bangladesh
SSLNG	Small Scale Liquefied Natural Gas
TA	Technical Assistance
TCF	Trillion Cubic Feet
TSA	Transmission Service Agreement
WB	The World Bank
US	United States
USAID	United States Agency for International Development
USD	United States Dollar ($)
VAT	Value Added Tax in Bangladesh

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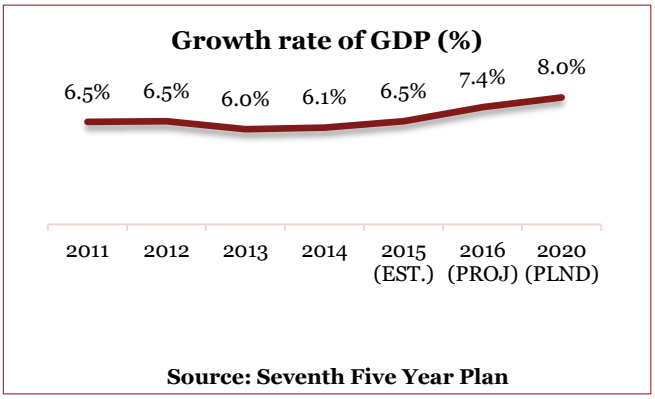
1. Introduction

1.1. Background

Bangladesh is a developing economy with agriculture and industries being the prime movers of its economy. It has the gross domestic product (GDP) of United State Dollar (USD) 172.9 billion in 2014, which showed growth rate of average 6.4% in the last 5 years. In order to boost the economic development in the country, the Government of Bangladesh (GoB) is planning to accelerate growth by setting up of various industrial areas including economic zones, industrial parks, increase textile export, etc. Bangladesh has witnessed an increase in peak electricity de mand by 8-9% from FY 2010 to 2015 due to increase in population, urbanization, and expansion of economic activities in the country.



Source: Seventh Five Year Plan

However, the energy access (74 %) and per capita consumption of 331 kilo watt hour (kWh) electricity is low as compared to many other developing nations. This necessitates the requirement for increasing energy supply and creation of necessary infrastructure to cater to the growing demand, provide better customer services, improve efficiency and support viability of the sector.

1.2. Need for energy security in Bangladesh

Energy side overview

Natural gas continues to be the primary driver of socio-economic growth. According to the BP Statistical Review of World Energy, the total primary energy consumption in Bangladesh in 2014-15 is 28.1 MTOE. Of this natural gas accounts for a sizeable 75.4%.

The domestic production of gas grew around at around 5% over last decade. However, the production growth has failed to match gas demand which is increasing steadily in line with faster economic activity (6.5% GDP growth). The current domestic production of gas is heavily dependent on existing mature fields with declining production trends. Bangladesh has one of the lowest Reserve to Production Ratio at around 10.7.

Assuming a conservative 6% annual increase in production, considering historical growth and planned augmentation programs, the cumulative production by 2025-26 is projected to be 14.96 TCF whereas the remaining recoverable 2P reserves are estimated at 14.55 TCF. In the absence of further successful exploration & development activities, the existing gas reserves are expected to be depleted in the next 10 years.

Gas demand has grown faster than projected with increasing socio-economic developments in the country. Natural Gas consumption has grown at around 6% over last 10 years. In 2013-14, the natural gas consumption was 2, 234 MMSCFD against the requirement of 3,200 MMSFD. However, it has been lower than projected demand across sectors implying supply constraints.

In a supply constrained scenario and with enhanced economic activities, the composition of gas demand is set to witness a gradual change over long term horizon. Assessing patterns in sectoral gas consumption is necessary for efficient allocation of scarce gas resources and exploring opportunities for fuel diversification.

In the power sector, although percentage share of gas based generation capacity has reduced from 85% in 2005 to 62% in 2014, it still remains the most vital fuel. The current installed capacity of gas based power plants is 7,628 MW of which 2,300 MW was added in the last 5 years and 4,031 MW was planned in the next 5 years. The existing power plants have been running below capacity due to gas supply constraints. In January 2016, 680 MMSCFD out of 1,548 MMSCFD demand could not be met. With new capacity additions, the sector's unmet demand is set to increase further. Moreover, the fuel efficiency of old gas power plants operating in Bangladesh varies between 23% to 30% which is very low and can be increased to more than 50% by converting them to combined cycle. There are initiatives proposed to be undertaken for repowering of gas plants implying conversion to combined cycle. Addressing energy efficiency issues of existing and upcoming plants can be one of the ways to reduce the demand supply gap. It is estimated that 38 MMSCFD of gas will be saved as a result of conversion to combined cycle.

Currently, 2/3rd of the urea demand is imported. Owing to gas supply constraints, the fertiliser production of state owned factories was rationalised due to gas unavailability. The capacity of the private factory also remain underutilised due to gas supply issues. Most fertiliser factories ae using obsolete technologies. This lead to inefficient utilisation and very high opportunity cost of using gas. Government's plans to suspend indigenous production and meet the entire demand through imports holds potential to derive greater economic value and reduce gas consumption further.

Industrial growth is set to increase in coming years with Bangladesh aspiring to become a middle income country by 2021. This, in turn, would enhance the energy needs of this sector. Although, the sectoral demand is projected to increase substantially in future, potential demand can increase further with rationing of gas from CNG and domestic sectors. Most of the major energy consuming industries are inefficient in their energy consumption compared to international benchmarks. For instance, textile and garment industry which is an important and growing sector of Bangladesh economy needs a lot of process heat, hot water and steam, and relies on gas-fuelled boilers for this. However, industrial boilers deployed in these industries tend to be highly inefficient, with estimated thermal efficiency of 50%–80%. Also, with greater private participation, this sector has higher affordability of consuming gas, which in turn can enhance the economic value of scarce gas resources.

In the domestic and transport sectors, with GDP growing at a healthy rate, the demand for gas from domestic and transport sectors is expected to increase significantly. In view of the depleting gas supplies and intermittent interventions by the Government, the number of CNG conversions has reduced drastically in recent years. Presently, the Govt. of Bangladesh has suspended new CNG and domestic gas connections and plans to promote LPG in these two sectors. Increasing focus on moving towards cheaper & cleaner fuels – gas from petrol & diesel (transport) and gas from firewood (cooking) also holds potential for increasing demand for gas.

Power side overview

Electricity generation in Bangladesh is predominated by gas based fuel source and which contributes to approximately 60% of the total gas consumed. Whereas, as per current status, the extractable reserve of gas is 27.12 Trillion Cubic Feet (TCF) out of which 13.03 TCF is produced and the remaining reserve is only 14.09 TCF which shall not be adequate to meet the energy demand for a long time if new gas fields are not discovered. As no significant gas discovery has been made in recent past, including off-shore and on-shore, some part of the power generation capacity has remain stranded, further widenings the demand-supply gap of electricity. For example, in financial year (FY) 2015 due to inadequate gas supplies, 800-1000 megawatt (MW) of generation capacity has been shut down. An estimate put the economic losses in the industrial sector in 2014 due to power outages as 1.7% of GDP. To sustain the continuity of supply, the use of furnace oil and diesel for power generation has been increased in the country, which leads to increase in cost of generation and subsidy burden on GoB.

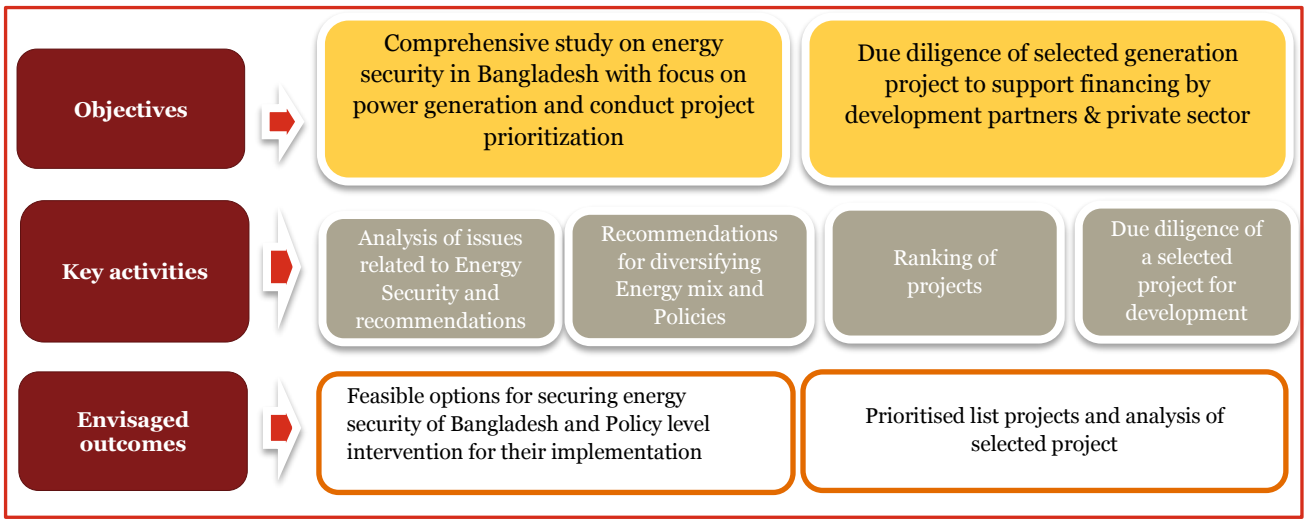
The key issues of the sector include:

Therefore, the GoB is now considering to diversify the energy mix by considering various conventional and non-conventional energy sourcing options. The Asian Development Bank (ADB), one of the key developmental partner in Bangladesh's growth story, is supporting the government through various initiatives in various sectors including energy and supported technical assistance project for conducting study on Energy Security and conducting due diligence of a selected project. Through this technical assistance (TA) assignment, ADB is aiming to help the GoB by to review various energy sourcing options and aspects of fuel diversification in order to enhance the country's energy security in the coming years.

1.3. Objective of the study

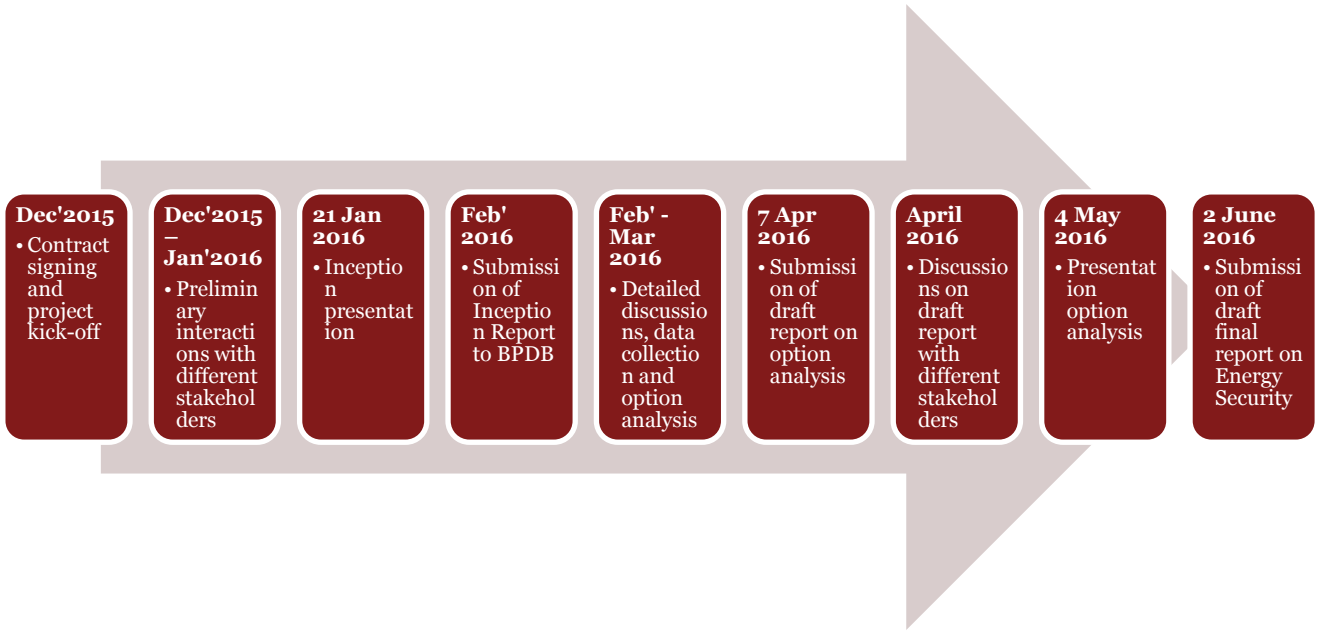
ADB's TA 8839 is aimed to help Bangladesh critically analyze issues underpinning energy security, assess and explore various energy sourcing / fuel diversification / power generation options (including cross-border power import and renewable energy), prioritize projects under various possible options, identify policy level interventions related to energy security, and to undertake diligence on one project for investment by development partners and the private sector.

The aims, activities and outputs are summarized and discussed below:



1.4. Progress till date on TA

The contract for TA-8839 "Study on Energy Security for Bangladesh" was awarded to PwC in the end of year 2015. To initiate the project, PwC team conducted the stakeholder consultation and noted the priorities of the key stakeholder for the engagement. In January 2016, PwC team conducted an Inception workshop and presented the understanding of energy sector scenario in the country, engagement work plan and details on approaching the engagement to the senior officials of various agencies of power sector of Bangladesh.



After detailed deliberations with various energy sector agencies including Power Division, Power Cell, Bangladesh Power Development Board (BPDB), Sustainable and Renewable Energy Development Authority (SREDA), Power Grid Company of Bangladesh (PGCB), Electricity Generation Company of Bangladesh (EGCB), North West Power Generation Company Limited (NWPGCL), Petrobangla, Bangladesh Petroleum Corporation (BPC), Titas Gas Transmission and Distribution Company Limited, Bangladesh Energy Regulatory Commission (BERC), etc. and developing partners like Japan International Cooperation Agency (JICA), The World Bank (WB), PwC team developed the report on Energy security by analyzing wide-range of energy sourcing options. PwC team followed the process of conducting multiple focused group discussion with these agencies.

On May 4, 2016, PwC team conducted 2nd workshop of the assignment on Energy security at Bijoy Hall, Bidyut Bhaban in Dhaka, which was attended by key energy (including power) sector officials. In this workshop, PwC team had a detailed discussion on key findings of the report and noted the inputs of various power and energy sector officials for further strengthening of the report. Please refer Appendix B. -Meeting notes of Second Workshop on Energy Security at page 23 of this report for key discussion notes of the workshop.

Subsequently, PwC team met Honb'le State Minister for Power, Energy and Mineral Resources, Additional Secretary, Power Division, key officials from energy division and received further guidance on the Energy Security report.

Based on the inputs of various power and energy sector representatives and ADB, PwC team has revised the Energy Security report and submitted the draft final report on 02 June 2016. The contents of the report include:

- Introduction
  - TA Overview and Progress Update
  - Background and Context
  - Gas Demand-Supply Scenario
- Analysis of Options for Ensuring Energy Security
  - Conventional Imported LNG
  - Small Scale LNG Opportunities in Power and Other Gas Based Industries
  - Fuel Diversification to LPG
  - Intensifying Domestic E&P Efforts
  - Import of Gas from North East India and Myanmar
  - Coal Based Power Plants

  - Cross Border Power Import
  - Domestic Hydropower
  - Solar
  - Wind
  - Biomass, Biogas and Waste-to-Energy
  - Energy Efficiency and Conservation
  - Other Options
  - Summary of Option Analysis
- Ensuring Energy Security – Way Forward
  - Development of LNG market, assessment of SS-LNG feasibility, development of LPG master plan, acceleration of E&P efforts, policy & regulatory changes in PSC
  - Coal Sector Development
  - Facilitating Cross Border Power Trade
  - Renewable Energy Development and Energy Efficiency
  - Project prioritization and due diligence of top ranked project
- Appendices

Draft Final Report on Energy Security is attached as Appendix C with this report.

2. Option Evaluation

2.1. Framework used for evaluation

One of the key objective of this TA is to conduct comprehensive study on energy security in Bangladesh with focus on power generation and evaluate various available energy sourcing option. For evaluation of various alternate options available for Bangladesh, Consultants assessed wide-range of options in following four key dimensions i.e.; Affordability, Reliability, Adequacy and Sustainability.

Parameters	Key Parameters for Option Analysis
Affordability	• Indicative price of energy sources/ electricity generated per unit from different source
Reliability	• Probability of disruptions of supply • Availability of facility / outages (frequency, period) expected on annual basis
Adequacy	Adequacy of option for meeting envisaged demand • Potential/ size of the option to meet demand • Base load and peak lead • Critical loads and non-critical loads
Sustainability	• Environmental & social (Resettlement & Rehabilitation, employment, etc.) impact/considerations

Detailed report contain analysis of following options in the context of energy security:

- Conventional Imported LNG
- Small Scale LNG Opportunities in Power and Other Gas Based Industries
- Fuel Diversification to LPG
- Intensifying Domestic E&P Efforts
- Import of Gas from North East India and Myanmar
- Coal Based Power Plants
- Cross Border Power Import
- Domestic Hydropower
- Solar
- Wind
- Biomass, Biogas and Waste-to-Energy
- Energy Efficiency and Conservation
- Other Options like tidal, geothermal and nucler

2.2. Conventional Imported LNG

In view of the depleting gas reserves, in the year 2010, the Government of Bangladesh (GoB) decided to go ahead with its plans of building a Floating Storage Regasification Unit (FSRU) and start importing LNG by 2013. However, the project failed to take off as per plans due to several constraints. Finally, after six years, Petrobangla signed an initial agreement on 31st March 2016 with US based Excelerate Energy to build the FSRU terminal at Moheshkhali island. The FSRU will have a capacity of 5 MMTPA, storage capacity of 138,000 cubic meters and regasification capacity of 500 MMSCFD. Regasification capacity is expected to be doubled within two years from the date of commercial operations. The terminal is expected to start importing LNG by early 2018. Although, Bangladesh signed a MoU with Qatar in 2011 to import 4 million tonnes of LNG per year from Qatar Petroleum, the final import deal is yet to be finalized. Apart from the floating terminal, the GoB has also taken recent initiatives to build two onshore LNG terminals at Matarbari in Moheshkhali Island and Payra in Patuakhali district. Both the projects are at a preliminary EoI stage. Matarbari terminal shall have a handling capacity of 3.5 million tonnes of LNG per year. In addition, there have been announcements by private investors such as Reliance Power, which plans to set up a 5 MMTPA capacity LNG Storage & Regasification Terminal with a regasification capacity of 500 MMSCFD in Southern Bangladesh to meet the gas requirement of its proposed Combined Cycle Power Plant.

The option of Conventional LNG is ranked medium attractive on the affordability parameter as price is relatively lower when compared to imported liquid alternatives but will cost high when compared to prevailing domestic gas price. At prevailing conditions, the import price (Delivered ex-ship) for Bangladesh is estimated to be around USD 7-8 / MMBTU. Adding regasification charges, import duties, marketing & transportation charges and other miscellaneous taxes, the final landed cost of RLNG for consumers is estimated to be around USD 10-11/ MMBTU. However, considering the fact that the Govt. of Bangladesh is planning a pooling mechanism with domestic gas, imported gas should be available at around USD 3-5/ MMBTU depending on the consuming sector. Use of high cost LNG in power sector will have a cascading effect on the cost of power generation thus warranting an upward revision in bulk power tariff.

Although, LNG ranks high on the reliability aspect, specific polices and guidelines need to be rolled out expeditiously by the GoB to translate LNG into a reliable source in the short to medium term. The global LNG market currently stands oversupplied. On one hand, global export capacity is expected to increase by more than 40 percent in the next few years from a capacity of 300 MMTPA (at end of 2014), on the other hand, global LNG demand is falling back in pace, especially with a slowing economy in China and a likely decline in Japan's needs for LNG imports. The resulting glut of LNG export capacity is gradually creating a buyer's market giving much more leverage to buyers. Complete development of LNG spot market in the next 3-4 years will make LNG a more reliable source of energy for importers. Besides, reflecting a more realistic pricing, it shall also protect importers against any short to medium term supply disruptions in long term contracts. Bangladesh's strategic location and proximity to Australia, Singapore and India presents a good opportunity to diversify its LNG sources, rather than solely depending on Qatar.

With the current level of infrastructure and work in progress, LNG can be ranked Medium on the parameters of Accessibility and Adequacy. In an oversupplied global LNG market, Bangladesh needs speedy implementation of enabling infrastructure to make LNG accessible and adequate for its end customers. For the planned land based LNG terminals at Matarbari and Payra and for other future land based terminals, sufficient land should be made available to terminal developers at concessional rates. Deep sea ports need to be developed to facilitate handling of large LNG carriers. Also, pipeline networks need to be laid to connect LNG terminals to the demand centres. GTCL is already commissioning a 91 km gas pipeline from Moheshkhali to Anwara to carry re-gasified LNG from the planned FSRU terminal to the Ring Network at Chittagong to connect to main gas grid. Based on the locations of future LNG terminals, more such pipelines need to be planned in advance to ensure accessibility and adequacy of RLNG supply as pipeline constructions have a long gestation period and their capacity and connectivity cannot

be increased in short term with a sudden increase in demand. On the parameter of sustainability, this option ranks high owing to its environmentally benign nature,

2.3. Small Scale LNG Opportunities in Power and Other Gas Based Industries

The **concept of small scale LNG** involves breaking bulk at conventional LNG import terminals or mid-sea LNG carriers and distributing in smaller sized parcels directly to end users using a combination of sea and land based transport. It has a quick turnaround time (10-12 months) and can also be integrated with upcoming FSRU terminals for break bulk provisions (redistribution). With draft requirements of minimum 7.5 metres, existing ports at Chittagong and Mongla or the upcoming ports at Payra & Matarbari can be used for SSLNG. It entails lower capital costs in the range of USD 40-50 million with options to build upon existing infrastructure (harbours, jetty, access roads, etc). Being modular in nature, capacity can be increased at a later stage with surge in demand. It can cater to smaller distributed demand within an optimum distance of 500 km from ports. LNG can be supplied to customers (industrial customers, power plants etc.) within a radius of 500 km from port. Thus, with its numerous advantages, Small Scale LNG offers a stop gap solution to meet gas supply deficit in the short to medium term

Small scale LNG is price competitive with liquid imported fuels but its inability to compete with domestic gas price makes it a medium attractive option when evaluated on the affordability parameter. When compared to conventional LNG, the landed cost of small scale LNG for end consumers is estimated at USD 2/MMBTU above the conventional LNG supply price. According to Gas Tariff Order, 27 August 2015 of Bangladesh Energy Regulatory Commission (BERC), Transmission Charge or the margin on transportation of Gas is 0.1565 Taka/CM and same for all consumers which is USD 0.06/MMBTU. For a typical demand of 1 MMTPA (100 mmscfd), broad cost comprises of FOB price of USD 4/MMBTU; approximate shipping cost (from Singapore/ India to Bangladesh) in the range of USD 1 to 1.5/MMBTU, jetty cost of USD 0.5/MMBTU, transportation cost by road from import terminals to demand center (Up to distance of 500 km) is estimated to be approximately USD 1 to USD 1.5/ MMBTU. The transportation costs can be reduced if transported through gas pipelines. Further, re-gasification costs in the range of USD 0.7 to 0.8/ MMBTU are additional in the total cost of SSLNG. In the absence of full or inadequate gas supply, the gas consumers have to rely on imported liquid fuels as an alternative. Small scale LNG entails low capital expenditure, low operational costs and quick implementation thus making smaller gas based power plants competitive and economically viable. From the affordability attractiveness perspective, small scale LNG is price competitive with liquid fuels. However, SSLNG may not be price competitive with current low domestic gas prices and pooled LNG prices. For consumers located within a radius of 500 km from the import facility, small scale LNG may be a financially viable option. SSLNG is an attractive option for consumers with Industries (EZs & EPZs) and power plants (stranded and upcoming) who otherwise have to use imported liquid fuels.

Seamless logistics operations needs to be ensured for uninterrupted gas supply. For a demand of 1 MMTPA, a typical 12,000 cubic metre vessel shall reach the import terminal every 30-40 hours. The entire supply chain needs to be well developed for reliable supply. Gas consumers want security of supply before committing to LNG, while potential suppliers need to secure a market to justify the investment. Absence of proper policies and guidelines can also affect the reliability of Small Scale LNG.

Smaller vessels with lower draft requirements can easily access shallow Chittagong and Mongla ports with draft of 7-7.5 metres. Last mile delivery of SSLNG to energy users, not currently connected to pipeline networks or too far from a pipeline system or too small demand to merit a pipeline extension. Small scale LNG can be made accessible through road tankers, pipelines etc. This option is fit for Bangladesh with distributed demand and limited pipeline infrastructure. It is easily accessible for consumers within a distance of 500 km from ports. Small regasification terminals could be located near customer points.

Being environmentally benign and modular in nature, Small Scale LNG ranks high on Sustainability and Adequacy parameters. Small scale LNG is expected to be stop-gas solution to bridge the gas deficit in the short to medium term.

2.4. Fuel Diversification to LPG

LPG Industry in Bangladesh is at a critical juncture, waiting to take off in a big way in Bangladesh. The current estimated demand for LPG in Bangladesh is 5, 00,000 tonnes with actual consumption at 1, 50,000 tonnes. While the demand for LPG has grown at an exponential rate of 60 % in the last 3 years, the consumption in the country has grown at an average rate of 13% in last 5 years, leading to a widening demand supply gap. Of the total supply of LPG in the country, only 13% is met through indigenous with the rest 87% being imported.

Currently, major chunk of LPG supply is consumed by the domestic sector. The industry is dominated by private players which are involved in import, storage, bottling, distribution & marketing of LPG. Public sector companies produce just 20,000 tonnes of LPG out of a total consumption of 1, 50,000 tonnes. LPG is supplied by both public sector companies such as Bangladesh Petroleum Corporation (BPC) and Rupantarita Prakritik Gas Company Limited (RPGCL) and the existing private sector players such Bashundhara LP Gas Ltd., Jamuna Spacetech Joint Venture Ltd., TotalGaz, Laugfs Gas Bangladesh (earlier Petredec Elpigi Ltd.), BM Energy Ltd., Omera Petroleum Ltd. Many new private players are entering the market such as Navana, Orion, Index, Sena Kalyan Sangstha etc.

LPG demand is expected to shoot up further in view of the plans of Government of Bangladesh (GoB) to deal with the issue of depleting natural gas reserves. To promote LPG usage further, GoB plans to double gas tariff for domestic sector and raise CNG Prices by 70%. GoB has stopped new gas connections for domestic and transport sector. Additionally, by 2025, the Govt. plans to convert 2.3 million NG domestic users and 0.18 million existing CNG automobiles to LPG. If the entire 3 million households switch to LPG that would alone create an additional LPG demand of 20, 00,000 tonnes. Greater attention towards discouraging households from using costly and polluting fuels like firewood, kerosene, etc shall also create an additional demand.

LPG coverage in Bangladesh is uneven and inadequate thus presenting scope for coverage. There exist region wise disparities in coverage of LPG. Dhaka and Chittagong exhibit both high LPG and PNG coverage though not completely covered. LPG coverage is quite low ranging between 10-30% across most districts in Bangladesh particularly the western parts of the country (Rangpur, Rajshahi and Khulna). The affordability of the end consumer, inadequate infrastructure to cater to rural. Far flung and remote areas and high logistics costs pose a deterrent.

However, existing supply infrastructure acts as a bottleneck to meet the growing demand and ensure equitable distribution in Bangladesh. All the existing import terminals are located near ports that have draft restrictions - Chittagong (9 meter) & Mongla (6 meter). Jetties cannot receive more than 3,000 tonnes gas carriers. This leads to higher freight charges for bulk LPG cargoes. Owing to the hazardous nature of LPG, existing jetties at Chittagong and Mongla ports cannot be used for the purpose of imports. Special jetties need to be constructed at least 10 km away from the main ports which entail huge land & capital costs. Laying down sub-sea pipelines for almost 3 km for Single Buoy Mooring (SBM) facilities consume capital costs further. In the absence of any funding, high capital costs deter private players to invest in such import terminals and bottling plants. Rangpur Division (districts like Rangpur, Dinajpur and Thakurgaon) has lower penetration in LPG coverage as compared to other divisions. This is due to absence of waterways in these regions with road transportation being much costlier. Moreover, with river bodies drying up in various parts of country, the potential to use inland waterways as an effective & cheaper mode of transportation sees a downward trend.

On the aspect of affordability, LPG is not an attractive option when compared to subsidized natural gas, yet At current non-subsidized price of 1400 Taka per 12.5 kg (USD 36/ MMBTU), LPG is a costly fuel compared to its alternatives for different sectors - domestic gas (USD 1-3/MMBTU), HSD (USD 24/MMBTU), Kerosene (USD 25/ MMBTU). Will not be an affordable option for rural parts of Bangladesh in short and medium term which

rely on biomass based cooking fuels that are available in abundance at much lower prices. Market price adjustments in accordance with fall in global LPG prices can improve affordability in short term.

Imports of LPG ensure reliable supply with infrastructure being a major impediment. As more than 80% of the LPG market is import dependant, there is an obvious exposure to global commodity cycles. Currently six private players operate in the country with more new players entering the LPG market. This would ensure greater competition which will lead to greater operational efficiency and increasing reliability. Steps taken to augment supply and distribution infrastructure can also have a positive effect by way of improving reliability. Lack of proper safety guidelines and investor-friendly policies from Govt. of Bangladesh can deter private companies to grow at their full potential. Also, existing malpractices like hoarding, non-transparent pricing and lower cylinder weights can reduce reliability of LPG supply.

Augmenting LPG supply and distribution infrastructure will not only ensure accessibility to rural, far flung areas but also make LPG supplies adequate to meet the growing demand. Most of LPG operators have a pan country coverage to serve urban and semi-urban areas with depots distributed in different parts. However, rural distribution network is still undeveloped. Existing import terminals (Chittagong and Mongla) with draft restrictions are unable to receive larger cargo vessels (5000 MT carriers) thus leading to higher freight charges. Almost half of private capacity remain underutilised currently. Additional import infrastructure planned in Kumira and Mongla. Also, the private players plan to enhance their capacities further.

On the sustainability aspect, ranks high as it is a clean fuel with no health hazards when compared to biomass based fuels. LPG with higher heating value (about 50 MJ/kg) makes it a very clean and efficient fuel for household cooking as compared to other fuels like natural gas, kerosene, firewood, etc. LPG as fuel is devoid of major health hazards as compared to usage of firewood, biomass, etc. Auto LPG is free of lead and is very low in Sulphur thus decreasing the exhaust emissions. It is also good for engines as they do not need any extra maintenance and do not require frequent refilling like CNG.

2.5. Intensifying Exploration and Production (E&P) efforts

International Oil Companies demonstrated a subdued participation in the 2008 and 2012 bidding rounds in Bangladesh. Certain clauses in the existing Production Sharing Contract (PSC) act as a deterrent in the face of foreign participation. Bangladesh witnessed lukewarm responses from International Oil Companies (IOCs) in its previous bidding rounds. Many IOCs refrained from participation citing 'inadequate fiscal terms'. In addition to unfavourable fiscal terms, lack of adequate seismic data and information discouraged the potential IOCs to participate in the bidding round. Certain conditions in the PSC appeared restrictive to the International Oil Companies when it came to participating in Bangladesh's bidding round. Some of them are listed below:

1) Contractor has the option to sell Contractor's share of Natural Gas in the domestic market to a third party, at a price and on such other contractual terms as the Contractor may negotiate and agree, subject to Petrobangla's right of first refusal

2) Cost recovery limited to 55% of all available oil, gas or condensate from the contract area

3) Current price of gas is pegged at USD 5.5 per thousand cubic feet

4) No tax holiday during the entire exploration, development and production phases

National Oil Companies (NOCs) are financially constrained to acquire latest state of the art facilities. NOCs are bound by processes to procure goods and services resulting in delays. This entails time and cost overruns due to delays in field operation. They incur higher costs when compared to their IOC counterparts for similar E&P efforts. They are constrained by technical capabilities to work in risky and challenging offshore projects. Hence,

there is a case to put in place a comprehensive Project Management Office for National Oil companies to accelerate their Exploration & Production efforts.

2.6. Coal based power plants

Bangladesh has around 3,100 million tonnes of high quality domestic coal reserves, with around 13% (402 MT) of reserves being under 'proved' category. Owing to its capacity to cater base load requirements and with the depletion of natural gas, coal has significant importance for the future generation capacity addition plans of Bangladesh.

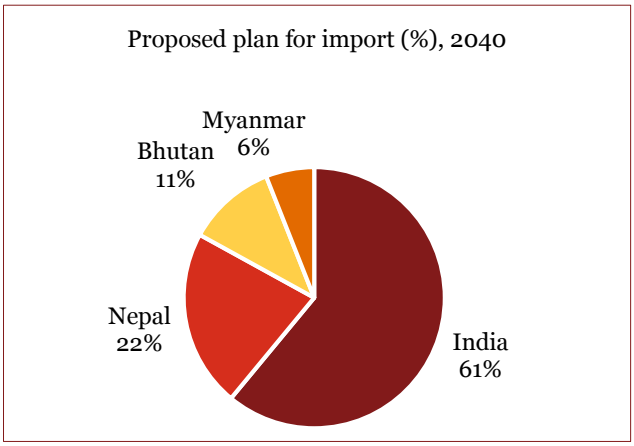
Considering the need, GoB has shifted its focus on coal and has proposed National Coal Policy to facilitate domestic mining, which is in its final draft stage. The key objective of this policy is to boost the national coal production, ensure steady supply of coal, and is expected to allow joint ventures (JVs) between local partners and foreign firms to explore and develop domestic coal mines in country. However, domestic coal mining in Bangladesh possesses some key concerns such as ground water depletion, water pollution, R&R issues etc. which makes domestic coal mining operation expensive. Therefore, with the challenges in development of domestic mines coupled with the increasing demand-supply gap of electricity, has opened up the option for imported coal.

As per Power Sector Master Plan (PSMP), around 16.5 gigawatt (GW) of imported coal based power plants are being planned and are currently under various stages of development in Bangladesh. Bangladesh's being adjacent to sea on one side is in strategically advantageous position in terms of coal imports. Australia, Indonesia, and South Africa are considered as preferable location for sourcing of imported coal. Moreover, cost of electricity generation from imported coal based generation is significantly lower than domestic coal based generation which makes imported coal an affordable option for electricity

Type	Estimated generation cost	
	US cents/kWh	BDT/kWh
Domestic coal	9.7	7.65
Imported coal	7.7	6.3

However, imported coal based power generation on one hand will call for various infrastructure development like, port, coal handling facility, strengthening transportation logistics facilities and logistics management capacity. On the other hand, it will require adequate environment and social protection measures, commercial agreements to source coal on long term with necessary risk mitigation to commensurate the development.

2.7. Cross border power import



Electricity demand-supply mismatch in Bangladesh is growing due to increase in demand every year, declining rate of domestic natural gas production and over reliance on single fuel source by the sector. One of the promising solution to address this concern is import of power through cross border interconnections. Analysis shows that neighboring countries including India, Nepal, Bhutan and Myanmar are going to be power surplus in near future and has the potential to offer low cost power. For example, the estimated cost of imported power at Bangladesh border from (one of the hydel power station in) Bhutan shall be BDT 5.7/ kWh, as compared to BDT 6.70/ kWh of Barapukuria coal based power plant. This shall also reduce the dependence on use of scarce land and domestic fuel reserves.

Various regional cooperation initiatives like South Asian Association for Regional Cooperation (SAARC) Energy Cooperation, Bangladesh, Bhutan, India, Nepal (BBIN) initiatives, ADB's South Asia Subregional Economic Cooperation (SASEC) and United States Agency for International Development (USAID) South Asia Regional Initiative for Energy (SARI/energy) are currently working towards facilitation of cross border power trade in the region and likely to drive these initiatives with the help of respective national government.

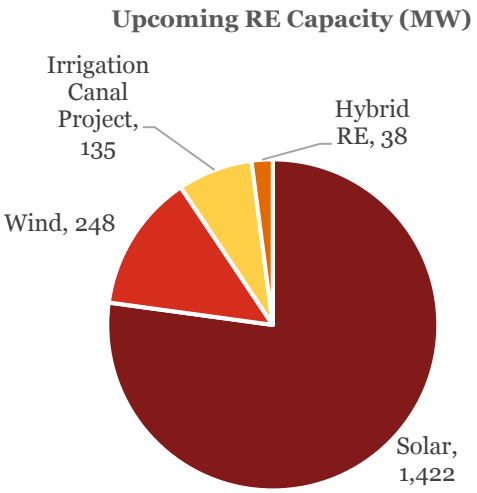
PSMP of Bangladesh envisaged that about 15-20% of total power supply, equivalent to 8.5 GW, shall be imported by 2040. Currently, Bangladesh is sourcing 600 MW of power from India and has plans to increase it further by another 500 MW in near future with the construction of second 500 MW transmission line from Baharampur to Bheramara. In addition, joint development of hydropower projects in Nepal and Bhutan (for projects including Dorjilung, Sunkoshi 2, and Sunkoshi 3 Hydel power plants) are under discussion.

Requirement of sovereign approvals from national governments may lead to long gestation period of the cross border power projects, especially when more than one countries are involved (say, Bhutan-India-Bangladesh). Sovereign consent on commercial transactions (between private agencies and BPDB), can also be challenging considering minimal benefit to intermediate country (like India). However the SAARC agreement for regional energy corporation is already in place and is currently under ratification by GoB. However various requirements in terms of regulatory harmonization, proper commercial arrangements, operating procedure etc. need to be in place to successfully carry-out cross border power trading. Other regional initiatives are also targeting to facilitate and smoothen these transactions.

2.8. Alternative and renewable energy

The need for alternate source of generation, off-grid supply to remote areas and increasing concerns related to environment has urged the government to focus on development of renewable energy (RE) (incl. big hydel power plants). In order to develop RE potential in the country, GoB has established a dedicated agency namely Sustainable and Renewable Energy Development Authority (SREDA) and also set targets of 100 MW of each solar and wind for various public sector generation utilities. GoB has plans to explore other RE sources like municipal solid waste and biomass which has decent generation potential mainly near cities and agriculture areas respectively.

Currently, over 1800 MW of RE projects are under various stage of development. The break-up of this upcoming renewable energy capacity shows that the major contribution in renewables will be from solar and wind accounting for more than 90% of total capacity.



However, considering the scarcity of land resource, ground mounted solar energy projects would be difficult to deploy and therefore there is a need to explore innovative models of grid connected roof top solar or hybrid sources of energy like solar-biomass to facilitate the use of RE which can in a way facilitate the government to give away with subsidies on supply of electricity for these consumers in future.

In addition, as the development of RE requires higher project cost and has high cost of generation compared to coal and gas, it require incentives and subsidies like tax incentives, feed-in-tariff (FiT) to make projects financially viable and investor friendly. To facilitate various incentives, GoB has come up with a RE policy in 2008 and is currently revising the existing policy to make RE generation viable and attract investors.

3. Ensuring Energy Security – Way Forward

The way forward has been developed based on the detailed analysis of various available energy sourcing options and inputs of key stakeholders for further necessary action by GoB, power and energy sector entities/ agencies and ADB.

3.1. LNG, LPG and E&P efforts

Imported LNG option ranks medium on affordability, high on reliability, medium on adequacy, medium on accessibility and high on sustainability. Hence, overall impact on energy security of Bangladesh is expected to be high. It may be noted that LNG based power plants can cater to base load of Bangladesh and provide a reliable source of electricity. Bangladesh has planned a few RLNG based power plants in the coming years. Also, the gas needs of several upcoming Economic Zones and existing Export Processing Zones can be catered to with future LNG imports. Building the enabling infrastructure shall be critical to ensure accessibility of RLNG to these demand centres.

Bangladesh is already planning Conventional LNG terminals/FSRUs which involve a gestation period of 4-5 years to commission. To meet the gas shortage in the short to medium term, Small Scale LNG has emerged as the next best alternative. Cost competitiveness of SSLNG vis-à-vis imported liquid fuels makes it attractive for stranded and upcoming gas based power plants and industries, who otherwise have to depend on imported fuels in view of current gas deficit in Bangladesh. Lower cost, modular nature and quicker turnaround time strengthens the case to explore this option as Bangladesh needs to secure avenues of accelerated access to hydrocarbons. Specific policies & regulations and enabling infrastructure & logistics network are critical success factors to make this option a reliable source of energy in the country.

Infrastructure constraints for import, storage, supply and distribution of LPG in the country may hinder accessibility and adequacy of LPG supplies in the country. Affordability of LPG when compared with low priced natural gas may pose a roadblock in LPG usage. Overall LPG may be considered a highly attractive option for energy security subject to appropriate policy and institutional level interventions and infrastructure investments.

In the current low crude oil price scenario, International Oil Companies may not be incentivised to invest given the returns not being commensurate with the risks involved. Key regulatory and policy changes in the existing PSCs may incentivise foreign participation in the future bidding rounds in Bangladesh and help meet the country's rising gas demand. There is a case for increased role of NOCs in accelerating domestic E&P activities.

3.2. Coal based power plants

To facilitate the development of domestic coal sector and imports the following key institutional level changes can be considered by GoB:

- A national level agency to address aspects such as overseas mine acquisition, supply contract, coal quality, supply chain management and associated market risk.
- Integrated Energy Policy for development of domestic coal sector to ensure policy framework, institutional development, and attracting investment.
- National level apex body should be set up to approve the plans and strategy for development of the mines and minerals sector.
- A ministry level body should be set up to deal with various agencies and facilitate in exploration license, mining lease, etc.,

- Two corporate bodies should be set up, to deal with development of coal & other minerals sector respectively.

3.3. Cross border power import

To facilitate the development of cross border energy trading (CBET) the following policy framework and institutional level interventions can be considered:

- CBET framework and policies such as SAARC framework agreement
- Bilateral frameworks such as power trading agreement between countries
- A forum of regulators to formulate common rules & regulations, codes & standards, etc.
- A forum of national level system operators to formulate detailed guidelines for grid and market operations
- A forum of national level transmission operators to co-ordinate and plan cross-border links
- Scheduling and despatch framework and timelines to be defined
- Regional power exchange for South Asian Countries
- Model Power Purchase Agreement (PPA) / Transmission Service Agreement (TSA) for CBET
- Transmission pricing framework and access rules to be defined for intra-country network

3.4. Alternative and renewable energy

To facilitate the development of renewable energy sector in Bangladesh the following policy framework and institutional level interventions can be considered:

- Reduction in Value Added Tax (VAT) or other sales taxes, exemption of import duty
- Tax credit on Research and development (R&D) activities on renewable energy
- Capital subsidy, grant and rebates for RE projects
- Introduction of preferential feed-in tariff (FiT)
- Introduction of accelerated depreciation, viability gap funding and generation based incentives
- Favorable policy implementation, such as policy for solar rooftop, waste to energy, provision in tariff policy to mandate certain percentage of renewable purchase / generation obligations

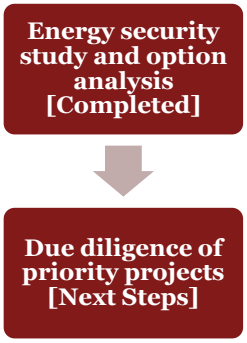
3.5. Project prioritization and due diligence of top priority project

With the results of option analysis for energy sourcing in place, a list of projects in consultation with key stakeholders is required to be identified for undertaking next phase of assignment i.e., project prioritization and due diligence of top priority project. The key considerations to prioritize the projects would include technical, financial, economic, social and environmental aspects. Broadly, our approach will be, as outlined in schematic below:

4. Next Steps for TA 8839 BAN: Study on Energy Security

Based on our analysis of different energy sourcing/ power generating options, we have identified five major options that can be explored further as a part of this TA to ensure energy security in the country:

- Imported Coal based Power Plants
- Imported LNG (particularly SSLNG as a quick win solution)
- Power import from neighbouring countries
- Renewable Energy (particularly Solar power generation)



However, during and after the workshop presentation on option analysis on 4th May, 2016, it was discussed with ADB that there may be a requirement to shift from conducting detailed due diligence on one project to conducting pre-feasibility or analysis for a couple of options/ projects as next steps for this TA.

Thus, based on the outcome of our study, some of the options that can be taken up in the next phase are as mentioned in the table below:

Option No.	Option Title
Option # 1	Pre-feasibility study for a coal based thermal power plant
Option # 2	Pre feasibility study for a Small Scale LNG project
Option # 3	Analysis of policy and institutional interventions required for coal (both domestic and imported) sector development and addressing issues related to coal supply chain and logistics
Option # 4	Analysis of energy/ power import options from neighbouring countries and policy & institutional interventions required to facilitate such import
Option # 5	Pre feasibility study of a roof top solar power project
Option # 6	Pre feasibility study for feeder segregation at 11kV level for enhancing power distribution efficiency

The option (s) which would be taken up as next step of this TA 8839 needs to be discussed and agreed between GoB and ADB. Subsequently, we will discuss with ADB and the concerned nodal agency in Bangladesh on the scope, resourcing and timelines for the next step.

5. Appendices

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Appendix A. - List of person met for preparation of report

Sl. No.	Name	Designation	Organization
1)	Mr. Nasrul Hamid	State Minister for Power, Energy and Mineral Resources	GoB
2)	Mr. Len V. George	Energy Specialist	ADB
3)	Mr. Kamruzzamam	Assistant Director, Tariff	BERC
4)	Engr. Mohammad Hossain	Director General	Power Cell
5)	Mr. Amzad Hossain	Director, Commercial	Power Cell
6)	Md. Atiqur Rahman	Deputy Director, Wind mapping resource project	Power Cell
7)	Mr. A K Mahmud	Director, System Planning	BPDB
8)	Engr. Jorifa Khatun	Executive Engineer, System Planning	BPDB
9)	Muhammad Bellal Hossain	Executive Engineer, System Planning	BPDB
10)	Mr. Nazrul Islam	Director, Directorate of Renewable Energy & Development	BPDB
11)	Mr. Ahmed Zahir Khan	Director, Directorate of Renewable Energy & Development	BPDB
12)	S.M Sanzad Lumen	Assistant Director	SREDA
13)	Engr. Kamrul Ahmed	Assistant Director	SREDA
14)	Engr. Arun Kumar Saha	Chief Engineer	PGCB
15)	Mr. Md. Nuruzzaman	Executive Director, Finance	NWPGCL
16)	Engr. Muhammad Saifuddin Ahsan	Executive Engineer (Planning & Design)	NWPGCL
17)	Ibrahim Ahmad Shai Aal Mohtad	Executive Engineer (Planning & Design)	EGCB
18)	Dr. Himanshu Ranjan Ghosh	Lecturer	University of Dhaka
19)	Dr. Mohammad Abdur Rouf	Chief Scientific Officer	Institute of Fuel Research & Development, Bangladesh Council of Scientific and Industrial Research

Note: Names are not on seniority basis

Appendix B. - Meeting notes of Second Workshop on Energy Security

Record of Discussions

Date and Venue:	04 May 2016 at Bijoy Hall, Biduyt Bhaban, 1, Abdul Gani Road, Dhaka-1000, Bangladesh
Participants:	• Chairperson: Secretary, Power Division; Chief Guest: Honb'le State Minister for Power, Energy and Mineral Resources; Participants: High officials from the Utilities, Companies, Power Division and Energy Division representatives • ADB and PwC representatives.
Agenda:	Second Workshop for "ADB TA 8839 BAN: Study on Energy Security"

Key takeaways:

- Hon'ble Minister in-charge felt the need of conducting a focused meeting with Energy Division representatives on the energy security along with ADB and PwC, which is tentatively fixed on 12 May 2016.
- Amongst all energy security options presented to GoB, the options may be further narrowed down to help GoB formulate policies.
- The time horizon of recommendation- short term, medium term and long term for undertaking the option should be mentioned for the options
- As one of the primary sources of energy is HFO, Liquid fuel based power generation may be included as a part of the report
- For suitable PPP model suggested for developing LPG supply and distribution infrastructure, it needs to be assessed if there exist gaps in existing PPP model and suggest ways to overcome it
- Opportunity value of fuels and comparative analysis of prices to be included as part of the report
- The time and costs incurred from point of import of LNG to point of delivery should be assessed
- Findings of Energy Security study should be integrated with other on-going studies including PSMP and GSMP
- The energy security study shall include the quantum of how much a Bangladesh should rely on Imported Power/ Electricity
- Environment and Climate Change related to options to be included in the report.
- As current HFO prices are low, the figures for cost of HFO based generation in the slides be revised
- The draft requirements and costs of Small Scale LNG and FSRU to be validated and provided in the report
- Considering the concerns of pressure of LNG, location of power plant and SSLNG unit may be studied further.

- The sector "Others" be elaborated upon with regards to Energy Efficiency and Conservation measures in the report.
- Whether scope for increase in hydropower capacity does include the social and environmental factor? Response: Hydropower potential although low and cannot serve base load but should be developed to meet other purposes like ancillary service and can help in grid stabilization. Social and environmental assessment will surely be carried out at the time of development of hydropower plant.
- There was a clarification on why realization of economic value of gas in fertiliser sector is low and social obligation is high. Economic value of gas used in fertiliser sector is low owing to high cost of production of fertiliser in Bangladesh as the sector uses obsolete technology and are inefficient. Given that fertiliser is a subsidized product, the social obligations of using gas is high but economic value is low.
- With regards to use of ethane in power sector, it was mentioned that use of ethane for cracking and thus its use in petrochemical sectors is high.
- Why Nuclear power is not addressed in the presentation: Nuclear power development requires high technical and management capability which is currently lacking in Bangladesh. In addition it requires safety management policy to be in place. Moreover, waste treatment plant is a part of Nuclear facility which adds to the cost and waste disposal is a challenge. Considering the benefits and challenges, decision for development of Nuclear power plant may be taken by the GoB. Detailed report contains an overview of on-going and future plans of GoB on Nuclear.
- Issues in related to coal supply chain need to be addressed in the report.
- Small Scale LNG may be further explored form implementation point of view.
- PwC communicated that draft energy security report contains the detailed analysis of various energy sourcing options including analysis of Adequacy, Reliability, Affordability and sustainability aspects and the presentation delivered on 4th May 2016 was a summary version only.

Appendix C. - Draft Final Report on Energy Security

Attached separately.

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