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ADB TA 8839 BAN: Study on Energy Security

Draft Final Report on Energy Security

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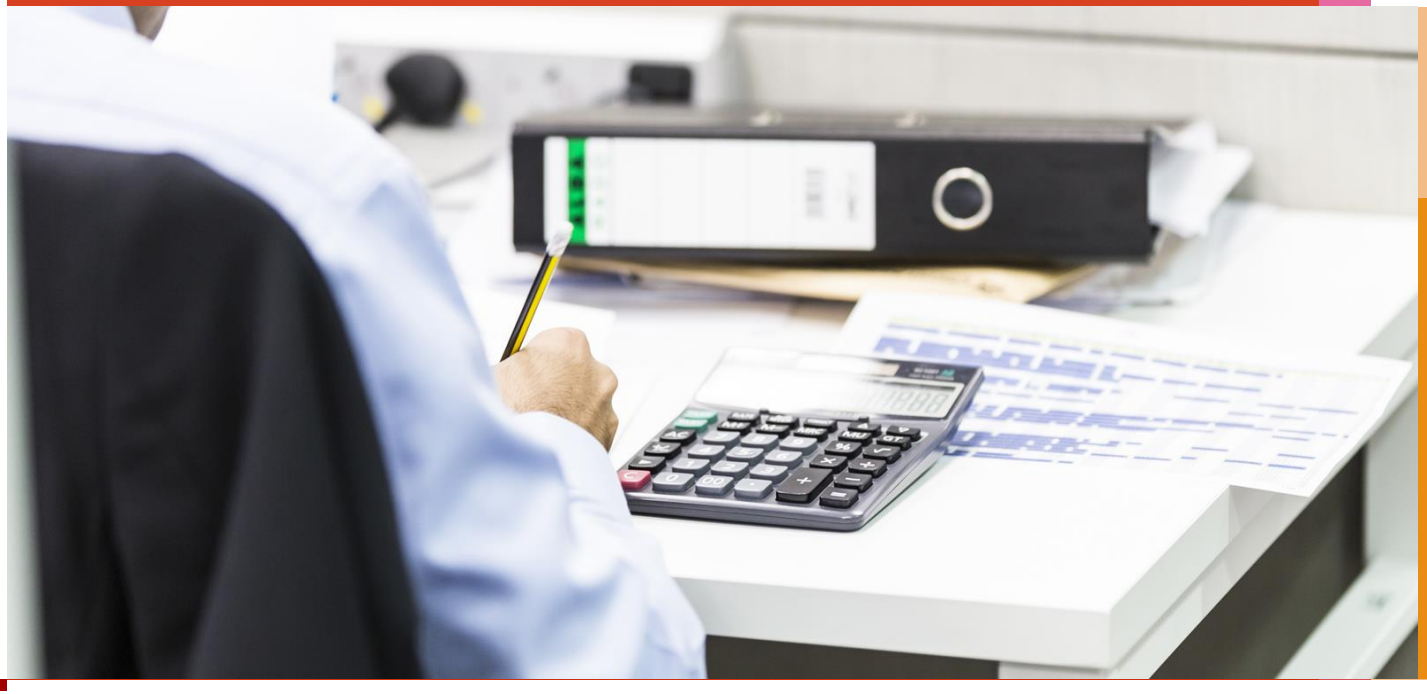
Draft

June 2016



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Introduction

Section 1.1
TA Overview and Progress Update

Key objectives of TA 8839 - Study on Energy Security

Fuel diversification option to ensure energy security

- Assessment of energy security issues and alternate fuel options from the perspectives of adequacy, affordability, reliability and sustainability
- Suggestions on interventions required to develop alternate fuel sources for ensuring energy security

Identification of priority projects

- Identification and prioritization of projects for ensuring energy security based on factors like envisaged power supply position, project development period, fuel availability, developments of associated infrastructure like fuel handling, evacuation etc.

Due diligence of priority project

- Due diligence (technical, financial, economic, environmental and social) for one project which to be taken up for development by development partners or private players

The original objective was to conduct the energy security study, identify a priority project and then conduct due diligence of the top ranked project; however, during the course of the study it was discussed that the Energy Security study should identify different priority areas so that GoB, ADB and other stakeholders can agree on next steps to ensure Energy Security for Bangladesh.

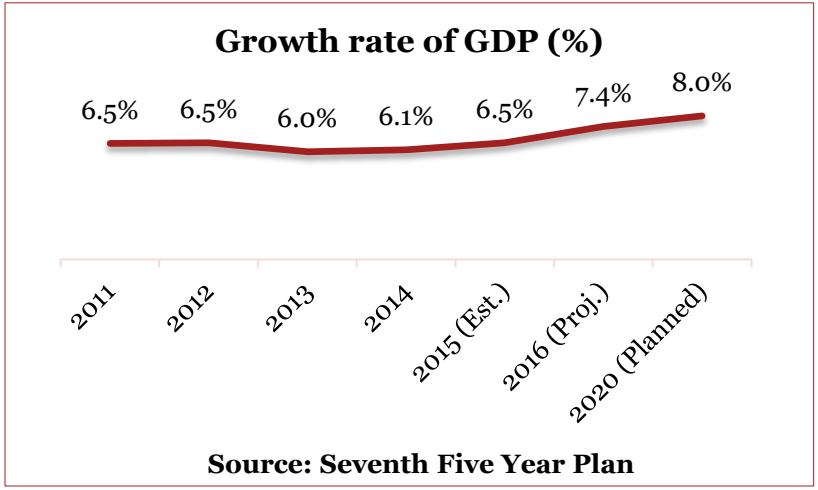
Progress till date

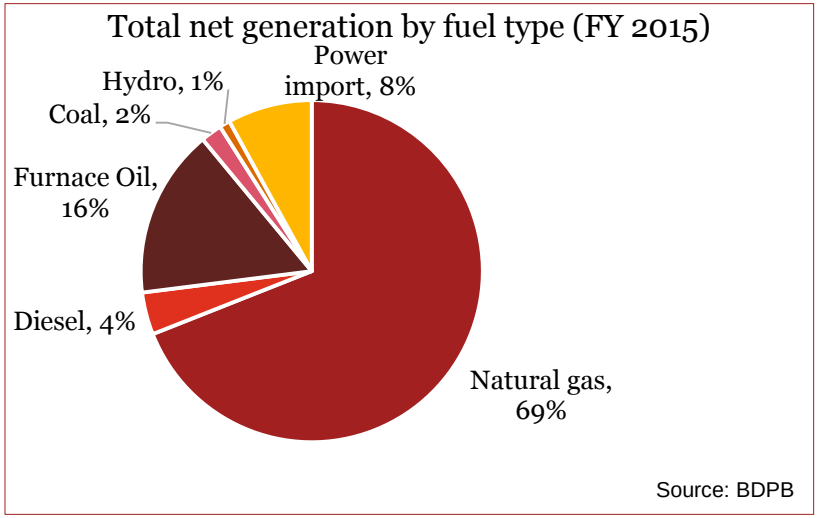
December 2015	• Contract signing and project kick-off
December 2015 – January 2016	• Preliminary interactions with different stakeholders (Inception phase)
21st January 2016	• Inception presentation
February 2016	• Submission of Inception Report to BPDB
February 2016 - March 2016	• Detailed discussions, data collection and analysis for fuel option analysis
7th April 2016	• Submission of draft report on option analysis
April 2016	• Discussions on draft report with different stakeholders
4th May 2016	• Presentation on option analysis

Section 1.2
Background and Context

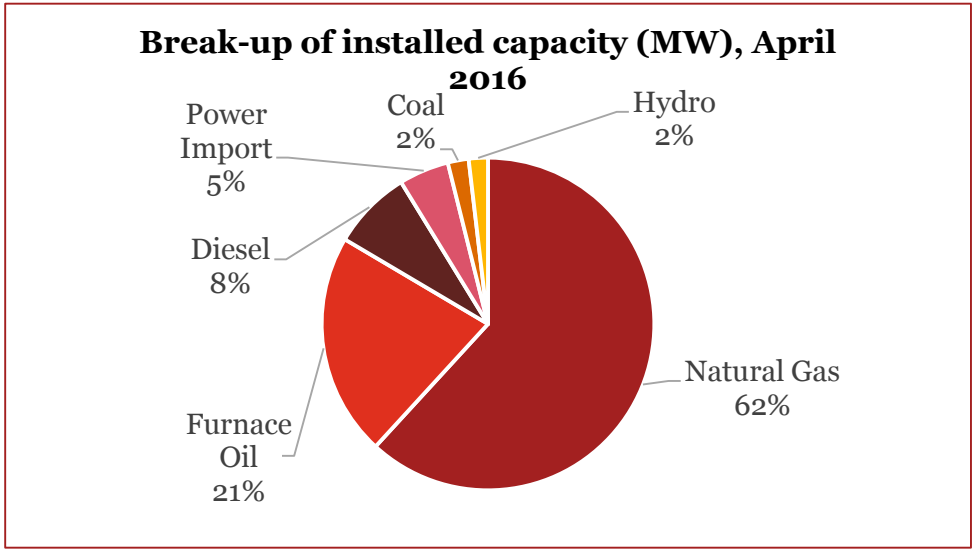
Background and context

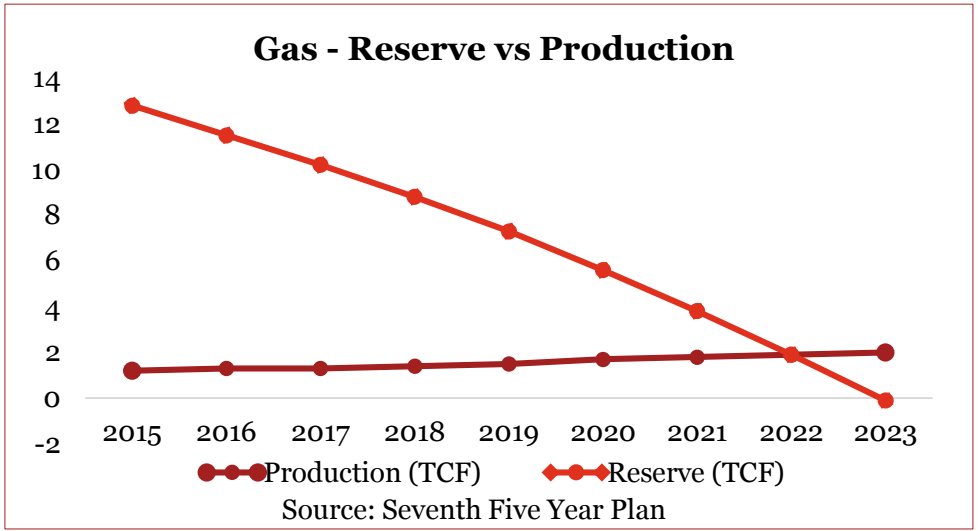
- Bangladesh, mainly an agrarian economy, has a gross domestic product (GDP) of USD 172.9 billion in 2014, which has been increasing at an average of 6.4% in the last 5 years.
- With increase in population and expansion of economic activities, the demand for electricity has increased with peak demand increasing by 8-9% in the last 5 years.
- However, energy access (74%) and per capita consumption of 331 kWh electricity has not increased much and is still low compared to some other developing countries.
- The reason for this low access and demand supply mismatch can be attributed to single fuel dependency for power generation i.e. natural gas, which has been depleting continuously and this leads to under utilization of power plants.





Limited domestic reserves is key driver for import of primary fuel sources





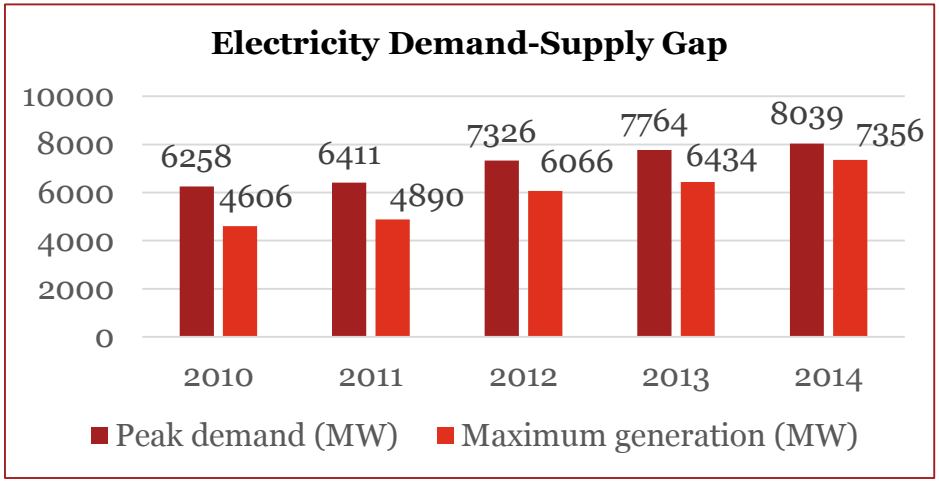
Domestic Gas

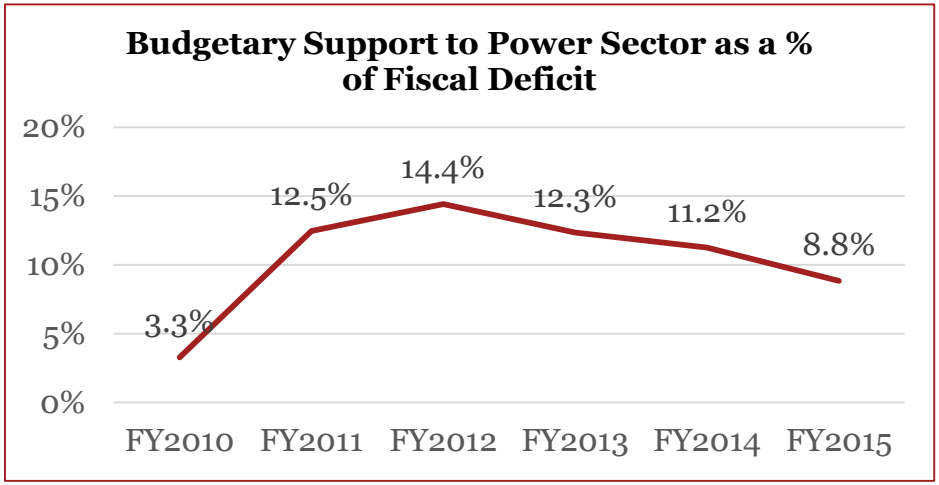
- The demand for natural gas has been increasing at a rate of 6.5% whereas supply growth rate still stands at 5% (last decade).
- In addition to low production, the reserves are also estimated to be exhausted by 2023 if no new gas fields are explored (Current reserve to production ratio stands at 10:7).
- However some potential has been estimated to be present in off shore areas but limited success has been achieved till now.

Domestic Coal

- Bangladesh has reserves of 3,100 million tons of coal with 13% in the proved category.
- Although high grade of coal is produced having high energy content and low sulphur but mining of coal fields are very difficult due to social and environmental challenges which limits its production.

Widening D-S gap, electricity pricing and subsidy continue to pose challenges for policy makers

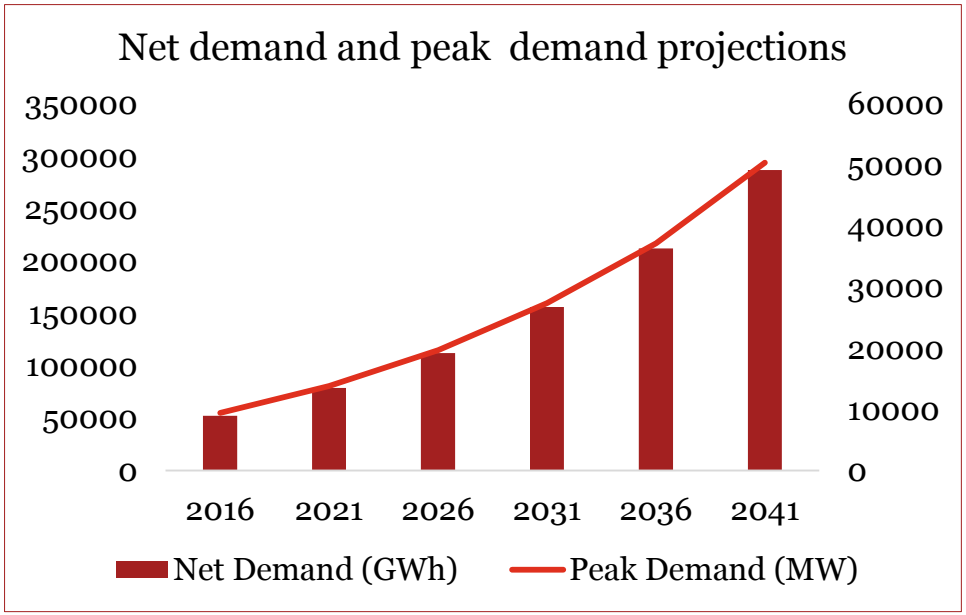




- Large dependency on gas (70% of total energy generation) and its non-availability has forced many power generation plants to operate at lower level of efficiency.
- This keeps the total capacity underutilized thereby resulting in demand supply gap (around 700 MW gap in 2014).
- In addition, a number of aged assets have also lead to inefficient utilization of natural gas
- Moreover, with decline in the rate of production of natural gas, the use of furnace oil has increased leading to increasing cost of generation.
- To cover the increased cost of generation and to keep tariff at an affordable level, GoB had to provide Taka 77 billion as budgetary support in FY 2015

Demand-supply projections and fuel diversification options as per draft PSMP 2015

- The demand for power has shown an gradual increase of 40% in every 5 year which will require supply to increase at more than 40% considering reserve margin and other losses
- Considering the depletion of gas reserves, fuel diversification is imperative to meet the growing demand in near future and ensure energy security
- The draft PSMP 2015 suggests an alternative mix of gas and coal keeping the fraction of oil, renewable and nuclear at a constant percentage in the mix.
- **This suggests the requirement of either imported LNG or imported coal as a major fuel for future power generation capacity addition.**



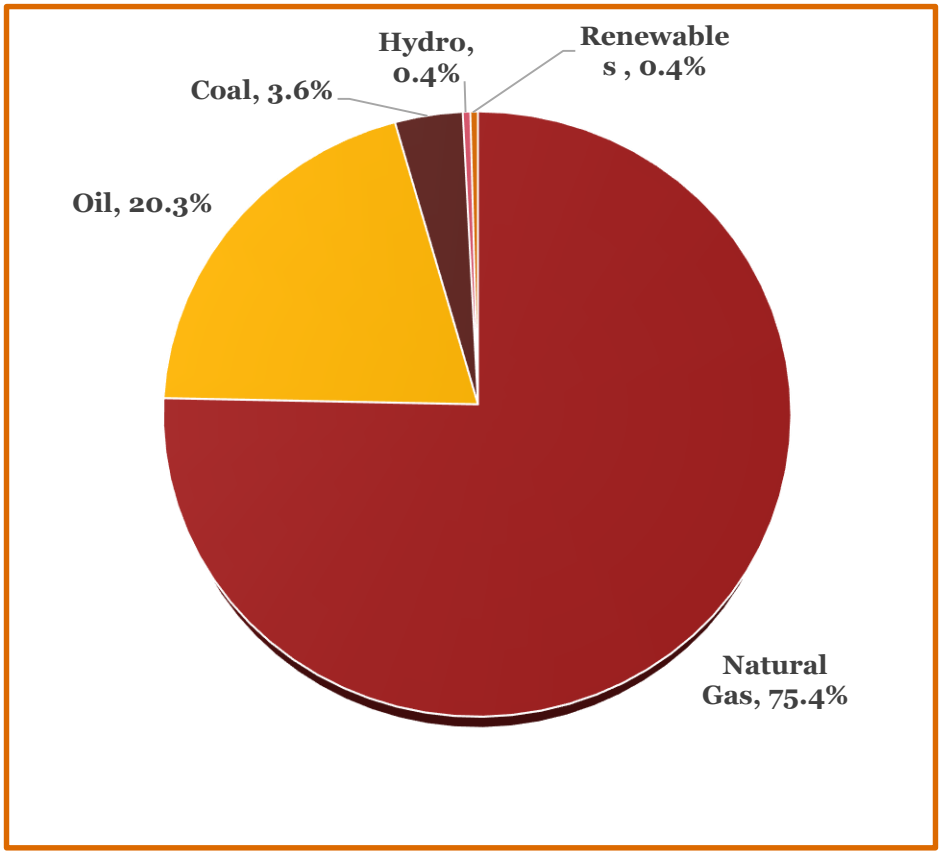
Fuel diversification options

Fuel type	Gas	Coal	Oil	Others
% Range	15%-55%	55%-15%	5%	25%

Section 1.3
Gas Demand-Supply Scenario

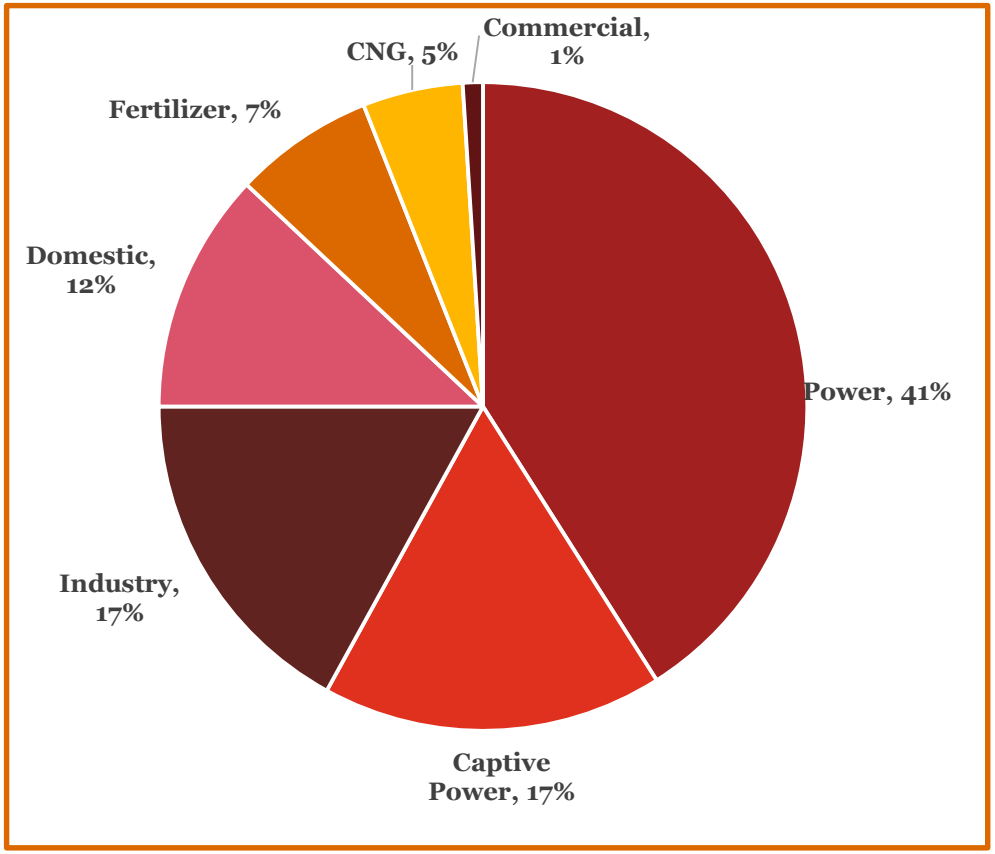
Gas continues to be the primary driver of socio-economic growth. The outstanding demand calls for efficient use and supply boost.

Primary Energy Consumption in 2014-15: **28.1 MTOE**



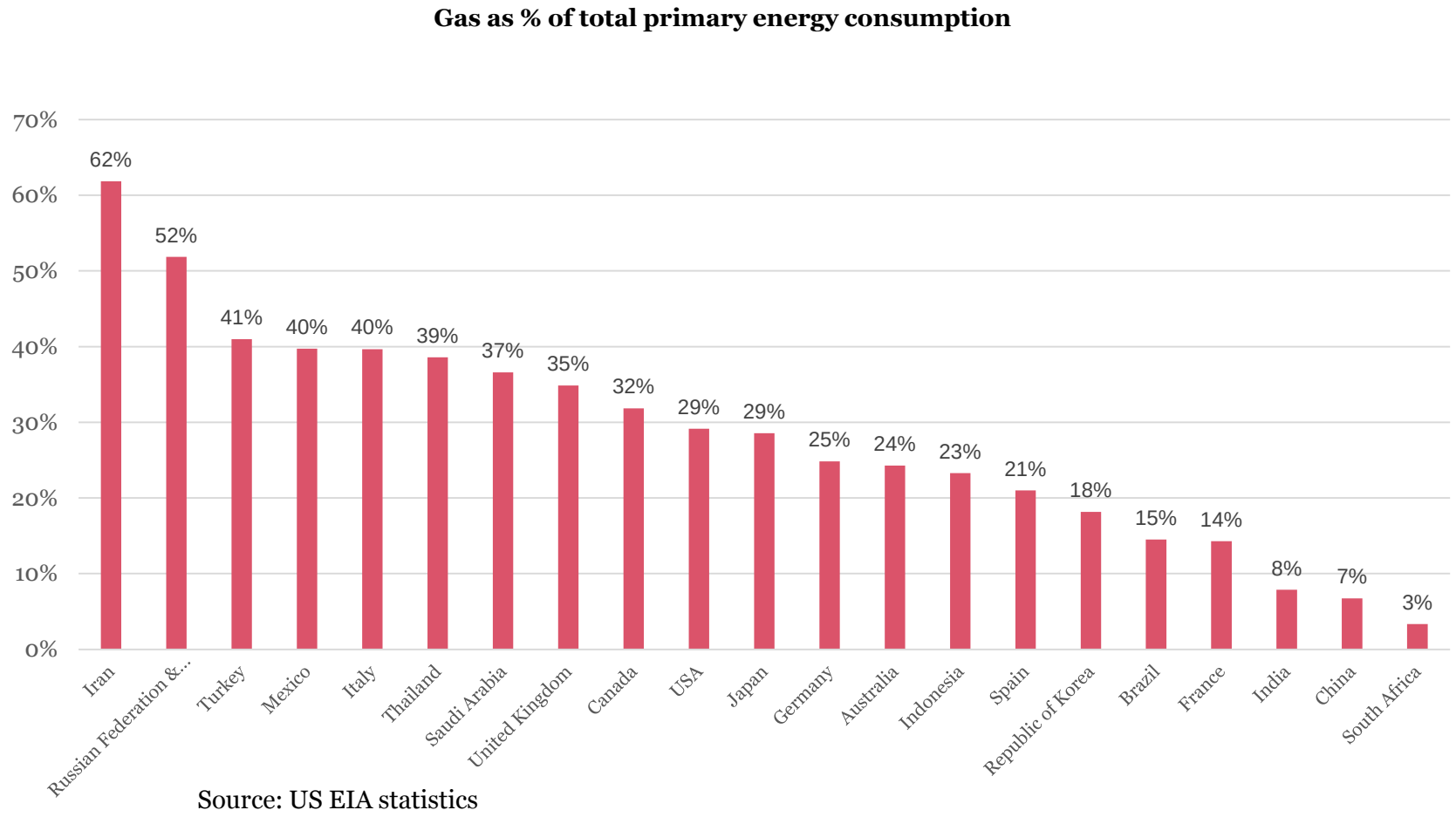
Source: BP Statistical Review of World Energy 2015

Total Gas Consumption: **2500 MMSCFD**



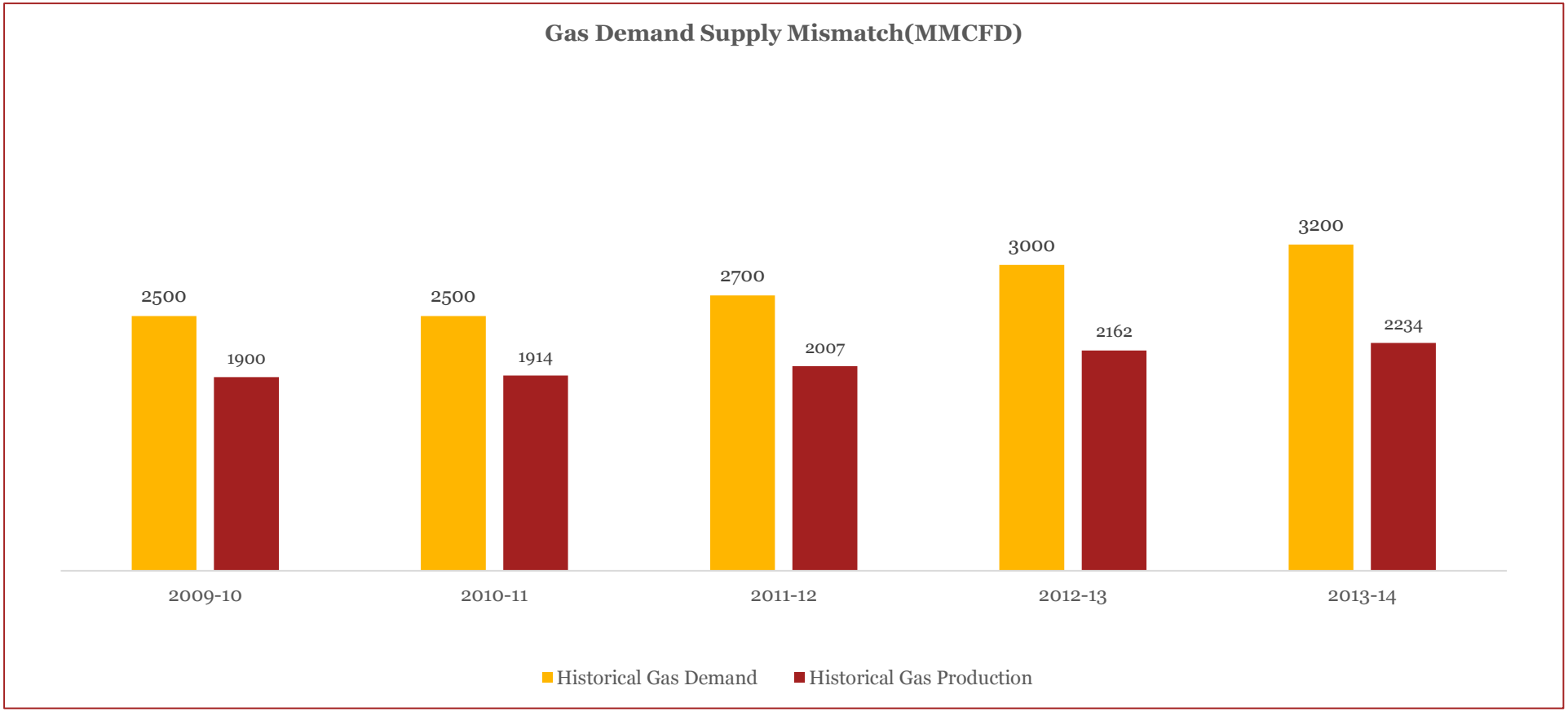
Source: Petrobangla Annual Report 2013-14

The dependence on natural gas in Bangladesh economy is much higher when compared to other gas based economies with gas constituting more than 3/4th of total primary energy supply



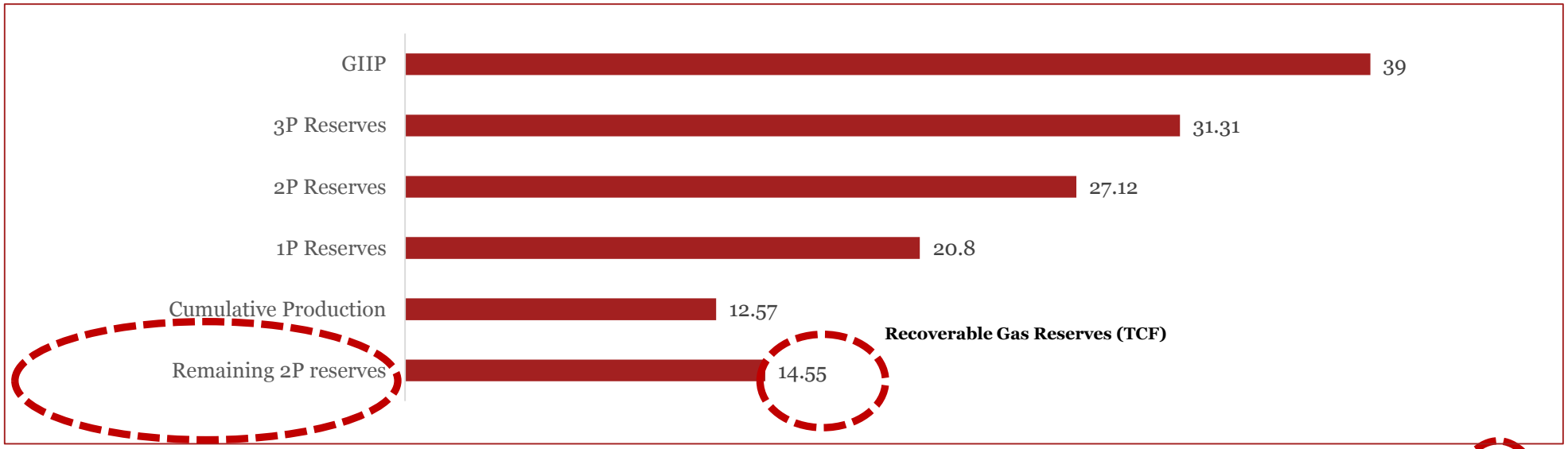
Source: US EIA statistics

Although domestic Gas Production grew around 5% over last decade, the production growth has failed to match gas demand which is increasing steadily in line with faster economic activity (6.5% GDP growth) thus widening the demand-supply gap



Source: Petrobangla Annual Report 2013-14

Bangladesh has one of the lowest Reserve to Production Ratio of 10:7; In the absence of further successful exploration & development activities, the existing gas reserves are expected to be depleted in the next 10 years



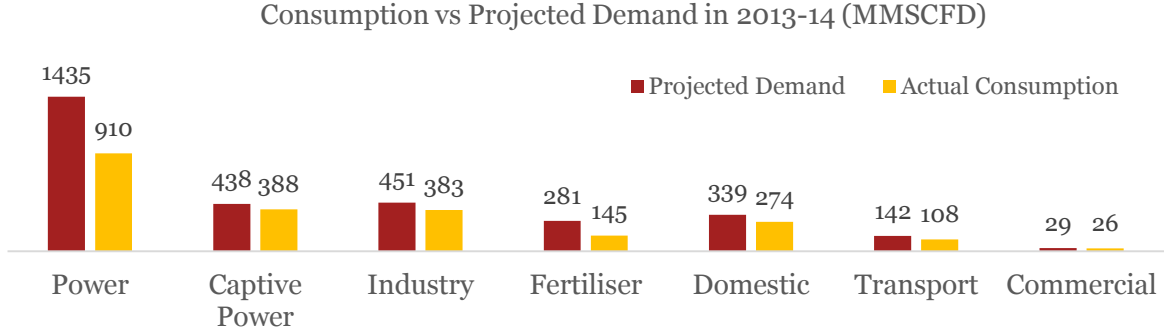
Source: Petrobangla Annual Report 2013-14

Year	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26
Production(TCF)	0.99	1.06	1.12	1.19	1.26	1.34	1.42	1.50	1.59	1.69	1.79
Cumulative Production(TCF)	0.99	2.05	3.18	4.37	5.63	6.97	8.39	9.89	11.48	13.17	**14.96**

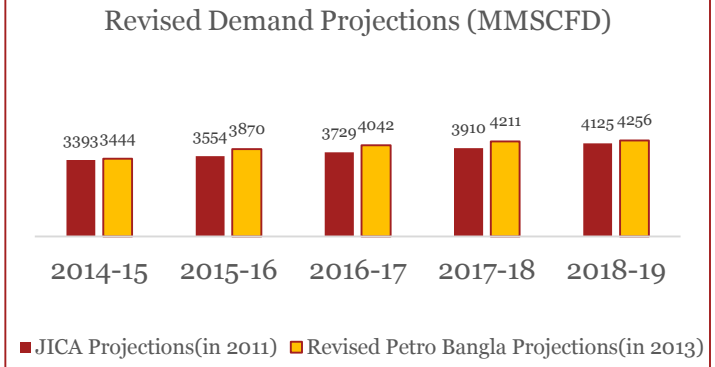
Note Assuming a conservative 6% annual increase in production considering historical growth and planned augmentation programs

Gas demand has grown faster than projected with increasing socio-economic developments in the country

Natural Gas consumption (2234MMSCFD in 2013-14) has grown at around 6% over last 10 years. However, it has been lower than projected demand across sectors implying supply constraints



Source: Petrobangla Annual Report 2013-14 & JICA Gas Survey 2012

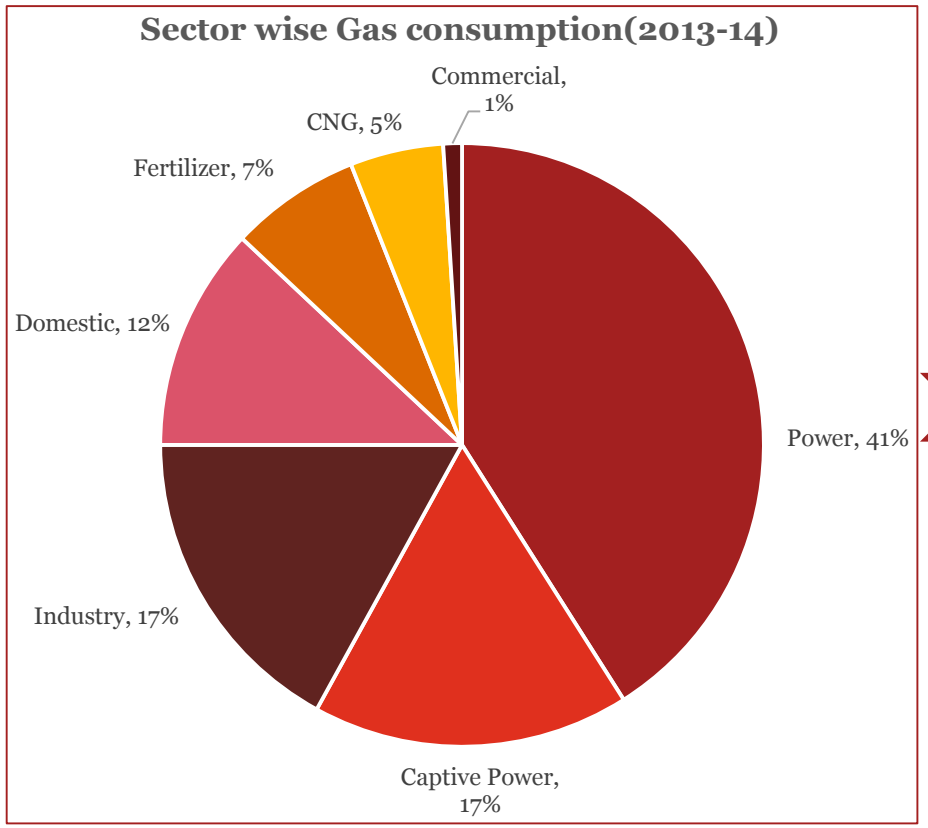


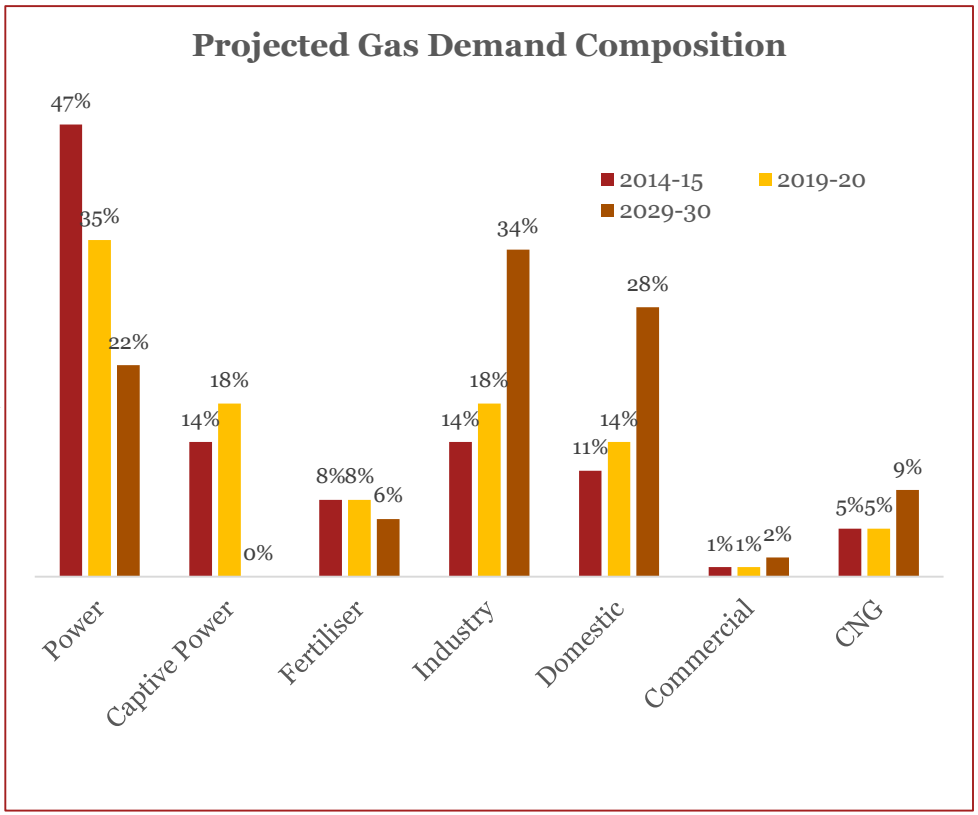
Source: Petrobangla Annual Report 2013-14 & JICA Gas Survey

- According to JICA report, for bulk sectors like power and fertilisers, projections are made on the basis of estimate of BPDB and Fertiliser authority based on the planned projects in next 5 to 10 year
- For non-bulk sectors, it is fist disaggregated at franchise level, their historical consumption is analysed. Thereafter, strength of relationship between sector demand and GDP is estimated.

Disclaimer: Demand Projections taken from various agency reports need to be validated and updated from primary sources

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





Source: Petrobangla Annual Report 2013-14

Source: JICA Gas Survey 2012

Disclaimer: Demand Projections taken from various agency reports need to be validated and updated from primary sources

Assessing patterns in sectoral gas consumption is necessary for efficient allocation of scarce gas resources & exploring opportunities for fuel diversification (1/3)

Power

- 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
- Current installed capacity of gas based power plants : 7628 MW. 2300 MW added in last 5 years and 4031 MW planned in next 5 years
- Moreover, the 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 45-50% if found technically and economically feasible by converting some of them into combined cycle. There are initiatives proposed to be undertaken for repowering of gas plants implying conversion to combined cycle.

- Plants have been **running below capacity** due to gas supply constraints. In January 2016, **680 MMSCFD out of 1548 MMSCFD demand could not be met.**
- With new capacity addition, the sector's **unmet demand is set to increase further**
- **Addressing energy efficiency issues** of existing and upcoming plants can be one of the ways to reduce the demand supply gap

Assessing patterns in sectoral gas consumption is necessary for efficient allocation of scarce gas resources & exploring opportunities for fuel diversification (2/3)

Fertilizer

- According to Ministry of Agriculture, Bangladesh has an annual demand of around 50 lakh tones of fertilizer and of them 27 lakh tonnes are urea with are non-urea fertilizers. The annual manufacturing capacity of the country's six public sector factories is about 20-22 lakh tonnes per year but the production in the factories is below capacity.
- There is an annual domestic urea demand for 2.5 million tonnes. The urea demand is now managed through production from state-owned plants 0.8-0.9 million tonnes(annual capacity 1.8 million tonnes) and 1.6-1.8 million tonnes import. The import includes 0.4 million tonnes from KAFCO and remaining 1.2 million tonnes from abroad. The KAFCO plant is capable to produce 0.7 million tonnes of urea fertilizer annually if adequate gas supply is made available.
- KAFCO is also considering the second urea plant having production capacity of 1.2 million tonnes per annum that would go a long way to meet the domestic demand . To reduce the import dependency, the government is setting up Shahjalal Fertilizer Factory with the production capacity 1760 tonnes (0.6 million tonne per annum) of urea a day which is expected to be completed by mid 2015.
- The operations of Chittagong Urea Fertilizer Limited, Urea Fertilizer Factory and Polash Urea Fertilizer Factory, Ashuganj Fertilizer Factory and Natural Gas Fertilizer Factory in Sylhet have been suspended. However, Jamuna Fertilizer Company Limited in Jamalpur continues operation. These are the latest developments in the fertiliser sector in Bangladesh . JICA had made the projections based on new planned projects and also upgradation of old plant. However, not much progress has been made owing to shortage in gas supply.
- Currently, 2/3rd of urea demand is imported. wing to gas supply constraints, the fertiliser production of state owned factories was rationalised due to gas unavailability. Capacity of the private factory also remain underutilised due to gas supply issues.
- Most fertiliser factories ae **using obsolete technologie**s. This lead to inefficient utilisation and very high opportunity cost of using gas.
- Government's plans to suspend indigenous production & meet the **entire demand through imports** holds potential to derive greater economic value & reduce gas consumption further.
- The large scale conversion to more efficient fertilizer may be looked at . The use of imported gas being used for fertiliser sector may not be an affordable option as the end product price cannot be increased due to agriculture sensitivities.

Assessing patterns in sectoral gas consumption is necessary for efficient allocation of scarce gas resources & exploring opportunities for fuel diversification (3/3)

Industrial

- 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.
- 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-fueled boilers for this. However, **industrial boilers deployed in these industries tend to be highly inefficient**, with estimated thermal efficiency of 50%–80%.

- Although the sectoral demand is projected to increase substantially in future, **potential demand can increase further** with rationing of gas from CNG & domestic sectors
- 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.

Domestic & Transport

- With GDP growing at a healthy rate, demand for gas from domestic and transport sector is expected to increase significantly
- 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
- In energy terms, price of auto LPG is USD 33.94/ MMBTU whereas CNG price ranges between USD 11-12 /MMBTU. Price of Domestic LPG is USD 36.32/MMBTU compared to PNG price of USD 2.44/MMBTU

- In view of depleting gas supplies and intermittent Govt. interventions , 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 2 sectors

Successful and time-bound gap bridging measures are necessary to save the country from a gas crisis situation (1/2)

Initiatives	Assessment
LNG Imports • LNG terminal (FSRU) at Moheskhali with a regasification capacity of **500 MMSCFD** is expected to be commissioned by December 2017 • EOI has been invited for conducting techno-economic feasibility study of two **land based LNG terminals** at Moheskhali and Payra	• Moheskhali terminal commissioning is already 3 **years beyond its planned deadline** • Even when it becomes operational, it shall only serve **12%** of projected gas demand. **Significant time lag** expected for land terminals due to funding and infrastructure related issues • In this context, **Small scale LNG may be considered as short to medium solution to** meet rising gas demand
Fuel diversification from natural gas to LPG • Against the backdrop of declining gas production, the Government has suspended providing additional PNG connections to households, commercial establishments and industries. No new CNG stations are being set up. • Thus, LPG is gaining prominence as the next best alternative and also as potential energy source for a large section of the population relying on biomass based fuels • Several private players have been granted licenses for import, storage, supply and distribution of LPG in the country	• The potential LPG demand in the country is estimated to be 5,00,000 MT. Switching over to LPG usage by the 3 million households presently using natural gas is expected to create an additional demand of 20,00,000 MT • **Creating supply and distribution infrastructure** is essential for ensuring adequate and equitable access to LPG. Reducing the cost of logistics for • Role of Government and its agencies is a key enabler for developing a viable LPG industry

Successful and time-bound gap bridging measures are necessary to save the country from a gas crisis situation (2/2)

Initiatives	Assessment
Enhancing Domestic Exploration & Production (E&P) • **6 out of 26** discovered gas fields are yet to start production • Bangladesh has at least **8.4 TCF of untapped potential of on-shore gas resources** • Bangladesh plans to launch its **next licensing round** for several shallow water and deep-water fields in **2016**	• In the **low crude oil price** scenario, the level of participation from interested companies for new bidding and exploratory activities is expected to be limited • Blocks offered to International Oil Companies (IOCs) during 2012 **bidding rounds still remain in exploratory survey phase**. • Thus, **major additions in domestic production capacity appear to be a distant possibility** at least in the short term unless there are significant gas discoveries
Imports of gas • Renewed efforts to import gas from **Myanmar** • Possibility of importing gas from **North East India** • Exploring potential to import regasified **LNG (R-LNG) from India**	• Amidst geo-political constraints, imports of gas through pipelines from neighbouring countries in the short and medium term is certainly an option to explore in detail

Options for Energy Security

In the current context, the following are the four options for attaining energy security in the hydrocarbon sector :-

- **Accelerated access to gas** with the use of **conventional LNG** and quick turn-around implementation plan for LNG shipping & re-gasification based on the concepts of **Small scale LNG** and Ship to Ship Transfers
- **Developing** a viable business model for import, storage and distribution of **LPG**
- **Accelerate domestic Exploration & Production (E&P) activities** in on-shore and offshore blocks
- **Imports of gas** from **Myanmar and North East India**
- Policy level interventions are facilitate these options….also infrastructural investments

There been an increasing reliance on HFO based power generation owing to gas shortage in power sector

- Owing to dwindling gas supply, there has been an increasing reliance on using liquid fuels such as HSD, HFO etc. as fuels for power generation
- Most of the liquid fuel-based electricity has come from rental and peaking plants that were fast-tracked to address the power crisis
- The total Liquid fuel based power generation capacity in the country stands at 3631 MW
- As compared to gas based power generation, the cost of Liquid fuel based power generation has been higher.
- However, with crude oil prices plunging to a low, HFO prices have witnessed a decline thus lowering the cost of power generation

Section 2
Analysis of Options for Ensuring Energy Security

Options being considered for ensuring energy security

LNG Imports

- Conventional imported LNG
- Accelerated access to gas through LNG imports (Large and Small Scale)

LPG

- Increasing LPG penetration

Exploration & Production (E&P)

- Intensifying domestic E&P activities

Import of Gas from North East India and Myanmar

Coal Based Power Plants

- Domestic
- Imported

Cross Border Power Import

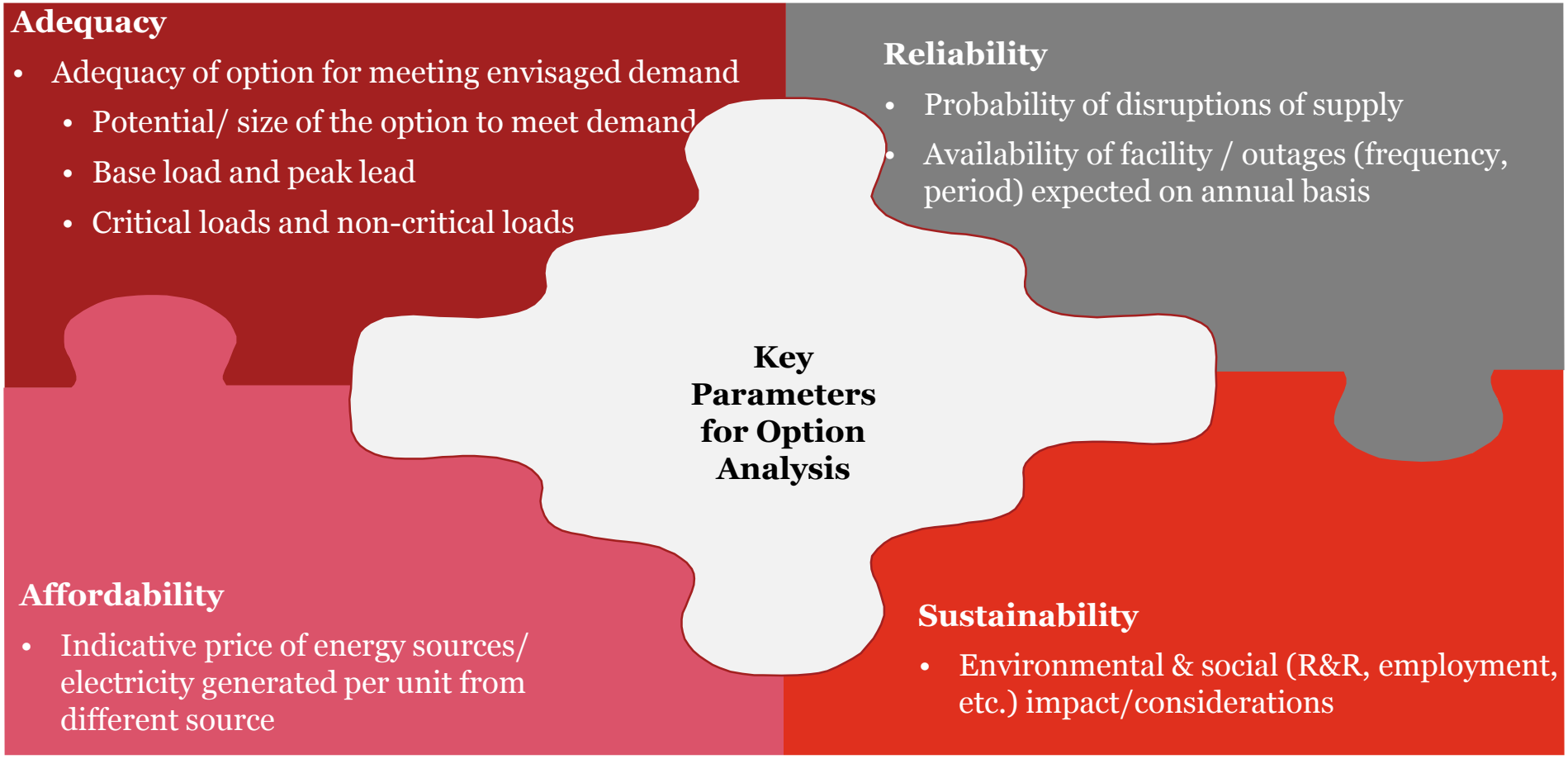
Nuclear Power Plant

Renewable Energy Development

- Hydro
- Solar
- Wind
- Others (Tidal, Geothermal, Biomass, Biogas, Waste-to-Energy)

Energy Efficiency & Conservation

Option assessment framework



In **Appendix 1** to this report, we have provided international case studies of policy level and institutional changes adopted by various countries to ensure energy security. The learning from this case studies have been used in assessing the various available options for Bangladesh and suggesting the next steps.

Section 2.1
Conventional Imported LNG

Developments on Conventional LNG in Bangladesh

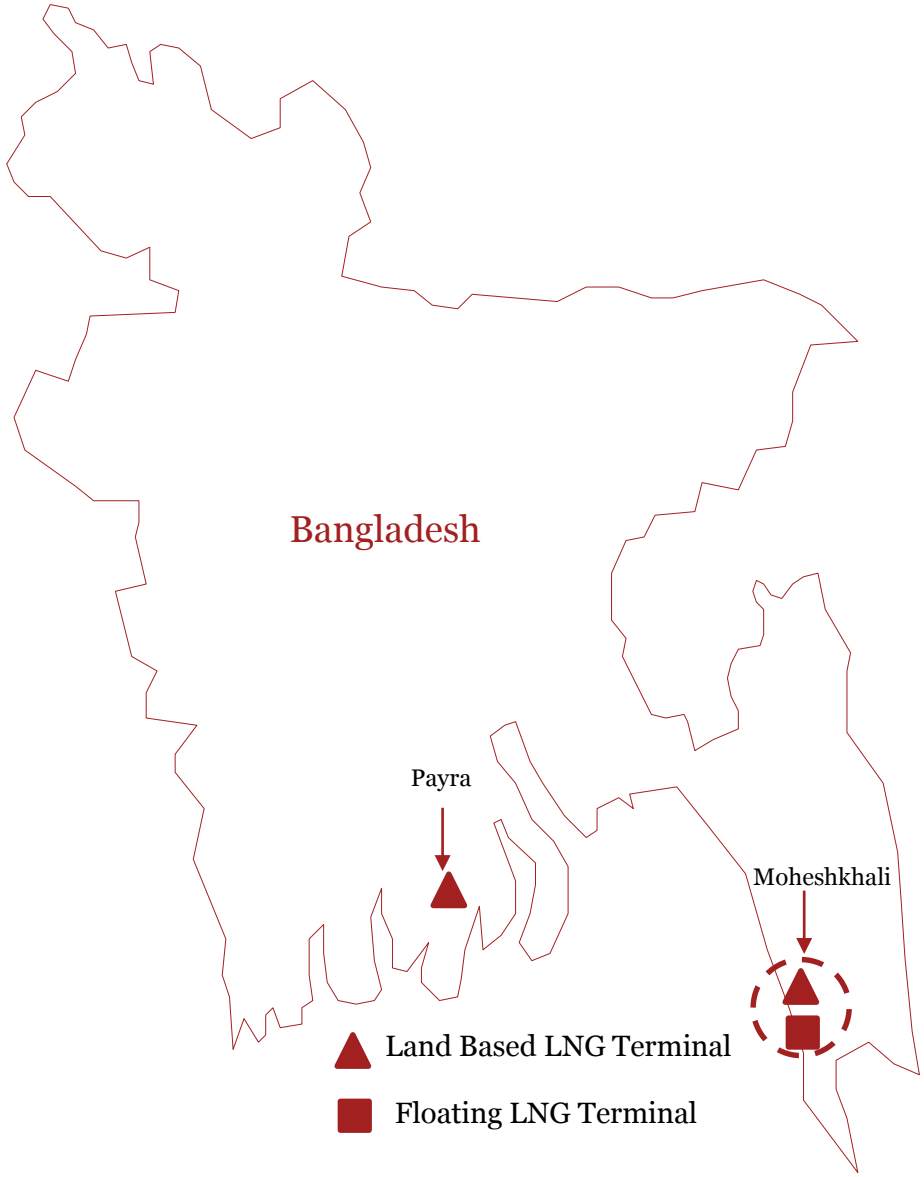
- In view of the depleting gas reserves, in the year 2010, the Government of Bangladesh (GoB) decided to go ahead with its plans of building a Floating Storage Regasification Unit (FSRU) and start importing LNG by 2013. However, the project failed to take off as per plans due to several constraints

- 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 of start of commercial operations. The terminal is expected to be commissioned by December 2017 and importing of LNG is likely to start 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** 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 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



Option 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

Impact of gas price on cost of generation for a standard 450 MW Combined Cycle Power Plant, running at 80% PLF

Gas Price(USD/MMBTU)	Cost of Power Generation (Taka/kWh)
1	3.42
2	3.99
3	4.55
4	5.12
5	5.68
6	6.25
7	6.81
8	7.38
9	7.94
10	8.51
11	9.07
12	9.64

Source: PwC Analysis

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

Build up of landed cost of LNG to end consumer

Parameter	Value (USD/MMBTU)
LNG FOB Price	5.5
Freight Charges, Insurance, Landing Charges	2.5
Assessable Value (Delivered Ex-ship)	**8**
Other charges including adjustment for Boil off, regasification Cost, transportation tariff, marketing margin, taxes and duties etc.	3
LNG price to consumer	**11**

Source: PwC Analysis

- 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.

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, India presents a good opportunity to diversify its LNG sources, rather than solely depending on Qatar

Strategic Location of Bangladesh

With the current level of infrastructure and work in progress, LNG can be ranked Medium on the parameters of Accessibility & Adequacy; owing to its environmentally benign nature ranks high on the parameter of sustainability

Accessibility and Adequacy

- With the global LNG market in an oversupplied scenario, 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 & 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 **91km 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 & connectivity cannot be increased in short term with a sudden increase in demand**

Sustainability

- Increasing focus of the Govt. of Bangladesh **develop alternate cleaner energy supplies**

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Medium	High	Medium	High	High

Imported LNG option ranks Medium on Affordability, High on Reliability, Medium on Adequacy & 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 all of these demand centres.

There are a host of critical success factors for development of successful LNG infrastructure and market in a developing country like Bangladesh

- Availability of sufficient **land**
- Fast track **licensing, regulatory approvals and environmental clearances for LNG**
- Adopting **a suitable Public Private Partnership model**. Clear and defined project ownership and objectives.
- Robust **project development and project monitoring** for LNG projects
- **Port development** with investments in dredging, jetties, etc to facilitate handling of large LNG carriers
- **Adequate Funding of LNG Projects** -Support required from strong project sponsors and multilateral agencies for equity infusion and providing credits & guarantees on behalf of LNG buyers
- **Proper connectivity**(pipelines) from LNG terminals to demand centers
- **Formulating clear and transparent policies and guidelines** for LNG imports including import duties, taxes, gas price pooling mechanism, gas allocation, etc
- **Flexible & diversified LNG supply contracts** with a mixed portfolio of short term and long term agreements
- Presence of an **LNG Aggregator Agency** in the country

Section 2.2
Small Scale LNG Opportunities in Power and Other Gas Based Industries

Small Scale LNG – The Concept

Concept: 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

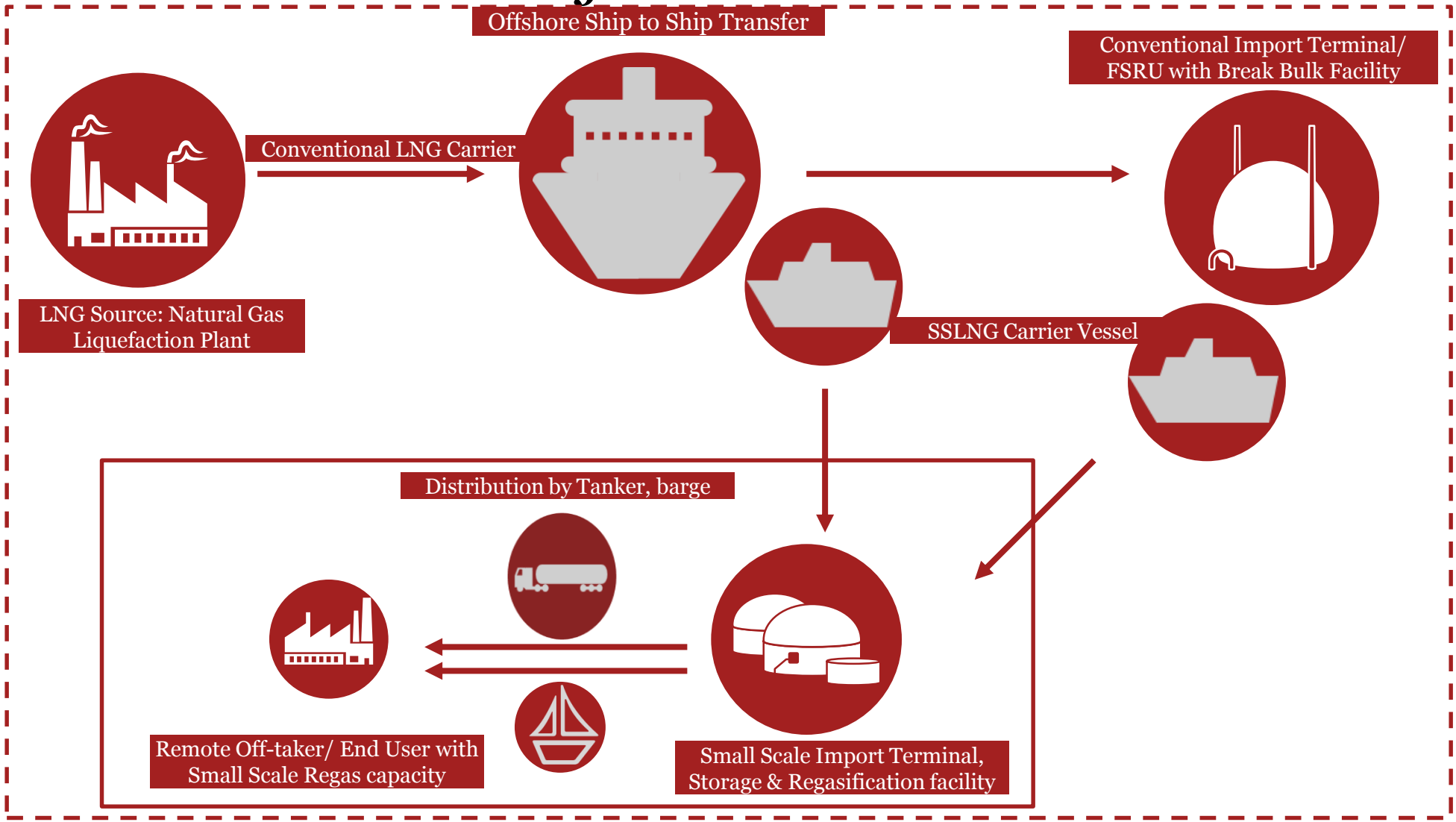
How does it differ from Conventional LNG?

- Caters to **smaller distributed demand** within an optimum distance of **500 km** from ports
- Smaller carrier vessels (< 30000 m^3), semi-trailers and barges constitute various modes of transport for **last mile delivery to its end consumers**
- **Lower capital costs (USD 40-50 million)** with options to build upon existing infrastructure (harbors, jetty, access roads, etc)
- **Quick turnaround time (10-12 months)** with the use of prefabricated equipment and pre-assembled modules – Convenient means of **accelerated access** to hydrocarbons
- **Lower port infra requirement** – Draft requirement of 7.5 meter vis-à-vis 15 meter requirement for large carriers
- **Modular** - Capacity can be increased at a later stage with surge in demand
- Typical Import terminal capacity of 20,000 m^3 vis-à-vis 300,000 m^3 for conventional import terminal
- **Small scale regasification facilities** located near end consumers with a throughput of 0.05 to 1 MMPTA

Key Drivers of Small Scale LNG

- Increasing interventions from national Governments to develop **alternate energy supplies**
- Making natural gas available 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
- Fit for countries with limited or underdeveloped pipeline infrastructure
- Making the most **environmentally friendly fossil fuel** available to customers who are otherwise using expensive fuel oils

The basic value chain can be customised to meet the needs of individual countries and regions



Like every new concept, SSLNG faces its share of impediments.

- Absence of specific policies in most of the countries unlike conventional LNG
- Difficult to compete with conventional LNG on economies of scale
- Delays in obtaining licences, permits, access to land & enabling infrastructure
- Potential stalemate where consumers wish for security of supply before committing to LNG, while potential suppliers need to secure a market to justify the investment
- Opposition from alternate fuel lobbies like Diesel, LPG, etc
- Absence of close cooperation between different strategic partners i.e. parties involved in the complete supply chain of SSLNG hinders to operate the value chain effectively and competitively

However, by imbibing global practices and putting in place critical enablers, SSLNG can be launched successfully in newer territories

International Success Stories

- **Norway**: Many locations in Norway are not connected to the main gas grid. To supply them with gas, many satellite LNG import and regasification terminals are available to supply industries and local distribution networks
- **China:** Enabling, investor-friendly policies from Chinese Govt. led to faster development of SSLNG infrastructure in the country
- **Sweden:** The first receiving terminal, in Nynäshamn, south of Stockholm, was recently commissioned and caters to the needs of local industry, domestic gas supply in the Stockholm area and an emerging demand from ferries crossing the Baltic Sea.
- **Japan:** Holds many small-scale import terminals, called satellite plants . Their small capacities are attributed to catering to low and distributed demand.

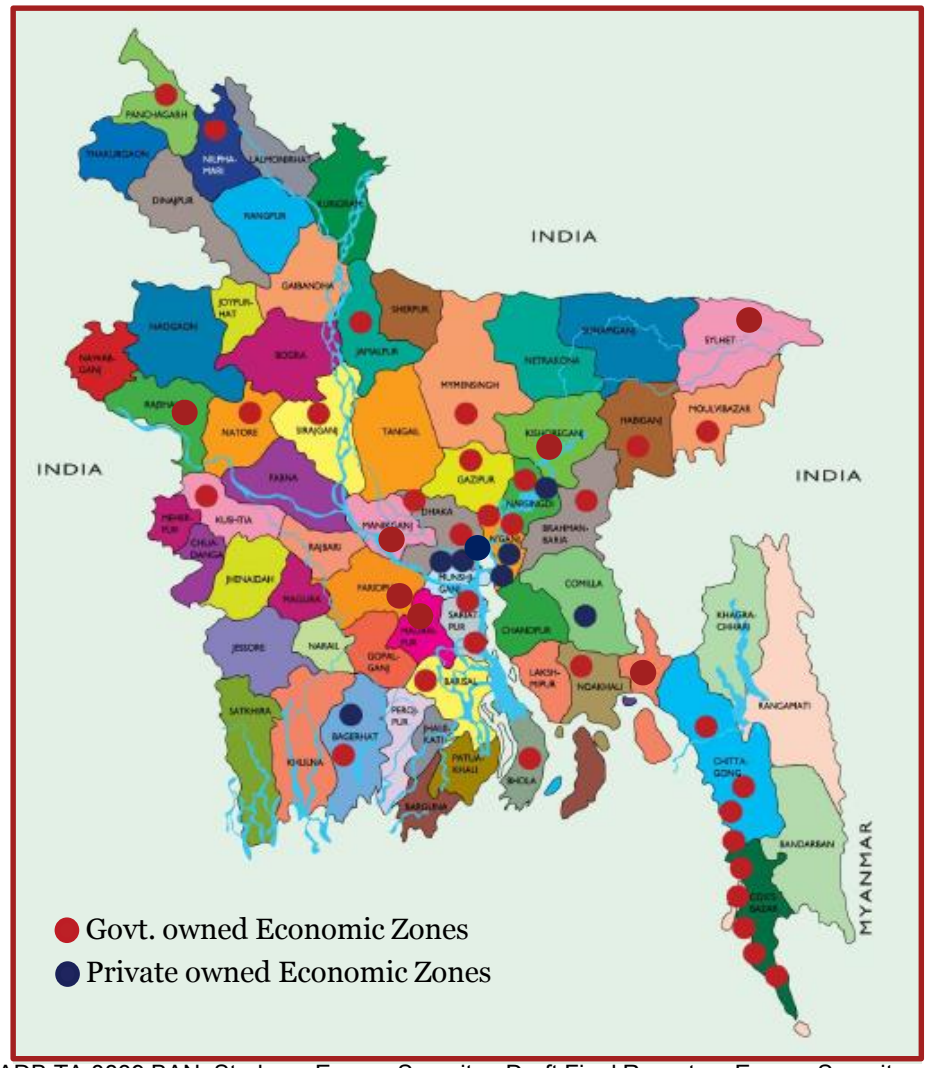
Key Enablers

- Development of **enabling infrastructure & logistics** – Jetty upgradation/construction, building road networks, pipeline infrastructure to connect to main grid
- Quick access to infrastructure
- Rollout of **specific policies &** quick licensing processes (Single window clearances)
- **Technological developments** in shipping (cargo containment systems, Ship to Ship transfers, etc)
- New project execution principles – **Modularization, Containerization, Standardization**

Establishing a case for Bangladesh to invest in Small Scale LNG

Underpenetrated gas pipeline infrastructure in Bangladesh	• SSLNG can easily cater to the hidden gas demand (catering to customers within a radius of 500 km from port)
Insufficient draft at existing sea ports act as a barrier to receive big LNG carriers	• SSLNG carriers with lower draft requirements (7 meter) can explore the opportunity of accessing existing ports at Chittagong and Mongla or the upcoming ports at Payra & Matarbari
Long lead time for Commissioning of full-fledged FSRU or land based terminals	• SSLNG Infra facilities can be setup in 10-12 months' time as stop gap solutions • Going forward, it can also be integrated with upcoming FSRU terminals for break bulk provisions (redistribution)
Number of power plants and gas consuming industries remain stranded due to unavailability of gas supplies	• SSLNG can facilitate short term LNG supply contracts to industries and power plants located near ports where terminals can be set up
Strategic location between India and Singapore	• Bangladesh can explore the option of importing LNG from conventional full scale terminals in Singapore or from the upcoming LNG terminals on the Indian east coast

Besides stranded power plants, a number of existing & planned industries in the vicinity of sea ports can be catered to with SSLNG imports



Small scale LNG is price competitive with liquid imported fuels but its inability to compete with upward domestic gas price makes it a medium attractive option when evaluated on the affordability parameter

Affordability

- Affordability analysis for power sector clearly reveals that new combined cycle power plants can **afford gas up to USD 7.11/ MMBTU**

- 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 break up is as under
    - FOB price: USD 4/MMBTU; Approx. Shipping cost (from Singapore/ India to Bangladesh) : 1 to 1.5 USD/ MMBTU
    - Jetty Cost: USD 0.5/MMBTU
    - Transportation cost by road from Import terminals to demand center (Up to distance of 500 km) : USD 1-1.5/ MMBTU. This shall be lower if transported through gas pipelines
    - Re-gasification cost : USD 0.7 to USD 0.8/ MMBTU

- 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 Capex, low Opex 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. In view of the impending upward revisions in domestic gas prices which Govt. is considering, SSLNG may become price competitive.**

- 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 & Upcoming) who otherwise have to use imported liquid fuels

Small Scale LNG fits well within Bangladesh's energy security agenda from accessibility standpoint although from the reliability standpoint parameter, this option is medium attractive

Reliability

- Seamless logistics operations needs to be ensured for uninterrupted gas supply
- For a demand of 1 MMTPA, a typical 12000 cu MT. vessel shall reach the import terminal every 30-40 hours
- The entire supply chain needs to be well developed for reliable supply

Accessibility

- 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.
- Option fit for Bangladesh with **distributed demand** and limited pipeline infrastructure
- Easily accessible for consumers within a distance of **500 km** from ports
- **Small regasification terminals** located near customer points

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

Adequacy

- The infrastructure for Small Scale LNG is modular in nature
- The **capacity of small scale LNG can be increased** with increase in demand.
- Therefore, supply should be able to meet the demand at all times

Availability

- The **current LNG market** in Bangladesh is **oversupplied**
- Bangladesh is strategically located between India and Singapore
- Therefore, if the required enablers and facilitators are in place, availability of Small Scale LNG will not be an issue

Sustainability

- Environmentally benign clean fossil fuel available to customers

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Medium	Medium	High	High	High

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 costs, 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.

Step-wise assessments shall test SSLNG's feasibility in Bangladesh

Identify potential ports where it is technically feasible to have SSLNG related infrastructure

Assess existing jetty/ berth occupancies and the need for jetty upgradations/new constructions

Feasibility of gas pipeline constructions from ports to main gas grid

Estimate an optimum radius from the port up to which it is feasible to service gas customers. Feasibility based on cost, logistics, safety, regulations, etc

Technical Feasibility

Assess the potential customers located within such radius

Potential LNG customer to be identified in following order of priority:

- ❑ Existing Stranded customers who are otherwise connected by gas pipelines
- ❑ Existing Large customers which are currently dependent on alternate fuels, but can convert to Natural gas
- ❑ Potential new customers who are ready to offtake gas in next 12-18 months
- ❑ Gas Aggregator agencies in future

Estimate the projected demand of gas from the above shortlisted customers

Identify feasible locations and avenues from where LNG can be sourced – Mid sea LNG carriers, Large scale Import terminals in countries like India, Singapore etc

Identify various strategic partners to design and operate the supply chain effectively

Commercial Feasibility

Assess the level of required infrastructure and their associated scale of investments

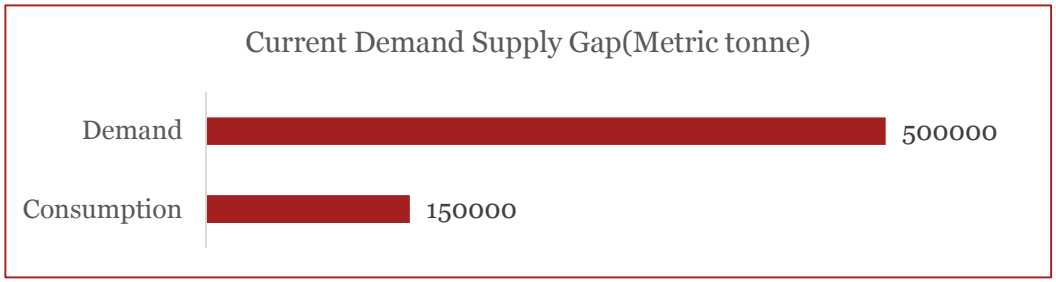
Estimate the expected rate of return for investors and also final landed cost of SSLNG to different segments of customers and perform an affordability analysis vis-à-vis alternate fuels

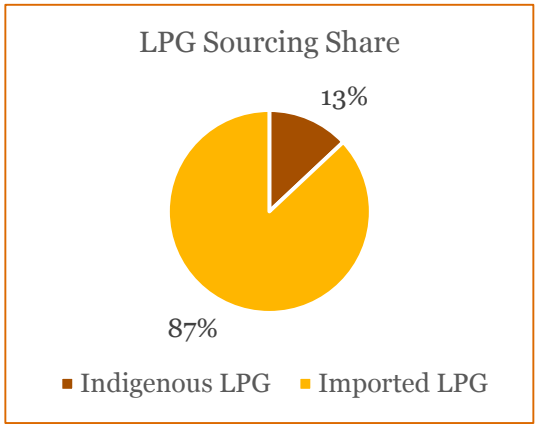
Financial Feasibility

Section 2.3
Fuel Diversification to LPG

The LPG Industry is at a critical juncture, waiting to take off in a big way in Bangladesh

- While the **demand** for LPG has **grown** at an exponential rate of **60 %** in last 3 years, **consumption** in the country has grown at an average rate of **13%** in last 5 years, leading to a widening demand supply gap
- 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 **20000 MT** out of total consumption of 150000 MT.
- **Existing Public Sector Companies**: Bangladesh Petroleum Corp., RPGCL
- **Existing Private Companies**: Bashundhara LP Gas Ltd., Jamuna Spacetech Joint Venture Ltd., TotalGaz, Petredec, BM Energy Ltd. ,Omera Petroleum Ltd.
- **New Players** entering the market: Navana, Orion, Index, Sena Kalyan Sangstha





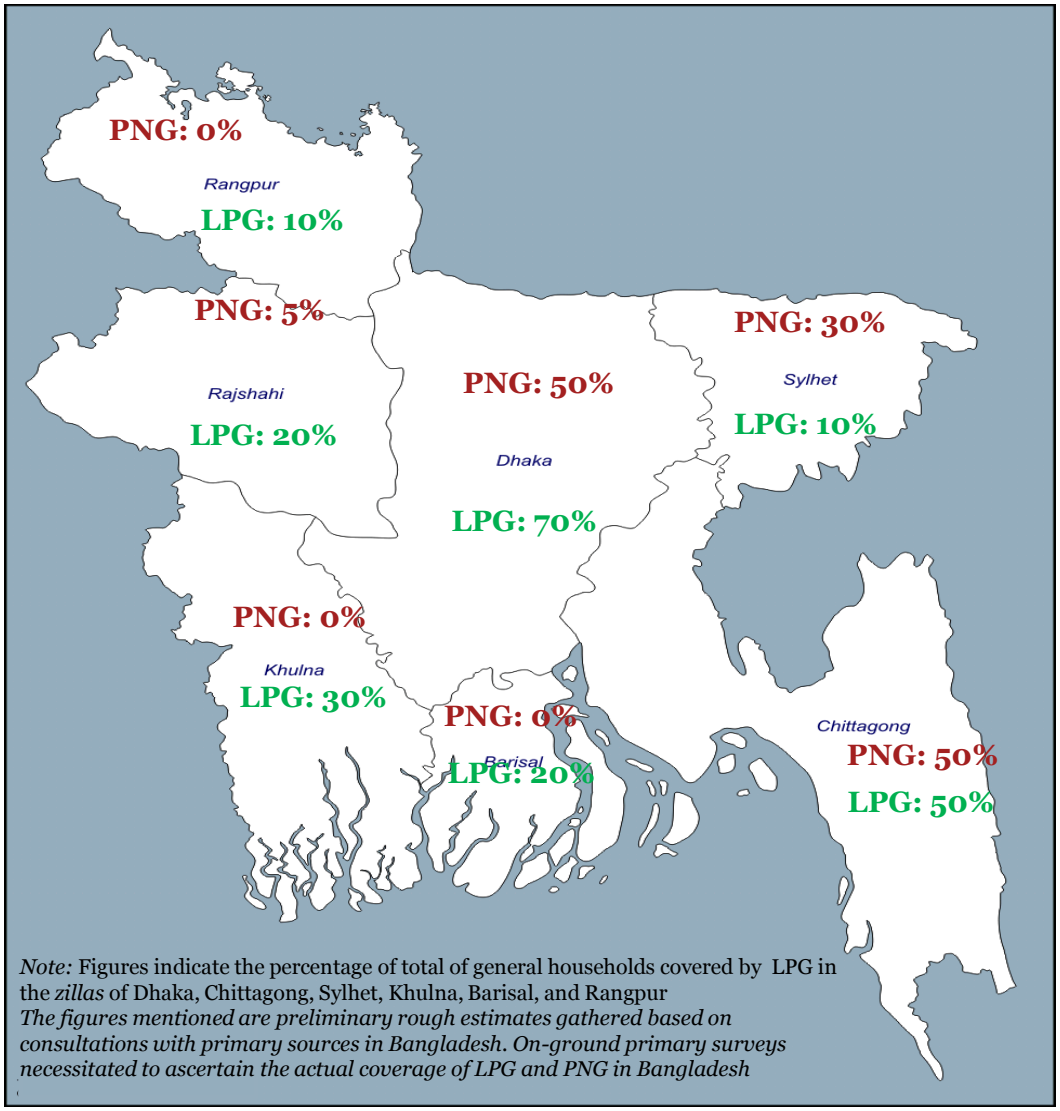
Sector	Consumption in 2014 (MT)
Household	89527
Commercial	3452
Industrial	3200
Transport	1400
Total	**97579**

Key Growth Drivers

- LPG **demand** is expected to **shoot up further** in view of Govt.'s plans 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 percent**
- GoB has **stopped new gas connections** for domestic & 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 MT**
- Greater attention towards discouraging households from using costly & polluting fuels like firewood, kerosene, etc shall also create an additional demand

LPG coverage in Bangladesh uneven and inadequate thus presenting scope for coverage

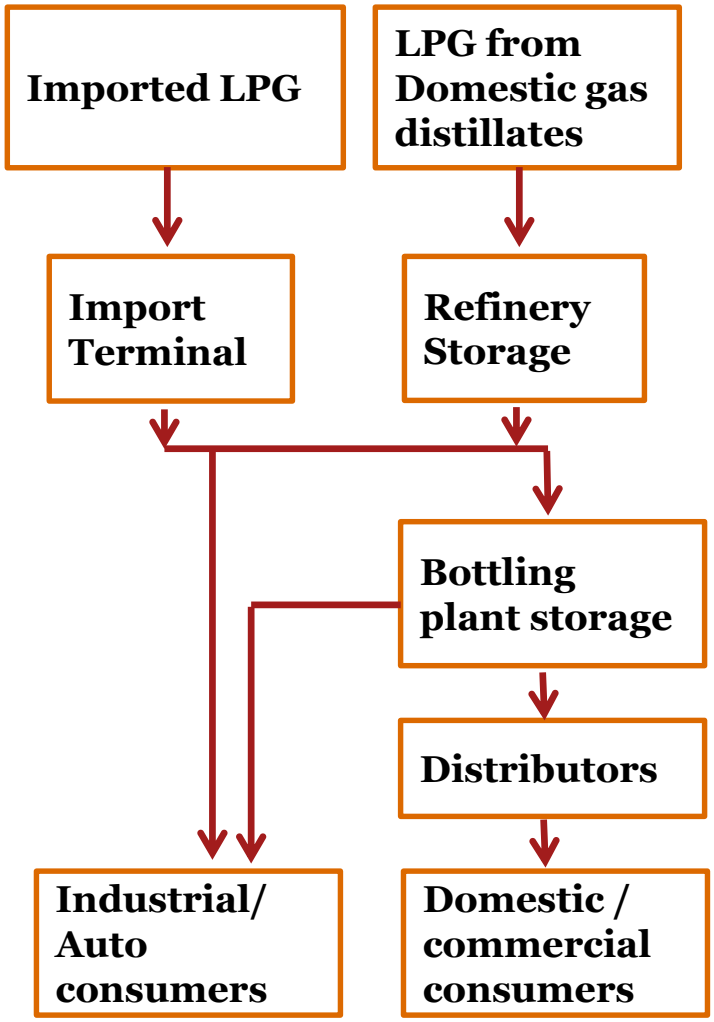
- There exist region wise disparities in coverage of LPG
- Dhaka and Chittagong exhibit both high LPG and PNG coverage though not completely covered
- LPG coverage is quite low ranging between 10-30% across most districts in Bangladesh particularly the western parts of the country (Rangpur, Rajshahi 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



Note: Figures indicate the percentage of total of general households covered by LPG in the *zillas* of Dhaka, Chittagong, Sylhet, Khulna, Barisal, and Rangpur
The figures mentioned are preliminary rough estimates gathered based on consultations with primary sources in Bangladesh. On-ground primary surveys necessitated to ascertain the actual coverage of LPG and PNG in Bangladesh

However, existing supply infrastructure acts as a bottleneck to meet the growing demand and ensure equitable distribution in Bangladesh

LPG Value Chain



Challenges

- All the existing import terminals are located near ports that have draft restrictions - **Chittagong** (9 meter) **& Mongla** (6 meter). Jetties cannot receive more than **3000 MT** 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 SBM facilities consume capital costs further.
- In the absence of any funding, **high capital costs deter private players** to invest in such import terminals & bottling plants
- **Rangpur Division (districts like Rangpur, Dinajpur & Thakurgaon)** has **lower penetration in LPG coverage** as compared to other divisions**.** This is due to **absence of waterways** in these regions and **road transportation being much costlier**. An illustration of transportation cost of a cylinder from Mongla to Rangpur via Bogra is as below:

From	To	Distance	Mode	Cost (Taka)
Mongla	Bogra	400 km	Waterways	15
Bogra	Rangpur	80 km	Road	20

- 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 a medium attractive option; Imports of LPG ensure reliable supply with infrastructure being a major impediment

Affordability

- 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. However, owing to increasing competition amongst private players, LPG prices are expected to come down . Further, the socio-economic considerations may also drive LPG prices to be affordable.

Reliability

- **80 %** of market is **import dependant** – Exposure to global commodity cycles
- Currently six private players operate. More new players entering the LPG market – **greater competition will lead to greater operational efficiency**, increasing reliability
- Steps taken **to augment supply and distribution infrastructure** can also have a **positive effect** by way of improving reliability
- **The Government is formulating** policies and guidelines to deter malpractices like hoarding, non-transparent pricing, lower cylinder weights etc. to improve 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; On the sustainability aspect, ranks high as it is a clean fuel with no health hazards when compared to biomass based fuels

Adequacy & Accessibility

- 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 & Mongla) with **draft restrictions are unable to receive larger cargo vessels** (5000 MT carriers) – lead to higher freight charges
- With **river bodies drying up** in various parts of country, the potential to use inland waterways for greater LPG penetration sees a downward trend
- Almost **2 lakh MT** of current LPG demand is **not catered** presently. Also, with depleting natural gas reserves, LPG demand is projected to shoot up further. Almost **half of private capacity remain underutilised** currently. **Additional import infrastructure** planned in **Kumira** and **Mongla**. Also **private players** plan to **enhance their capacities** further.

Sustainability

- LPG with **higher heating value** (about 50 MJ/kg) makes it a very **efficient fuel for household cooking** as compared to other fuels like natural gas, kerosene, firewood, etc. Also **no major health hazards** as compared to firewood, biomass, etc

- **Auto LPG** is free of lead & very low in Sulphur – **decreases exhaust emissions**. It is also good for engines as they do not need any extra maintenance and do not require frequent refilling like CNG

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Medium	Medium	High	High	High

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 although it is expected that socio-economic considerations may lead to Government subsidizing LPG prices.

Overall LPG may be considered a highly attractive option for energy security subject to appropriate policy and institutional level interventions and infrastructure investments.

Key interventions are required to increase LPG usage and unlock the latent demand potential in the country (1/3)

Investments in Infrastructure

- **Exploring various Public Private Partnership (PPP)** models for constructing & operating capital intensive import & bottling infrastructure; **Viability Gap Funding** to fund projects; **Financing investments in necessary infrastructure by funding agencies**
- Developing **new higher capacity import terminals near deep sea ports** like Payra (Draft – 50 meter) to facilitate handling of higher capacity carriers
- Constructing **high capacity Bulk storage facilities (**Mother Storage) near deep sea ports and smaller storage facilities across major strategic locations. **Inland waterways** should be utilized to transport bulk LPG from the Mother facilities to smaller storage units to ensure efficient distribution across the country
- **Greater investments**(Jetties, discharge terminals, barges etc**) along inland waterways** to utilize river routes in best possible way for efficient & cheaper way of LPG distribution across the country
- Investments in country-wide **LPG pipelines** to have a penetrated distribution network and transport LPG to greater number of households and industries
- Investments in **mid sea platforms** with break bulk facilities to import aggregated bulk cargoes and distribute to smaller terminals through smaller carriers (Ship to Ship transfers)

Key interventions are required to increase LPG usage and unlock the latent demand potential in the country (2/3)

Policy Interventions

- Policies to **promote usage of LPG** across consuming sectors-**Reduce initial costs of connection**, equipment and LPG first buy for **domestic customers**
- **Grants/tax credits** for vehicle conversions or purchases.
- Incentivizing more private players to invest in import infrastructure through **reduction/ waiver of duties and taxes** on import of LPG, cylinders, machinery. The Govt. of Bangladesh has significantly reduced import duties on Bulk LPG and machinery . Further, **duties need to be reduced for imported cylinders**
- **Tax credits** to companies for investment in **distribution infrastructure** and **research & development**.
- **Sales tax exemption/ rebate** on sale of LPG. **Excise Duty exemptions/ rebate** on manufacture & sale of cylinders
- Rolling out concessions to private parties to set up **greater number of Auto-LPG filling stations** throughout the country. At present, only 15-20 stations exist in the country.
- Incentivizing industries to **modify their plants and construct LPG storage tanks** in their units to switch to LPG
- Favourable **land acquisition policies** to build new jetties

Key interventions are required to increase LPG usage and unlock the latent demand potential in the country (3/3)

Institutional Interventions

- Formation of a **dedicated agency** under the Energy and Mineral Resources Division to frame policies and guidelines governing the LPG industry – **Capacity building of existing institutions** by having well trained and well acquainted personnel in such body
- Strong **market monitoring mechanism** to create a **level playing field** among all industry competitors and also **protect the interest of consumers**
- Laying down of **standard regulations, operating and HSE guidelines** for players in this industry
- Standards to **harmonize refueling facilities & vehicle conversion norms**
- Clear & uniform guidelines for **selection of LPG dealers & distributors** throughout the country
- Stronger **checks and balances** to prevent any form of **malpractices** in industry – e.g. hoarding, lower than rated cylinder weights
- Information dissemination and **public awareness campaigns** for promotion of LPG
- **Voluntary agreements with OEMs** to develop and market alternative fuel technologies

From a broader perspective, a comprehensive LPG Master Plan is the need of the hour to address the different parameters of Energy Security

Ensuring reliable supply

- Additional LPG import capacity and facilities
- Development of adequate transportation
- (roads, waterways in short to medium term & pipelines in long term)
- Throughput improvement and more storage installations

Increasing affordability

- Willingness to pay (WTP) for the cylinder to be studied and appropriate product sizing shall help reduce the affordability gap to an extent
- Reduce initial costs of connection, equipment and LPG first buy
- Reduce regular cost of refill

Ensuring accessibility

- Reliable distribution system even in rural areas
- Multiple coverage points to be ensured to timely meet customer needs
- Hassle-free refill mechanisms for end user convenience

Need for Government to formulate a comprehensive LPG Master Plan encompassing all parameters of energy security with an actionable roadmap for implementation

Section 2.4
Intensifying Domestic E&P Efforts

International Oil Companies demonstrated a subdued participation in the 2008 and 2012 bidding rounds in Bangladesh; Certain clauses in the existing PSC act as deterrents 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:
    - 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***
    - Cost recovery limited to ***55%*** of all available oil, gas or condensate from the contract area
    - Current price of gas is pegged at ***$5.5 per thousand cubic feet (mcf)***
    - ***No tax holiday*** during the entire exploration, development and production phases

Key regulatory and policy changes in the existing PSC may foreign participation in the future bidding rounds in Bangladesh and help meet the country's rising gas demand (1/2)

Sale price of gas
An increase in the current sale price of gas. The current sale price of $5.50/mcf dissuades many foreign players from participating in the country's gas sector

Cost recovery
An upward revision to the cost recovery limit (currently it is at 55% of all available oil / natural gas / condensate / NGL)

Marketing Freedom
Contractors to be allowed to sell their explored and extracted volume of oil or gas to the third parties without Petrobangla's right of first refusal

Key regulatory and policy changes in the existing PSC may foreign participation in the future bidding rounds in Bangladesh and help meet the country's rising gas demand (2/2)

Export of gas

Currently, the PSC does not include provisions for exporting gas. Including such a provision, subject to negotiations, might be a useful tool to attract foreign players

Tax holiday

A tax holiday to be extended to the contractors during the exploration, development and production phases

Import duty for equipment

Zero import duty for equipment and machinery imported for petroleum operations during, exploration, development and production phases

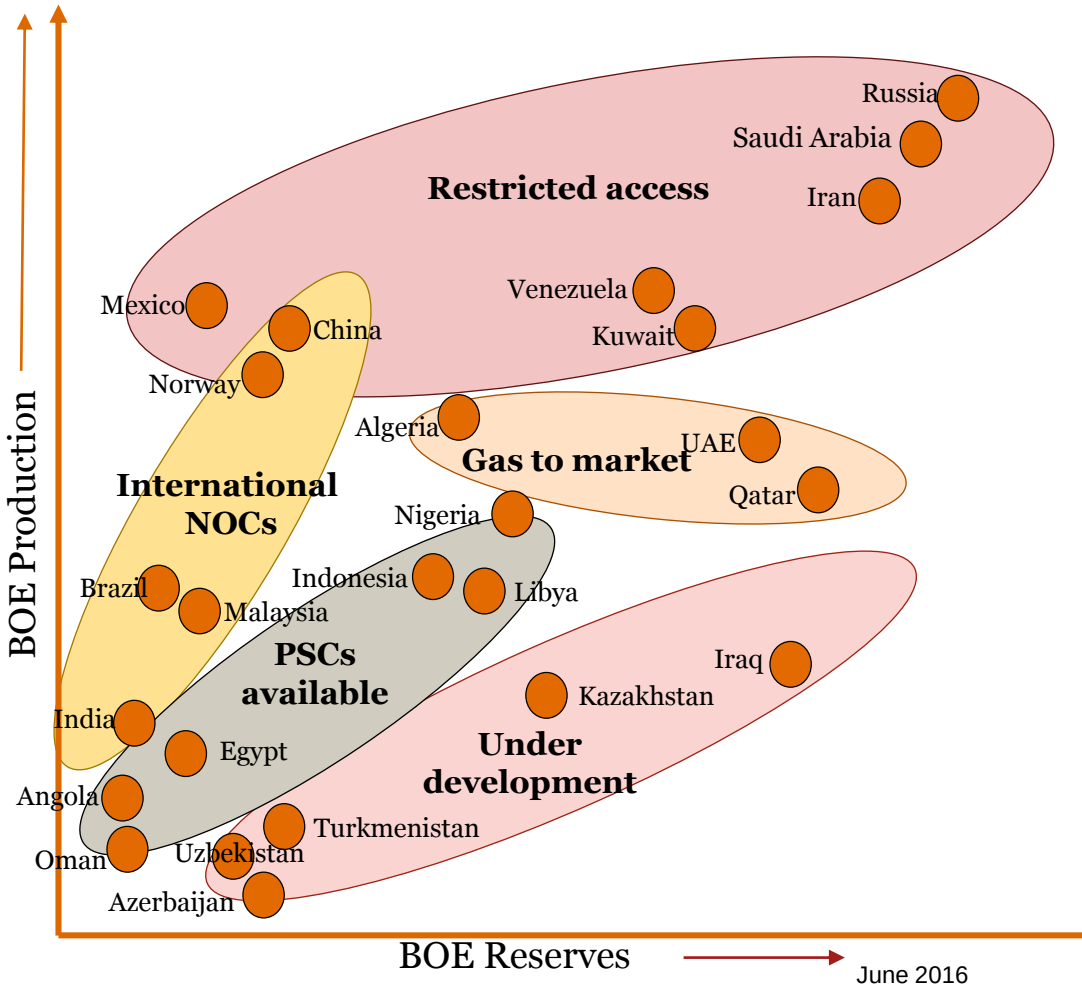
There is a case to put in place a comprehensive Project Management Office for National Oil companies to accelerate their Exploration & Production efforts

- NOCs Financially constrained to acquire latest state of art the facilities
- Bound by processes to procure goods and services resulting in delays
- Time & cost overruns due to delays in field operation
- Incur higher costs when compared to their IOC counterparts for similar E&P efforts
- Constrained by technical capabilities to work in risky and challenging offshore projects

F&D Cost		
	Partner	*Non-Core*
	Core	*Retain*

Lifting Cost

Top 25 countries with NOCs reserves & production



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

Option	Overall Assessment	Remarks
Intensifying domestic E&P efforts	Medium	• 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 PSC may 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.

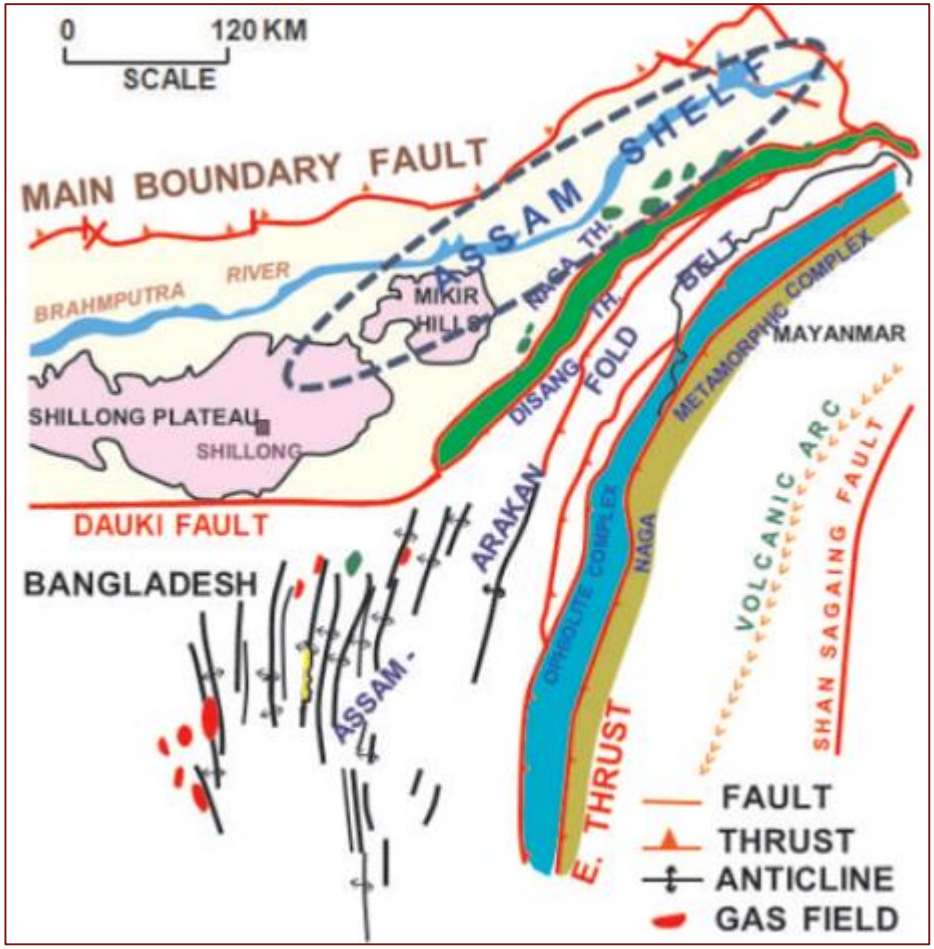
Section 2.5
Import of Gas from North East India and Myanmar

Gas Imports from North East India (1/3)

Natural Gas Profile in North East India

- There are **two sedimentary basins** -Upper Assam Shelf and Assam-Arakan Basin.
- The Upper Assam Shelf covers the plains of upper Assam and parts of Arunachal Pradesh and the Assam Arakan basin covers the hilly terrains of Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram and Tripura.
- The two sedimentary basins cover an **area of 116,000 sq km** and contain prognosticated hydrocarbon resources of around **5,040 MMT**, out of which 2,224 MMT(44%) has been established so far, leaving considerable opportunity to establish and develop the remaining 56%.
- Almost 90% of the Upper Assam Shelf has been explored and current production of oil and gas is mainly from this basin
- The Assam Arakan fold belt is a well-established gas province. The major gas production is obtained from Tripura.
- The existing gas pipeline network in the northeast is around 950 km, with a cumulative capacity of 472 MMSCFD

Sedimentary Basins in North East India

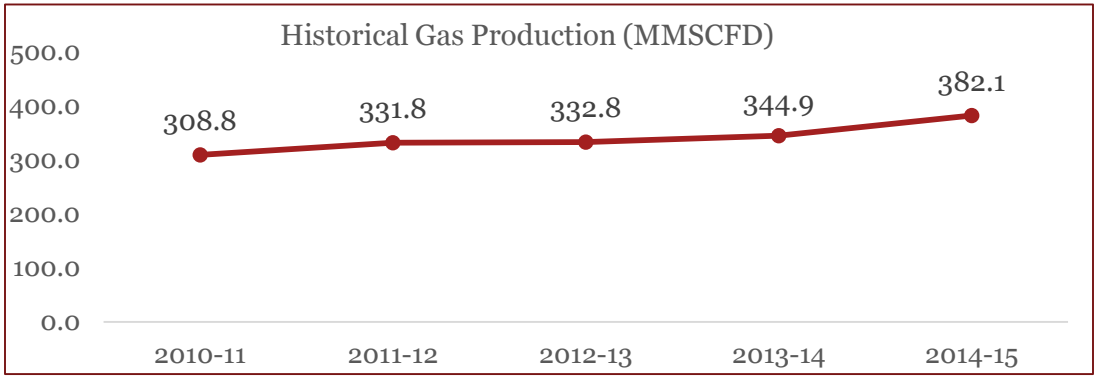


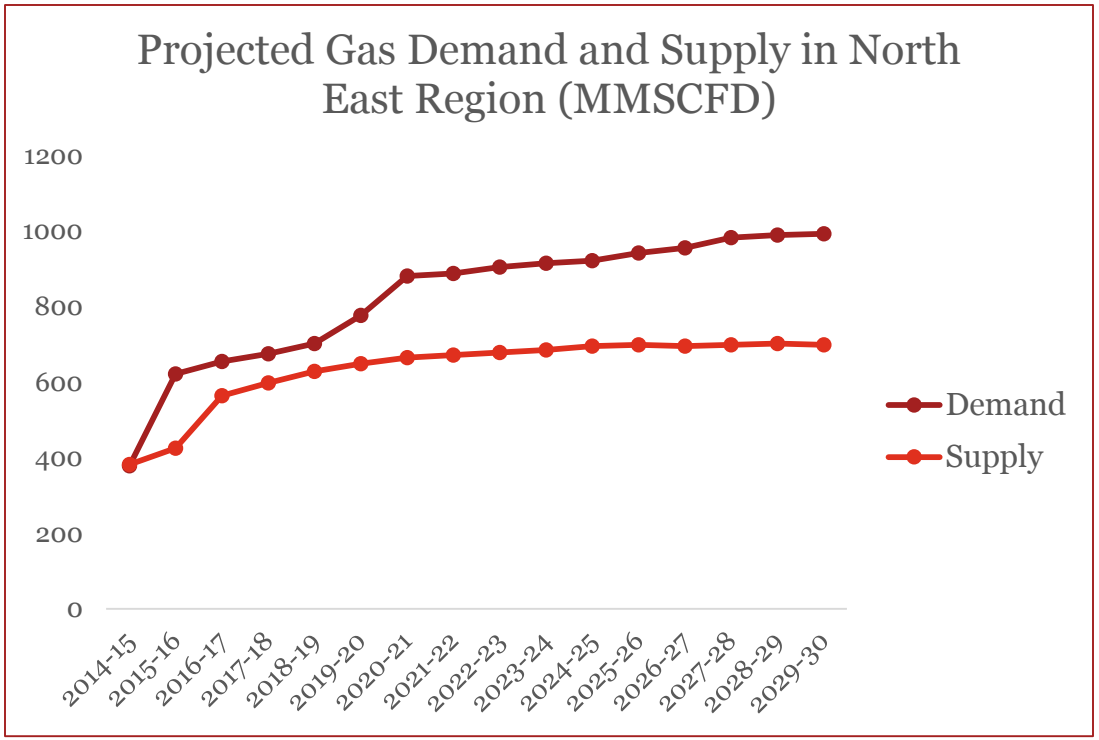
Source: Hydrocarbon Vision 2030 for North East India

Gas Imports from North East India (2/3)

Assessment of Demand & Supply in NE region

- Gas Production from this region has grown at a **CAGR of 5.5%** over the last 4 years.
- However, potential for CGD network and industrial development consisting of proposed power projects, cracker plants, fertilizer plants, cement industries and other industrial projects would drive the **demand** for natural gas in this region to around **992 MMSCFD** by 2029-30.
- On the other hand, **gas production** is expected to increase to **698 MMSCFD** in an optimistic scenario, expanding at a CAGR of 4.1% from the current production level.
- The **potential demand supply gap could further widen** due to the following **inherent challenges** in this region:
  - Difficult terrain and extreme weather
  - Poor infrastructure and limited connectivity
  - Law and order issues
  - Unavailability of service providers
  - Unavailability of adequate gas evacuation infrastructure



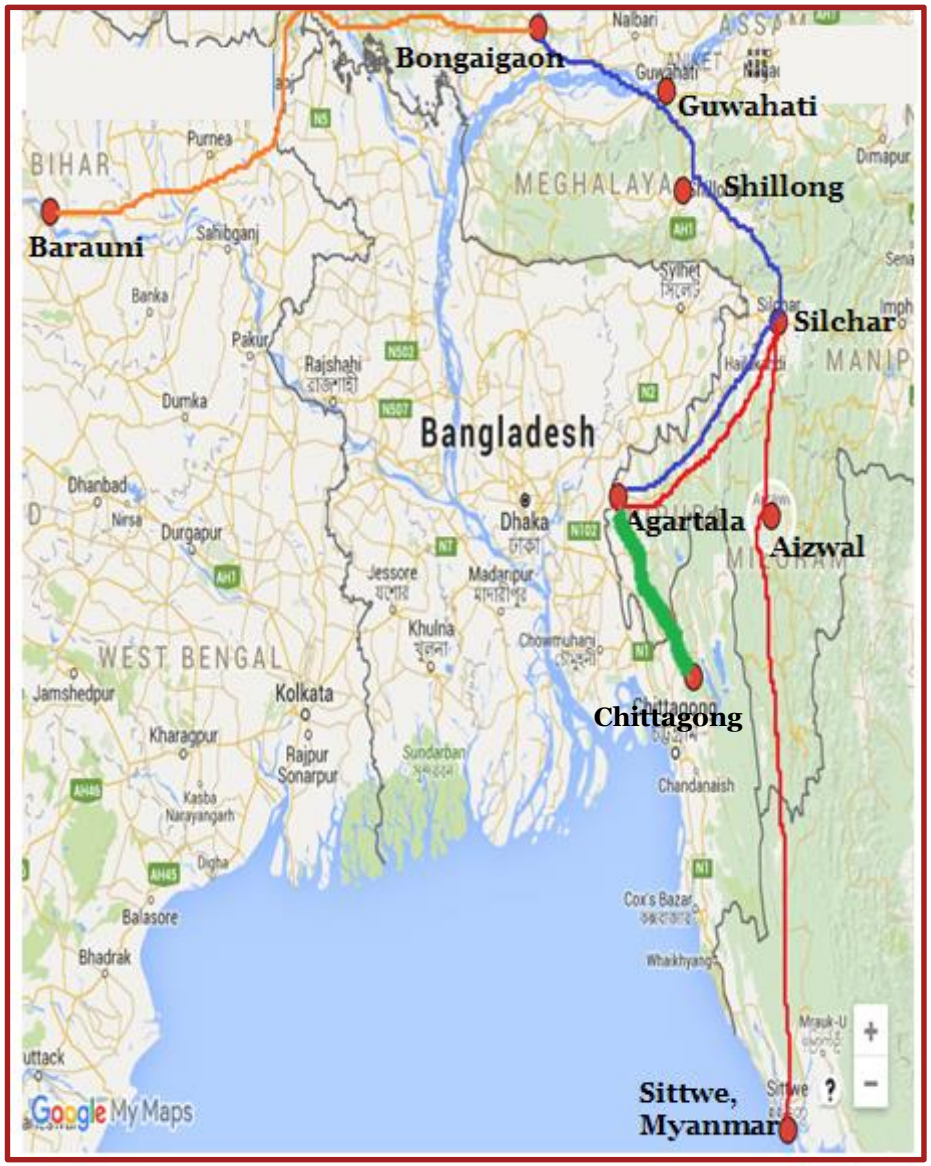


Source: Hydrocarbon Vision 2030 for North East India

Gas Imports from North East India (3/3)

Factors that can make gas imports from India a favourable option in the long term

- **Govt. of India's vision** to make North East region a dominant **hydrocarbon hub** and integrate with rest of Asia, particularly East Asia and Southeast Asia.
- Although crude oil production has shown a declining trend, **natural gas production in this region has been positive over the last few years**
- All areas in **west Tripura** explored so far have proved to be gas bearing, and **success ratio of exploratory prospects has been encouraging.**
- **Only 10% of the Assam Arakan Basin has been explored so far** with a large potential in Manipur and Mizoram. **Therefore, going forward, Tripura, Mizoram and Manipur are expected to account for bulk of gas.. Bangladesh shares its boundary with Tripura and Mizoram.**
- With the future plans of **Agartala-Silchar-Shillong-Guwahati-Bongaigaon gas pipeline** and **Bongaigaon-Barauni gas pipeline**, greater volumes of gas supply is expected into the region as Barauni is connected to the national gas grid. Surplus gas coming into this region can also prove to be a source for Bangladesh
- Oil India Limited has been offered two offshore blocks in **Myanmar**, with total estimated gas resources of about **3280 BCF**. 75 % of total production (estimated to be 270-300 MMSCFD) shall be exported to India from Myanmar. **After meeting India's domestic needs, gas can be re-exported to Bangladesh though a pipeline between Tripura & Bangladesh**.



Gas Imports from Myanmar

- Myanmar has **proven gas reserves of 11.8 TCF**. Natural gas production in the country has accelerated from **306 MMSCFD in 2000** to **1180 MMSCFD in 2014**, at a **CAGR of 12.1%.** Economic development has also resulted in higher consumption, which reached **413 MMSCFD** in 2013. Therefore, there exists a significant gap between production and consumption of natural gas, making the country **a net exporter.**

- **Most of the produced natural gas is exported to Thailand and also recently to China**. China has recently commissioned an onshore natural gas pipeline from Myanmar with a capacity 12 BCM per year to import gas from the **Shwe gas project**. The **Zawtika gas project**, operated by Thailand's national oil company, PTTEP is expected to produce 280 MMSCFD of gas. This project shall increase natural gas exports to Thailand and also serve Myanmar's domestic market.

- Recently, in anticipation of greater local gas demand from power, fertiliser and transportation industries, Myanmar has placed a domestic obligation to retain 25% of its production in any new project for the domestic market.

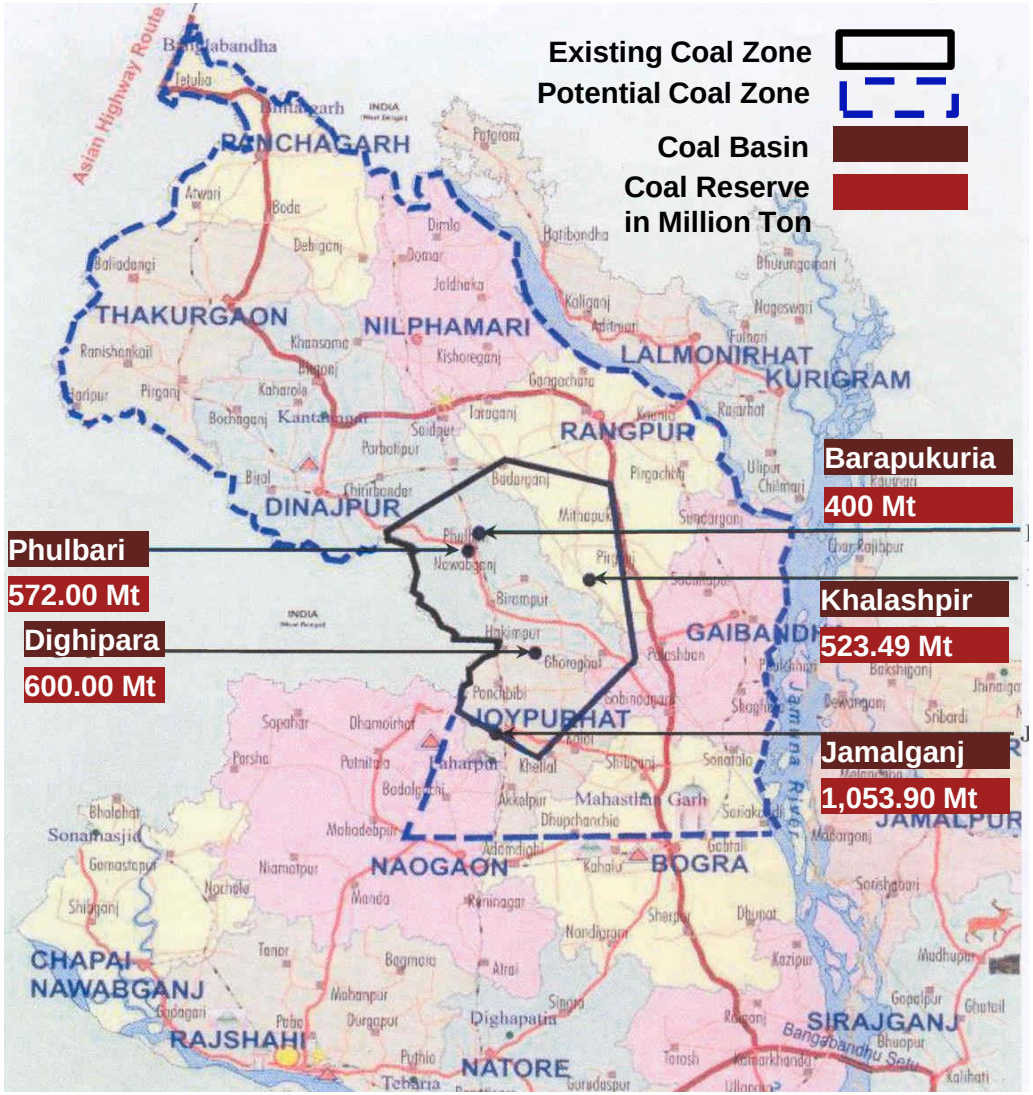
- **The potential surplus creates an opportunity for Bangladesh to import gas from Myanmar in future**. However, any potential deal clinching is only subject to new gas discoveries in Myanmar and further negotiations with Governments of Myanmar and India, as an earlier initiative among the Governments of Myanmar, Bangladesh and India for import of gas fell through then in inception stage itself due to misalignment of political considerations.

Section 2.6
Coal Based Power Plants

Domestic coal reserves mostly located in north-west Bangladesh

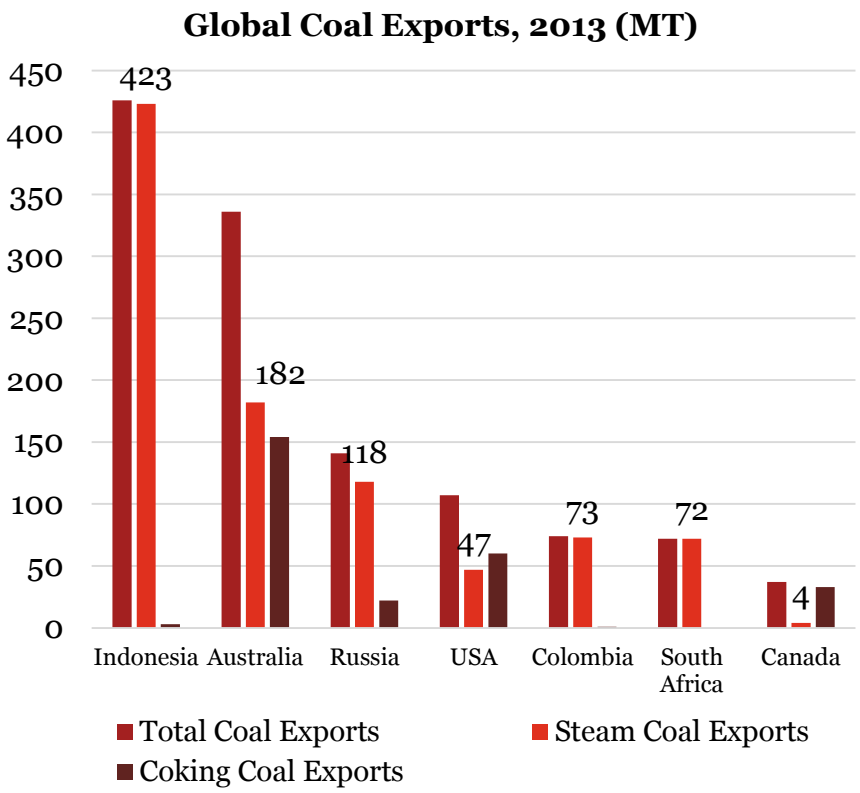
- Bangladesh has around 3,100 million tonnes of domestic coal reserves. Domestic coal zones include Jamalganj, Barapukuria, Khalaspir, Dighipara & Phulbari.
- Out of total coal resources, around 13% (402 MT) is under 'proved' category, around 27% (840 MT) under 'indicated' category and about 60% (~1900 MT) under 'inferred' category.
- Domestic coal in Bangladesh is considered to be of high quality in terms of heat generation capacity as well as low sulphur content.
- Presently, mine development activity in Bangladesh is limited, and Barapukuria is the only operational mine.
- Advanced technologies are available for coal mining and logistics and production of electricity from coal, but challenges like land acquisition, ash utilization, control of impact on environment remains.

Around 6 to 7 GW capacity can be installed considering 402 MT proved domestic coal reserves, 25 years of plant life, SHR of 2100 - 2,300 kcal/kWh, Coal GCV of 6,100 kcal/kg and PLF of 80%



Source: Report on Mineral Resource Assessment Report, PwC

Possibility of importing coal from countries like Indonesia, Australia and South Africa



Bangladesh's location is well suited to import coal. Its vicinity to the largest thermal coal exporter Indonesia, makes it further attractive in terms of total landed cost. However, given non-availability of good quality coal on a long-term basis from Indonesia, other options are South Africa and Australia (an overview of coal reserves and production in Indonesia, South Africa and Australia is provided in Appendix 5.

Source: World Energy Outlook, IEA, PwC Analysis

Estimated landed cost of imported coal at Mongla Port

Country of Import	Port	Distance to Mongla Port (NM)	Draft at the source port (in m)	FOB cost (USD/T) (5700 Kcal/ kg GAR) (April 2016)	Logistics cost (USD/T)	Total Landed Cost (Estimated) (USD/T) *
Indonesia	Balikpapan	2,635	13.0	43.0	17	60
Australia	Newcastle	5,651	16.5	48.0	29	77
South Africa	Richards Bay Navitrade Terminal (RBT)	4,641	12.5-19.0	51.0	25	76

Source: PwC Analysis

Project planning and technology (1/2)

Key factors to be considered for imported coal based power plant

- Around 0.2-0.4 acres of land per MW is required. **Sample:**
  - **5x800MW: 1065 acres:**
    - Power Plant: 430 Acres,
    - Ash Disposal Area: 220 Acres,
    - Township: 100 Acres,
    - Corridor for Ash Slurry, Raw Water & Coal: 125 Acres
  - **3x660MW: 785 acres:**
    - Power Plant: 435 Acres,
    - Ash Disposal Area: 110 Acres,
    - Township: 150 Acres,
    - Corridor for Ash Slurry, Raw Water & Coal: 140 Acres

- Coal requirement for imported coal fired plants for imported coal of GCV between 4,200-4,600 kcal/kg and 85% PLF is around 4.5-5.0 MTPA for 1200 MW (2x600) /1320 MW (2x660) Super Critical Power Plant .
- Blending of imported and domestic coal can be considered
- Critical role of port handling and logistics management in coal imports
- Flue Gas Desulphurisation (FGD) is used for higher sulphur content imported coal
- Generally, such power plants are located near the coastal area, to save on transportation cost. Assessment of coastal hydrology and ecology is important for planning such projects.

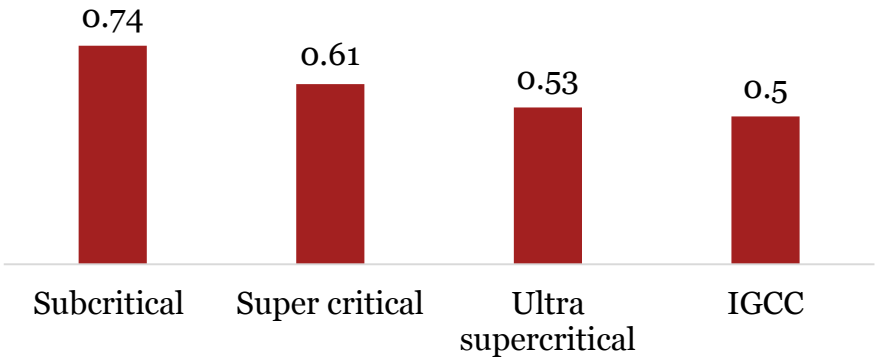
Key Pre-requisites are:

Project planning and technology (2/2)

Technological Consideration

- Sub-critical, super-critical, ultra-supercritical and Integrated Gasification Combined Cycle (IGCC) are key technologies available.
- IGCC Technology is not matured and challenges are faced when ash content in coal goes up.

Example: Specific coal consumption (kg/gross kWh)



http://www.indiaenergy.gov.in/docs/Thermal-power-generation-documentation.pdf

Comparison of Super and Ultra Super technology

Parameters	Super Critical	Ultra Super Critical
Main Steam Pressure, MPa	22.1-25 MPa	Above 28 Mpa
Main Steam temperature, Centigrade (Deg C)	540-580	565-625
Average Efficiency	38-40%	40-42.5%
CO2 Emissions g/kWh	722	Less than 722

- Ultra-supercritical technology offer higher efficiency and reduced emissions.

Coal fired power plants are reliable source of electricity generation in general

- Stocking of coal at plant end plays a critical role in ensuring uninterrupted power generation, generally 15 days of stock is necessary.
- Limited probability of disruptions in power supply for imported coal fired plants on account of disruptions in coal supply issues (e.g. because of geo-political events).
- Disruption in coal supply may be caused due to severe weather conditions like heavy rain, depression or cyclone – common in Bangladesh
- Generally, individual units of coal fired plants are overhauled on an annual basis; this requires shutdown of 20-30 days:
  - O&M requires experienced and skill manpower – currently, limited availability in Bangladesh.
- Establishment and operation of supporting infrastructure like port, water channels, road are critical for uninterrupted supply of coal to the plant.

Performance of existing power plant at Barapukuria:

- Unit#1 was out for operations for 3 months (Nov'13-Jan'14) in FY 13-14 due to boiler maintenance
- Unit#1 was out for operations for ~1 months (Nov'14-Dec'15) in FY 14-15 due to coal mine maintenance
- Unit#2 was out for operations for ~2 months (Dec'15-Feb'15) in FY 14-15 due to DCS system upgradation

Financial Year	Energy generation (GWH)	PLF (%)	Efficiency (%)
FY 12-13	1320.55	75.36	27.56
FY 13-14	1038.33	59.27	27.56
FY 14-15	940.91	53.7	25.39

Coal fired plants are reliable source of electricity generation; however ensuring continuous supply of affordable coal needs to be planned through adequate commercial arrangements.

Coal fired power plants can act as base load plants

- Apart from acting as base load plants for Bangladesh, critical as well as non-critical loads can also be supplied from imported coal fired plants.
- Domestic coal may not be sufficient for meeting the increasing electricity demand of Bangladesh.
- High quality domestic coal is available but difficulty of land acquisition possess challenge in development of mines – longer gestation period in development of domestic coal mines
- Coal policy is in advanced stage of finalization, which is expected to provide focus on coal mine development in the country and result in adequate coal supply.
- Currently a 250MW (2x 125) pit head coal fired power plant is operating at Barapukuria, and the units are de-rated to 100 MW. Additional capacity of 250-275 MW (3rd unit) by BPDB
- A 1320MW plant by APSCL is planned at pit head

- Total estimated global coal production in 2013 was 7,823 MT, with overall international trade at around 1,334 MT.
- Imported coal is expected to be sufficient for meeting the electricity demand of Bangladesh.

Parameter	Australia	Indonesia	South Africa
Thermal Coal Production	248 MT (for 2013-14)	~400 MT (for 2013)	~250 MT (for 2013)
Thermal Coal Export	195 MT (for 2013-14)	~350 MT (for 2013)	~100 MT (for 2013)
GCV	5,200 – 6,300 kcal/kg	5,400 – 6,200 kcal/kg	5,700 – 6,200 kcal/kg
Total Moisture	8 – 16%	10 – 20%	<10%
Ash	<15%	<15%	14 – 22%
Sulphur	<1%	0.5 – 0.9%	0.4 – 0.9%

Coal fired power plants can supply electricity adequately to Bangladesh, and can meet base load, critical & non critical demand. However, continuous supply of domestic coal would require development of mines and handling social and environmental issues.

Affordability analysis for coal fired power plants

Existing domestic Coal Based Power Plant

- In FY 2014-15 Barapukuria had a tariff of Tk. 6.70/ kWh. Fuel Charges: Tk. 5.03/kWh, Capacity Charges: Tk. 1.12/kWh, Variable O&M Charges: Tk. 0.54/kWh.
- The plant has a PLF of around 53.7% due to long maintenance outages; low efficiency of 25.4%.

Imported Coal Based IPPs

- 3 IPP contracts with Orion group for 1,200 MW. BPDB to buy power at Tk 4.095, Tk 3.795 and Tk 3.785 per unit.
- Orion was further awarded 3 coal-based plants with maximum generation capacity of 1,400 MW, and the tariff was set at Tk 6.69 to Tk 6.76/unit.
- Two other coal-based plants were to be set up by a JV of S Alam group and HTG Development Group with maximum generation capacity of 1,100 MW and tariff was set at Tk 6.60 and Tk 6.79/unit.
- Location of the plants were at Dhaka, Chittagong, Khulna, Barisal and Mawa.

PwC's calculation:

1. Domestic coal based power plant with super critical technology, with a coal GCV of 6100 Kcal / kg at 130 USD/ ton, at debt: equity ratio of 80:20 and interest rate of 4% determines following levelised cost (refer annexure for details):

Estimated levelized cost of generation for : 9.7 US cents/kWh or BDT 7.65/kWh

2. Imported coal based power plant with super critical technology, with a coal GCV of 5500 Kcal / kg at 85 USD/ ton, at debt: equity ratio of 80:20 and interest rate of 4% determines following levelised cost (refer annexure for details):

Estimated levelized cost of generation : 7.7 US cents/kWh or BDT 6.03/kWh

3. Blended (Imp-70%,Dom.-30%) coal based power plant with super critical technology, with a coal GCV of 5680 Kcal / kg at 99 USD/ ton, at debt: equity ratio of 80:20 and interest rate of 4% determines following levelised cost (refer annexure for details):

Estimated levelized cost of generation : 8.4 US cents/kWh or BDT 6.56/kWh

Please refer **Appendix 4** for assumptions taken

Environmental and social issues related to coal fired power plants

- Coal fired power plant and mining projects has environment, health and safety concerns. The pollution from coal fired power plants has adverse impact on environment, however with the advanced technologies, environment impact can be reduced.
- Mining and power plant operations have reported to have impacted agricultural production and ground water level. Research articles validate negative impact on environment near the mine operation areas of Barapukuria.
- Media reports identifies drop in ground water level near Barapukuria mine and damage of agriculture land and crop production. Phulbari coal project also reported be stalled due to social and environmental problems.
- Exploiting Bangladesh's domestic coal reserves may require displacing large population.
- Social concerns like depletion of ground water, waste water discharge/ dredging operations impacts livelihood of local can be overcome by mandating CSR activities, providing employments, developing distribution system around the power plants etc
- Developed of coal fired power plant would require implementation of stringent environment and social norms, usage of advanced technologies and technics for coal handling, Operations of coal fired power plants, ash disposal.
- Currently, world wide clean and sustainable mode of power generation like renewable are more considered for electricity generation, whereas coal fired power plants are discouraged due to environmental and social impact.

Coal fired power plant are often the cause of environmental and social concerns, and would require stringent environment and social norms, usage of advanced technologies and technics for coal handling, Operations of coal fired power plants, ash disposal.

Option analysis
Overall assessment (Imported coal)

1. Affordability, Reliability, Adequacy, and Sustainability analysis summary:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Medium	Medium	High	Low	Medium

Imported coal option has medium affordability, medium reliability, high adequacy and low sustainability. Hence, overall impact on energy security of Bangladesh is expected to be medium.

However, it may be noted that imported coal fired power plant can cater to base load of Bangladesh and provide reliable source of electricity. Bangladesh has planned multiple imported coal fired power plants – sourcing and logistical arrangement of coal shall be critical to ensure generation of uninterruptable power.

Option analysis
Overall assessment (Domestic coal)

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Medium	Medium	Medium	Low	Medium

Domestic coal option has medium affordability, medium reliability, medium adequacy and low sustainability. Hence, overall impact on energy security of Bangladesh is expected to be medium.

However, it may be noted that domestic coal fired power plant can cater to base load of Bangladesh and provide reliable source of electricity. In our earlier HCU study, key recommendations for development of mining activities included institutional strengthening and regulatory review to bring global standards, standardization of exploration and resource classification, exploiting domestic coal at larger depth through CBM/UCG, etc.

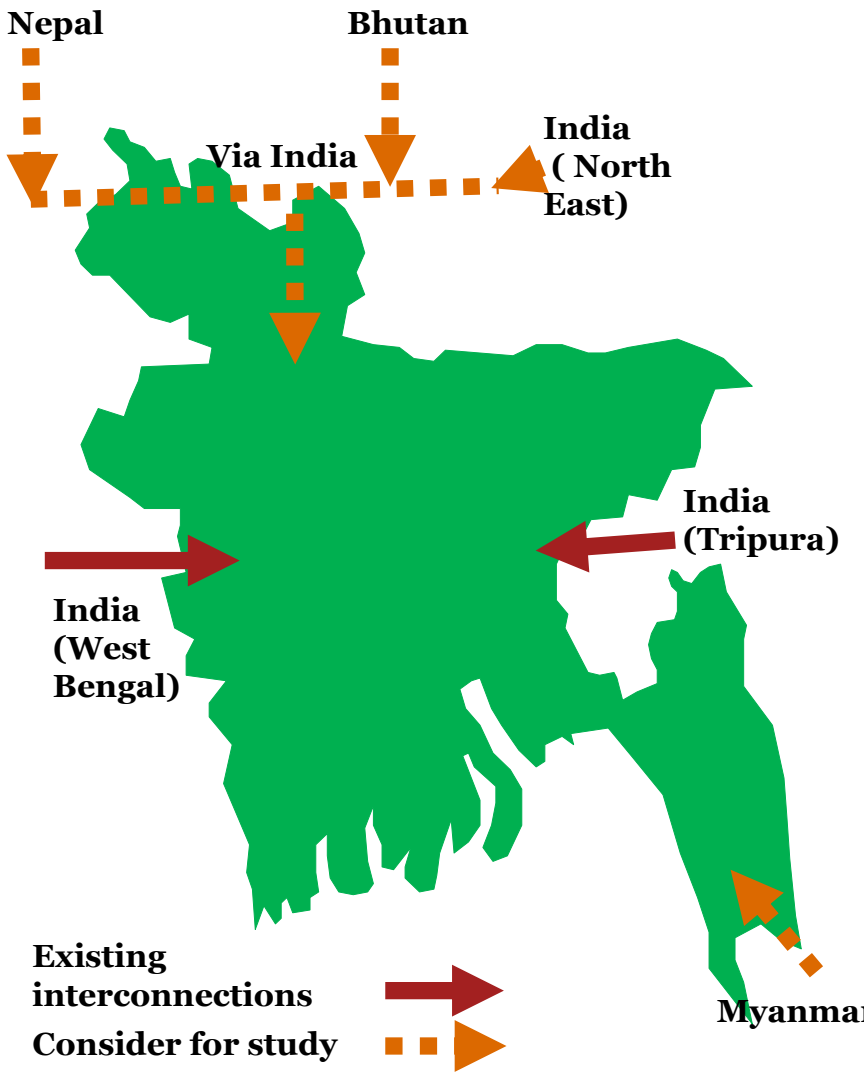
Section 2.7
Cross Border Power Import

Strategic location of Bangladesh for cross border power import

- Bangladesh-India shares more than 4000 kms of border while Bangladesh-Myanmar shares more than 270 km of border
- Close to hydro rich nations like Nepal and Bhutan
- Supply scenario in the region:
  - Eastern & NE region of India has potential for power export.
  - Nepal and Bhutan are exploring options for sale of surplus power to Bangladesh.
  - Proximity Myanmar has options to export.
- Various regional cooperation initiatives like SAARC Energy Cooperation, BBIN Initiative, ADB SASEC and USAID SARI initiatives envisage to facilitate cross border power trade between these countries.
- Political stability in Myanmar and Nepal and cordial relationship of Bangladesh with neighbouring countries shall be critical for sustainable cross border power trade.

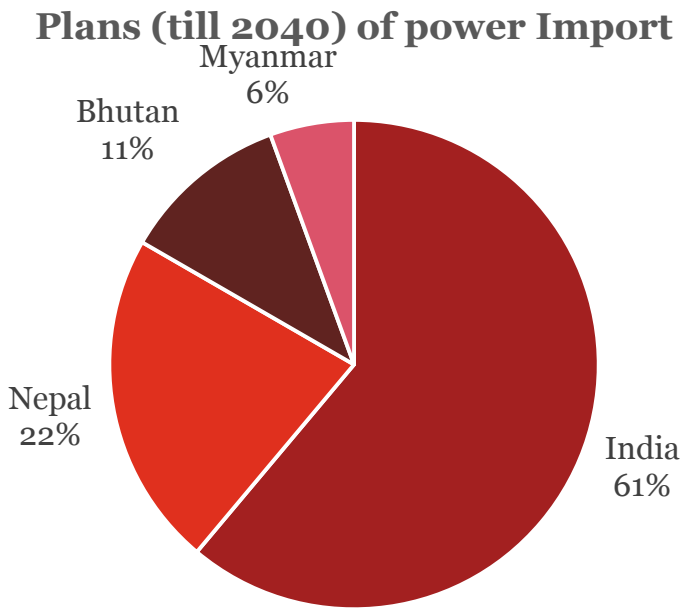
Critical success factors:

- power surplus neighbours, transmission connectivity, viable commercial arrangement, system reliability, and E&S safeguards.



Options for power import

TEPSCO/TEPC's presentation on PSMP 2015 suggest 15-20% of total power supply (8,500 MW) is envisaged to be imported by 2040 with the following break-up:

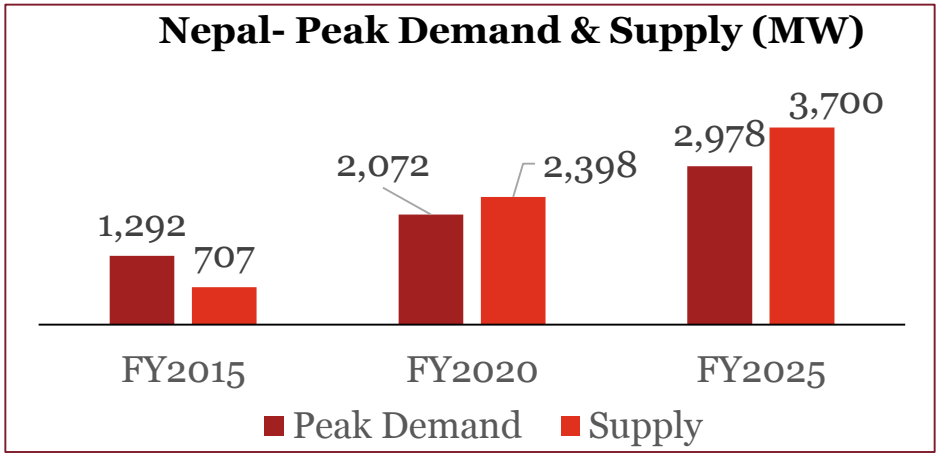


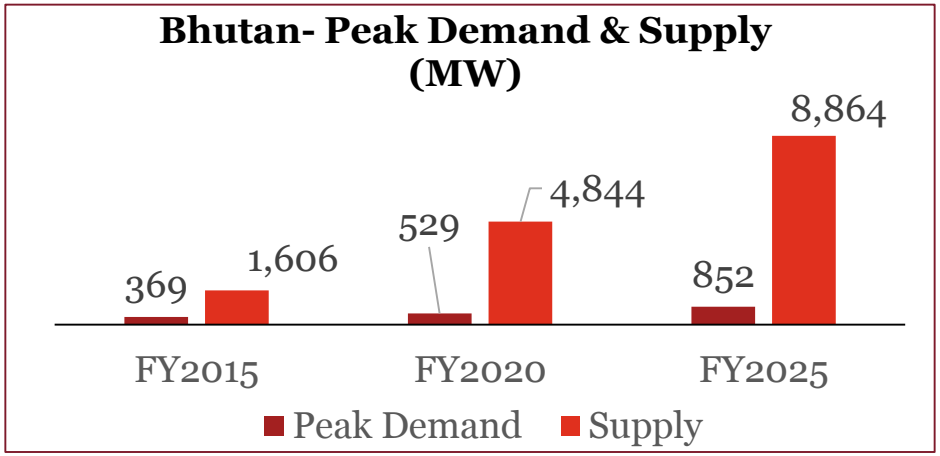
Import shall be predominantly from India. While electricity from Nepal and Bhutan shall also be imported by using Indian transmission system.

Power import for energy security – international examples

- In the Greater Mekong Subregion (GMS), Thailand imports 9% from Lao PDR and Malaysia, Cambodia imports 11.9% from Vietnam, Thailand and Lao, Vietnam imports 2% of electricity requirements.
- In the Southern African Power Pool (SAPP), South Africa imports 4.6% and Zimbabwe imports 11.9%.
- The report of Working Group of Lithuania while assessing the Lithuanian energy strategy highlighted that import of power should be around 10-15% for an energy secure country.
- The European Commission, presenting European Energy Security Strategy, proposed to extend the target as regards interconnection of installed electricity capacity to 15%.

Opportunity to import from Nepal and Bhutan

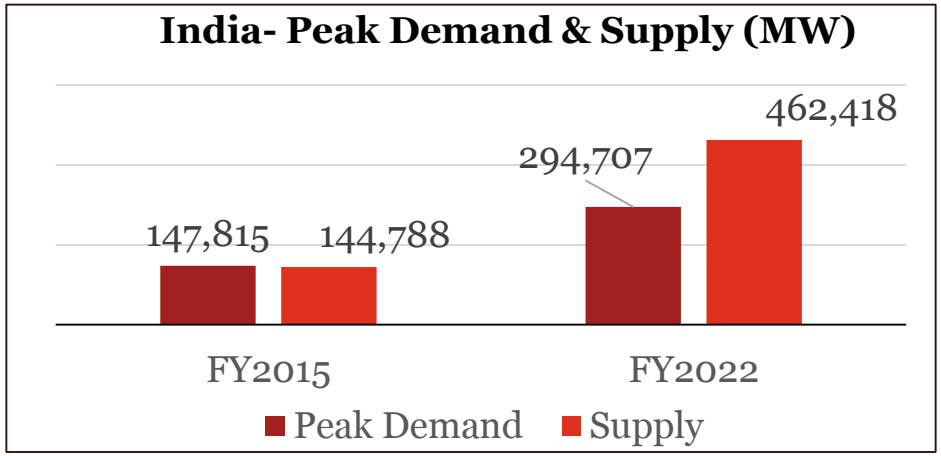


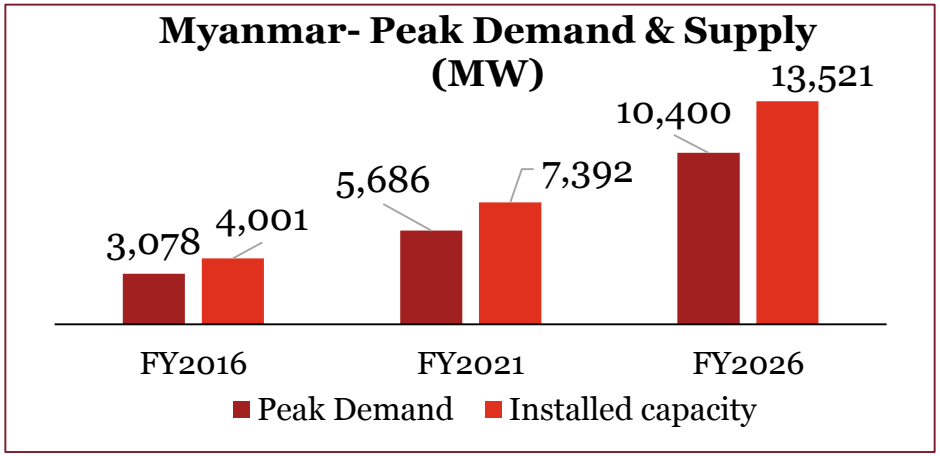


- Commissioning of following hydropower projects is expected to result in surplus power for export.
  - Major upcoming projects - Upper Tamakoshi (456 MW), Rasuwagadi (111 MW), Middle Bhotekoshi (102 MW)
  - In addition, there are many small size projects (<=100 MW)
- Currently, multiple hydro projects are being explored for export of power to Bangladesh by joint corporation under BBIN initiative.

- Bhutan is power surplus and exports around 70% of its generated energy to India
- As per current plans, around 8864 MW amount of capacity to be added in the system by 2025.
- Many upcoming hydro projects are being explored for export of power to Bangladesh by joint corporation under BBIN.
- With the D-S situation in India improving, Bhutan hydropower can be exported to Bangladesh.

Opportunity to import from India and Myanmar





- Existing India-Bangladesh power trade; India exports to Bangladesh:
  - 400kV Bheramara- Baharampur: 500 MW
  - 132kV Comilla- Surjyamaninagar: 100 MW
- Most of the regions in India are expected to be power surplus by 2022.
- Many private players in India are exploring power export options to outside India.

- Estimated hydropower potential of more than 100 GW; 302 projects have been identified with potential of 46 GW.
- 16.6 TCF of gas and 145 MMbbl of crude oil reserves (proven).
- Development of major projects, e.g. Thaketa gas based (500MW), Hutgyi HPP (1360 MW), Naungpha HPP (1000 MW) is expected to help the country achieve energy self sufficiency and have surplus power for export.

Technology and policy aspects

Project implementation

- Typical project implementation duration is 2-3 years
- Right of Way (RoW) and land acquisition are key challenges faced in project development.
- Cross border power trade is prevalent through synchronous and synchronous mode across the world.
- Current power import from India is in both synchronous and synchronous mode.
- Bangladesh has experience of construction and O&M of cross border transmission system.

Key requirements for facilitating cross border power trade and SAARC Energy Cooperation

- Though bilateral cross border power trade is currently operational between India and Bangladesh, enabling multilateral power trade (between Bhutan or Nepal-India-Bangladesh) will require consent and sovereign approvals from more than one national governments and may have long gestation period.
- Sovereign consent on commercial transactions (bet. Pvt. and BPDB and not G2G), can be challenging considering minimal benefit to intermediate country.
- Discussions on setting-up of cross border power exchange in the region is under consideration; however sovereign approvals and agreement of operational aspects is likely to take time given the involvement of multiple stakeholders.
- Institutional arrangements like Forum of Regulator (comprising of national regulators) and Forum of System Operators (comprising of Transmission and System Operators) can facilitate cross border power trade on bilateral, multilateral and commercial basis.

Other key commercial & regulatory aspects

- Transmission pricing framework, guidelines for corridor allocation and congestion management
- Guidelines and uniform framework for system operation, granting open access, balancing & settlement mechanism, trading etc.
- Setting-up dispute settlement mechanism.
- Financing cross border lines.

Reliability and adequacy of cross border transmission systems (1/2)

- Reliability of transmission systems depend on weather conditions, line loading, equipment performance, geographical terrain, etc. with a reliability of around 98% being the general standard.
- HVDC system is as an effective solution for connecting two systems with different frequencies/ phases; increases protection against faults.
- Discussions on development of a HVDC system between Rangia/ Rowta (IND) - Barapukuria/ Jamalpur (BAN) and a 765kV HVAC for connecting the Eastern and North Eastern grid of India through Bangladesh are being considered for import of 1000-2000 MW of power by Bangladesh.
- Capacity augmentation of 500 MW is being done for the link between Baharampur (IND) to Bheramara (BAN) under ADB's SASEC program.

- Research reports suggests that interconnections by HVDC system across asynchronous borders results in following benefits:
  - Control the flow of power
  - Avoids proliferation of grid disturbance between two system
  - Increasing grid stability and independence
  - Over 500-800 kms the DC and AC system has breakeven
  - HVDC system has lesser effect on environment and people as compare to AC

- Existing HVDC circle of PGCB has observed very limited trips and outages in 2015:
  - Some trips and outages were observed between April and September due to severe weather conditions like heavy rain, high wind etc.

Reliable transmission systems are currently in operations between India and Bangladesh. For further flow of electricity between the SAARC countries, strengthening of interregional transmission system shall be required.

Reliability and adequacy of cross border transmission systems (1/2)

- Import of power can cater to base load of Bangladesh. It can also supply power for critical as well as non-critical loads.
- HVDC system provides flexibility of control of bi-directional flow of power, which can help in power banking facility
- Long term contracts and cordial bilateral (G2G) relations can ensure supply of electricity.
- SAARC agreement for regional energy corporation (Nov'14) is in place and currently it is under ratification by GoB.
- BBIN corporation and Bangladesh-India joint technical teams are working for enabling flow of power across the region.
- GoB has signed MoU with GMR energy for import of 500 MW of power from two hydropower projects (Upper Karnali and Upper Marsyangdi) in Nepal.
- A coal based power plant of 1600 MW capacity is planned by a leading power sector entity of India in Jharkhand (India) for power export to Bangladesh.
- At the BBIN Summit in January 2016, it was discussed that the following planned hydropower plants may be developed by joint participation of 3 countries (Bhutan/ Nepal, India and Bangladesh):
  - Dorjilung, Bhutan: 1125 MW
  - Sunkoshi 2, Nepal: 1110 MW
  - Sunkoshi 3, Nepal: 536 MW

As discussed before, neighboring countries like India, Bhutan, Nepal and Myanmar are expected to be power surplus in the medium term and are likely to be in a position to export power to Bangladesh with appropriate sovereign, regulatory and institutional arrangements in place.

Current tariffs for cross border power trade in the region

India → Bangladesh (600MW)

Source	Type	Trader	Tenure	Tariff/kWh
250 MW NTPC	G-G	NVVNL	25 years	4.05 INR**
250 MW Market	Comml	PTC	3 years	7.26 INR**
100 MW Palatana	G-G	NVVNL	5 years	5.5 INR**(only energy charge)

- Some of Indian private players have offered to supply power to Bangladesh at Tk. 6-7 per unit.
- However, burden of setting-up and maintaining of HVDC system are not factored in the pricing.

India → Nepal (~ 250 MW by NEA)

Source	Type	Tenure	Tariff/kWh
237 MW India	G-G	-	5.40 INR**
20-30 MW Market	Comml	4 months@	3.75 INR#

Note: Nepal has contracted 150 MW from PTC but supply has not yet commenced.

Bhutan → India (~1200MW)

Capacity$/Source	Type	Tenure	Tariff/kWh
1020 MW Tala	G-G	35 years	~2.00 INR*
336 MW Chhukha	G-G		
60 MW Kurichhu	G-G		
126 MW Dagachhu	Comml	25 years	2.98 INR**

Note: PTC has signed 15-year PPA for import of power from 118 MW Nikacchu Plant at a levelised rate of 4.05 INR/kWh. Supply is yet to commence.

** Dec'11 onwards; ** FY15; # FY14; @ dry months (winter) during FY'11-FY'15*
$ - Installed Capacity; traders will procure power after deducting APC, royalty power and merchant sale (if any)

Affordability analysis considering import of hydropower from Bhutan

Particulars	Assumptions & Calculations	Remarks
Tariff at Bhutan border	4.7 taka/ kWh	Indicative; hydropower tariffs will vary from project to project.
Approx. volume available for x-border power trade	196 MUs (40% of capacity)	
Transmission (PoC) charges for Bhutan injection	0.101 taka/kWh	CERC order No.L-1/44/2010-CERC dated 12.3.2016
Transmission (PoC) charges for Bangladesh withdrawal	0.073 taka/kWh	
Impact on transmission tariff due to Cross border interconnection project between India and Bangladesh	0.61 taka/ kWh	Considering Bangladesh India Interconnection Project Phase-II for 500MW
Transmission loss due to Bhutan injection and Bangladesh withdrawal	1.69%	NRLDC report on PoC and Transmission loss dated 06-Apr-2016
System operations charges	0.035 taka/ kWh	Assumed
Landed cost of power at Bangladesh border (minimum)	5.7 taka/ kWh	

Estimated cost of imported power at Bangladesh border – BDT 5.7/kWh or USD 7.1 cents/ kWh

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Medium	High	High	High	High

Power trade option has medium affordability, and high reliability, adequacy and sustainability. Hence, overall impact on energy security of Bangladesh is expected to be high.

However, regulatory procedures, mechanisms and institutional arrangements needs to be in place (along with sovereign approvals and consents on various aspects) for further development in cross border power trade between Bangladesh and most of its energy surplus neighbours.

Section 2.8
Domestic Hydropower

Limited scope for hydropower generation in Bangladesh

- Bangladesh is mostly a country with flat terrain (apart from some hilly regions in the north-eastern and south-eastern region); a network of river criss-crosses the country, of which Padma, Jamuna, Teesta, Brahmaputra, Surma, Meghna and Karnafuli are significant. More than 90% of Bangladesh's rivers originates outside the country
- Existing hydropower plants are:
  - 230 MW Karnafuli Hydro station (at Kaptai);
  - 10 kW plant in Bamerchara;
  - There is a scope for capacity increase of Karnafuli HEP by 100 MW.
- Due to the country's flat terrain and potentially large social and environmental impacts, the scope of hydropower generation is limited to small scale hydro (mostly in hilly regions of northeast and southeast part)
- A study by Stream Tech (US based) in 2014 identified potential small scale hydropower sites at different locations along the Sangu, Matamhuri,& Bakkhali rivers as well as the Banshkhali Eco- Park Stream. The total capacity of these 19 sites are 59.1 MW having a generation capacity of 207,051 MWh.

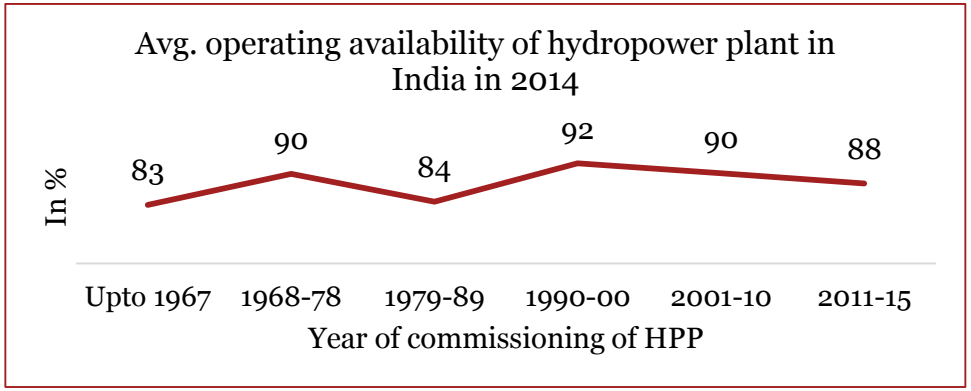
River	Capacity	Potential
Sangu	**55.44 MW**	**194176 MWh**
Mata-muhuri	**3.44 MW**	**12046 MWh**
Bakkhali	**0.23 MW**	**799 MWh**
Bansh-kahli	**0.01 MW**	**30 MWh**

GoB has a target to install 4 MW in small hydropower by 2021. The plan includes sufficient financing to cover installation of 3 to 4 HPP at sites with 1-2 MW of technical potential.

Reliability and adequacy analysis of domestic hydropower

- Generally during initial years of operation, hydropower plants experience higher number of forced outages until a stable stage of operational experience is attained and the number of incidents requiring corrective and emergency maintenance declines, in part due to preventive maintenance.
- Effective O&M of hydro power plants is important to reduce unplanned outages; proper implementation of preventive maintenance schedules can lead to timely detection and analysis of potential faults.
- Hydropower can quickly go from zero power to maximum output, making them exceptionally good at meeting rapidly changing demands for electricity throughout the day (quick ramp -up and ramp-down).
- Hydro generation has the ability to meet peak demand, maintain the system voltage levels and provide essential back-up power during major electricity disruptions / blackout.
- However, developing multiple projects on the same river often compromises the capacity of a project to meet peak demand due to other peak load projects subsequently developed.

Sl. No	Avg. Availability	%
1	**First Year of Operation**	
a	Operation Life	95
b	Maintenance & Breakdown	5
2	**After 3 years of operation**	
a	Operation Life	97
b	Maintenance & Breakdown	3



Hydropower can play a very important balancing role in ensuring the reliability of power system as it can be ramped up or down rapidly. However, the current hydropower potential is not adequate to play a role in ensuring the country's energy security.

Affordability and sustainability analysis of domestic hydropower

Current tariff

- Last year's tariff (Tk./ kWh) of Karnafully Hydro Power Station was Tk 1.03/ kWh (Variable cost = Tk 0.04/ kWh and fixed cost = Tk 0.99/ kWh.

PwC Analysis:

- **10 MW hydel power plant**, at debt: equity ratio of 70:30 and interest rate of 6%, 15% return of equity determines following levelised cost. Refer **Appendix 4** for assumptions taken.

Estimated levelized cost of generation for: USD 0.104/kWh or BDT 8.16/kWh .

Sustainability Analysis

- Contributes to flood control, irrigation and potable water reservoirs.
- Clean power with minimal GHG emission. Small-hydro power generation is believed to be more environment or ecology friendly.
- Development of multiple projects in a basin may impact social-environment more severely.
- Hydropower dams can significantly affect natural river systems as well as fish and wildlife habitants.
- Involve submergence causing the displacement of project area people.
  - Kaptai dam construction in 1961 displaced about 100,000 people from Chittagong Hills Tracts due to flooding caused by dam's reservoir

Since the benefits and negative effects of natural resource development are often unevenly distributed, benefit-sharing mechanisms and mitigation measures are crucial for sustainability and stability in development.

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Low	High	Low	Medium	Low

Hydropower has low affordability, high reliability, low adequacy and medium sustainability. Hence, overall impact on energy security of Bangladesh is expected to be low.

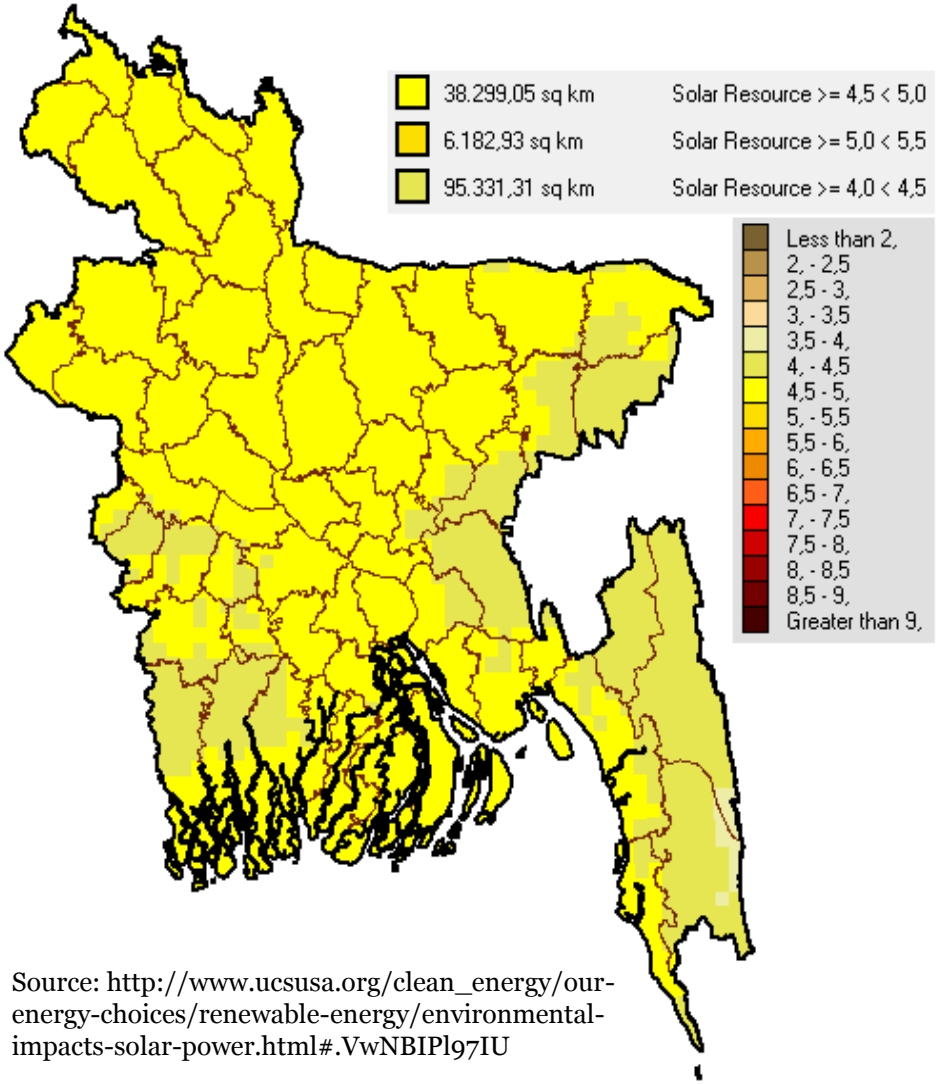
Further, it may be noted that Bangladesh has very limited hydropower potential and limited experience in development and operation of hydropower projects.

Section 2.9
Solar

Overview of Solar potential in Bangladesh

- Average solar radiation in Bangladesh is about 4.5 kWh/m2/day . Average peak sunshine hours per day is 4.5 h, and the annual operational days is more or less 340 days.
- Urban areas as well as un-electrified areas are deploying solar based plants for generating energy in grid connected or off-grid mode.
- Crystalline silicon and thin film technologies are used for solar power generation globally, current trend usage is:
  - Crystalline silicon based: 70 to 80% of projects.
  - Thin film based: 20 to 30% of projects.
- Typically, 3.5-4 acres per MW of land is required for setting up utility scale solar plant.
- Generally, projects take 10-12 months from award of contract to commissioning.
- **Critical Success Factors:**

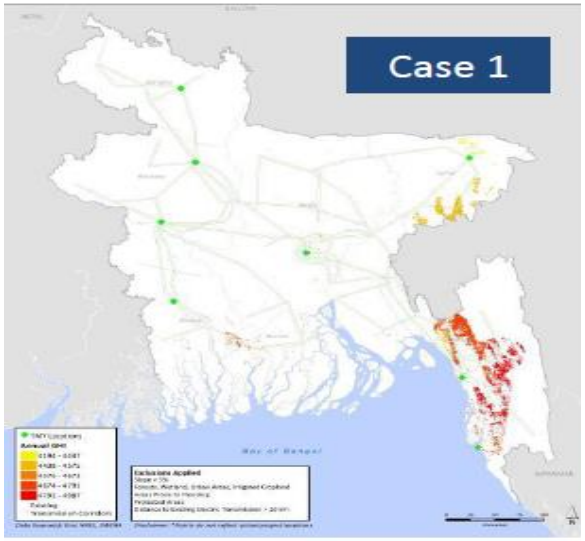
Availability of land/ area	Power evacuation arrangement	Commercial arrangements and subsidy



Source: http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-solar-power.html#.VwNBIPl97IU

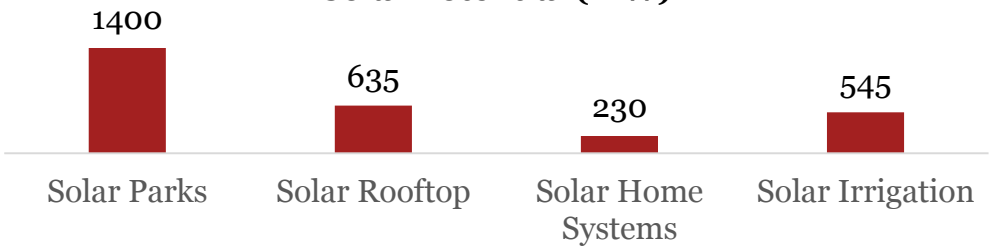
Overview of Solar potential and development plan

In a recent study for Scaling Up Renewable Energy (SREP), following potential has been identified:



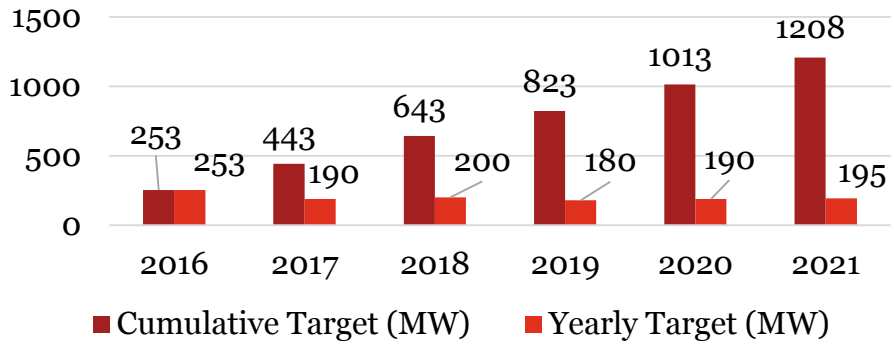
Admin. Division	Case (MW)
Barisal	14
Chittagong	1050
Dhaka	18
Khulna	50
Rajshahi	-
Rangpur	2
Sylhet	274
Total	1,408

Solar Potential (MW)



Solar Home System: IDCOL

GOB's target for Solar Park



- GoB has set a target for development of 1211 MW of solar power plants till 2021 with support from development partners and by facilitating private investments.

Govt. in govt. land	**23%**	**Utility target:** • **BPDB-100 MW,** • **EGCB-100MW,** • **NWPGCL-5MW,** • **RPCL-50MW,** • **CPGCBL-50MW**
IPP in govt. land	**28%**	
Private in private land	**50%**	
Break-up of planned potential		

Reliability and sustainability analysis for solar power generation

Reliability

- Reliability of solar power generation depends mainly on following aspects:
  - Weather condition.
  - Outage due to O&M activities.
  - Outage in T&D system for grid-connected system.
- Reliability of electricity generation by solar resources increasing with the advancement of technology
- For un-electrified areas, without grid connectivity, solar provides dependable energy supply.

Key maintenance requirement for utility scale park	**Frequency**
Panel cleaning	Every 15 days (block wise)
Vegetation control	1-3 times a year
Water drainage	Variable
Inverter servicing	1-2 times a year (as needed)
Tracker maintenance	
Equipment replacement	As needed

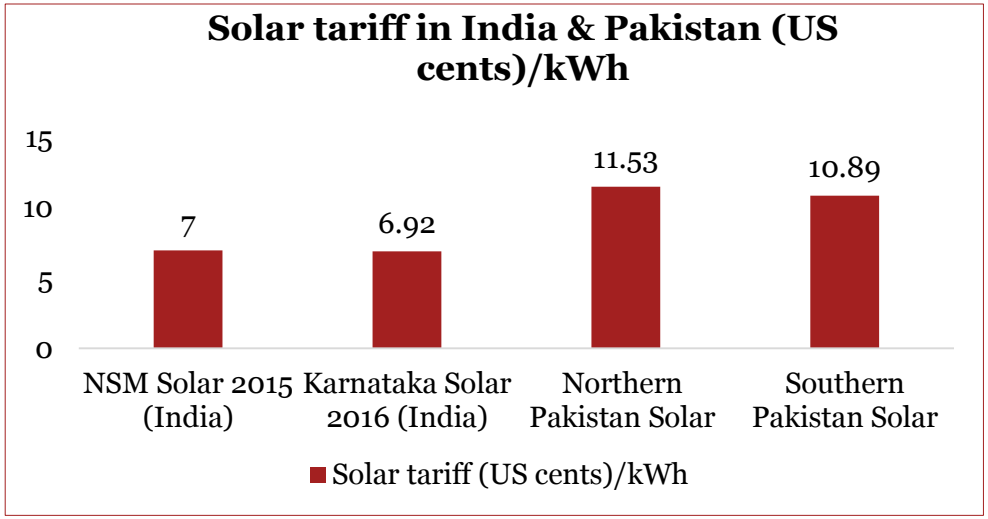
Sustainability

- Solar power is one of the cleanest and sustainable source of electricity generation.
- Considering the scarcity of barren land in Bangladesh, solar generating stations will have impact on the locals and will have Resettlement &Rehabilitation (R&R) related concerns.
- Utility scale plants can lead to loss in habitat, degradation of land, affect vegetation, etc.
- Concentrating solar parks can impact operations of aircraft, depletion of ground water, etc.
- Solar manufacturing facilities creates environmental and social concerns.
- Solar system has minimal impact on environment; whereas social concerns may be addressed by planning solar panel in transportation system (rail), water canals/bodies, etc.

Affordability analysis for solar power generation (1/2)

Following tariffs are received in the recent time by GoB:

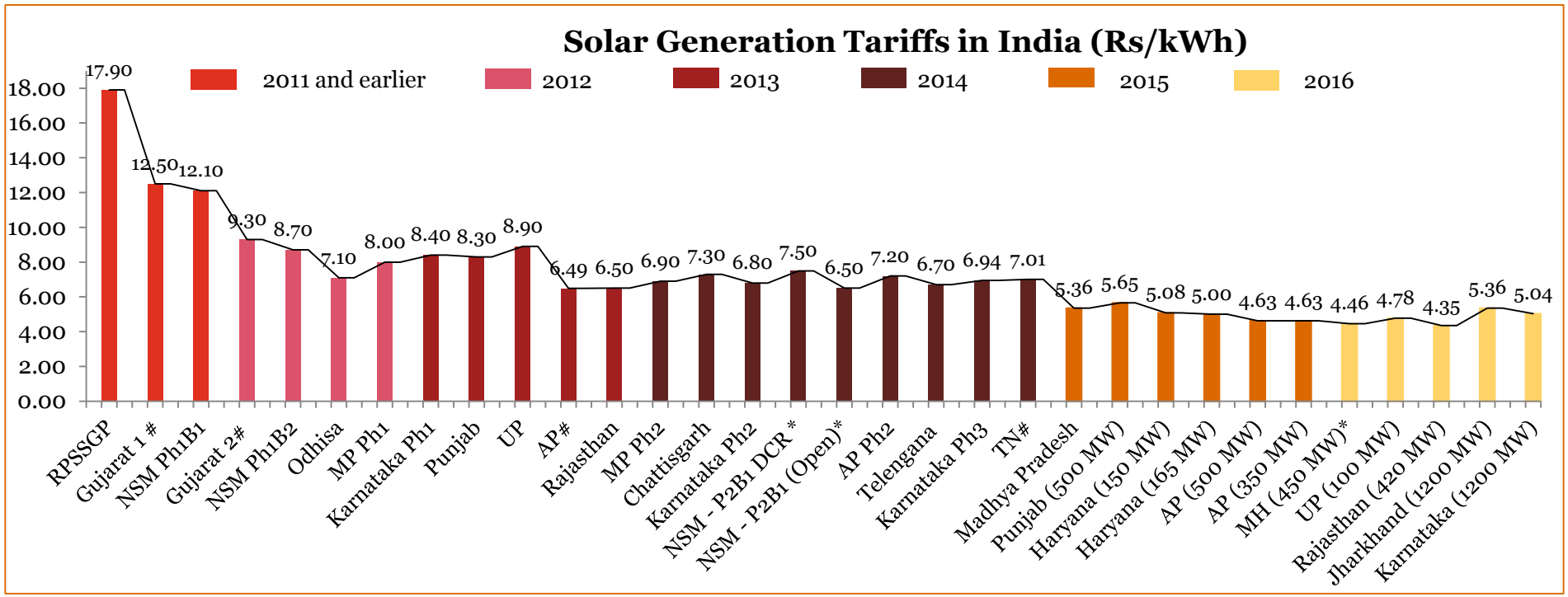
Project location	Developer	Mode of allocation	Tariff in US cents/ unit
30 MW Kurigram	ETERN-CCCE-HAREON consortium	Solicited	17
3 MW Jamalpur	Engreen Sharishabari Solar Plant Ltd.	Solicited	18
200 MW Teknaf	Sun Edison Energy Holding Singapore Pte. Ltd.	Unsolicited	17
32 MW Myamansingh	Edisun-Power Point-Haor Bangla-Korea Green Energy Ltd.	Unsolicited	17
20 MW Teknaf	Joules Power Ltd.	Unsolicited	14



Drivers for lower tariff in India & Pakistan

- High capacity utilization factor due to high solar irradiance
- Availability of barren land and provision for land allocation on lease to bring down the capital cost
- Provision for FIT, sale of REC, various tax exemptions, subsidy, etc. to bring down the cost
- Provision for soft loan at a concessional rate.
- Indigenous production of solar equipment in India reduces the cost of equipment & machinery
- In Pakistan, the tariff is higher due to high financing costs and lack of domestic manufacturing facility.

Affordability analysis for solar power generation (1/2)



Feed in Tariff (no bidding), levelised tariff of Gujarat
* Awarded on basis of VGF; Tariff calculated as levelised tariff

From the above chart it can be seen that the average purchase price of solar power in India in 2016 is INR 4.8 per unit

PwC Analysis

A utility scale solar project at debt: equity ratio of 80:20 and interest rate of 6%, Return of equity of 15% determines following levelised cost (Refer **Appendix 4** for assumptions):

Estimated levelized cost of generation: USD 0.142/kWh or BDT 13.17/kWh.

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Low	Medium	Medium	High	Medium

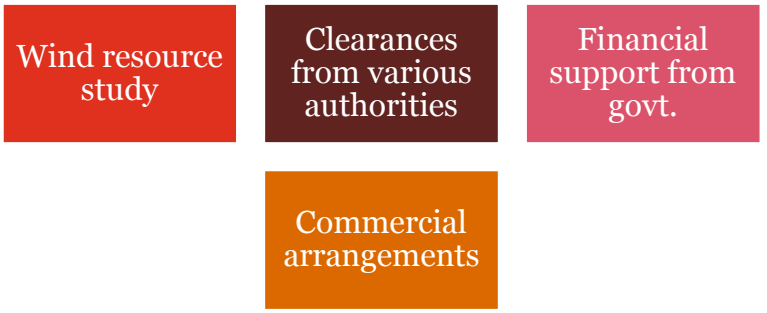
Solar generation option has low affordability, medium reliability, medium adequacy and high sustainability. Hence, overall impact on energy security of Bangladesh is expected to be medium.

Policy, regulatory and institutional arrangements can be put in place for incentivize and accelerate development of solar generation in Bangladesh.

Section 2.10
Wind

Overview of wind generation potential

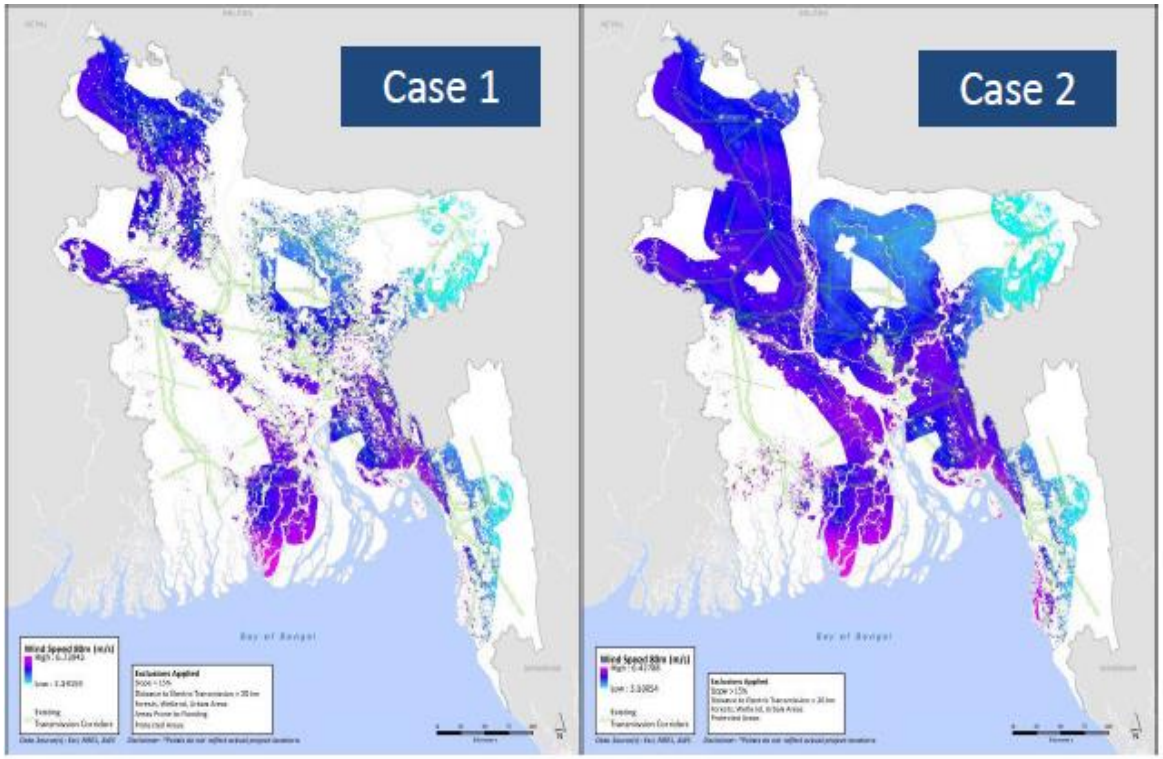
- Bangladesh falls under low to medium wind regime in terms of potential for electricity generation.
- Complete wind resources assessment is not available to identify the potential; some studies are currently on-going to collect the wind data, which would be able to determine the wind resource potential.
- Some studies evaluate that in Bangladesh installation of 4,000 MW of wind power is technically feasible#.
- Currently two wind projects namely 900kW in Feni and 1MW wind battery hybrid project in Kutubdia island are operating.
- Regenpowertech India has completed wind mapping of Feni and Mognamaghat and mapping of another 3 sites (Anawara, Rajapalang & Chilimari) is under process at 30, 55 and 80 MTrs. A 15MW Wind and 3 MW Solar hybrid power plant has been proposed by Regent Power Tech at Feni.
- NREL, USA has also undertaken wind mapping of 9 sites at 70-80 MTr (USAID funding); to be completed by 2017.
- Wind mapping is going on for a 60 MW wind power plant at Cox Bazar.
- We understand that most of the area has wind power density less than 200 W/sq. m which will require low wind speed turbine for better generation.
- The height of the towers also needs to be increased to 120 meter to expose the turbine to a more higher and steady wind (for 1.6 – 2 MW capacity of units).
- Appropriate technology selection is only possible based on the wind mapping data.
- Typical project development timeline for a 20-30 MW wind farm is 3 years (including wind mapping and construction time)
- Grid integration poses challenges; hybrid models are preferred (e.g. wind-bio mass, wind-gas, etc.)
- Typically, 2-2.5 acres per tower of area is required.
- **Critical Success Factors:**



 # Source: Implications of renewable energy technologies in the Bangladesh power sector: Long-term planning strategies-2010

Review of Wind power generation based on option assessment framework (1/3)

In a recent study of Scaling Up Renewable Energy (SREP), Two cases were developed showing the resource potential when flood prone land is excluded (Case 1) and when it is included (Case 2):



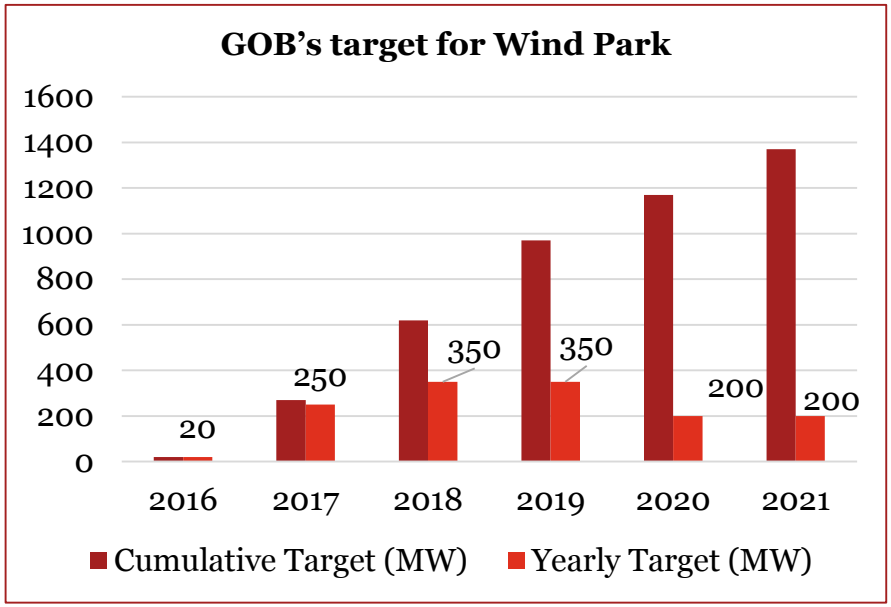
Buildable MW as per SREP study:

	20-25% Capacity Factor	25-30% Capacity Factor
Case 1	624 MW	13 MW
Case 2	996 MW	37 MW

Wind power generation is an intermittent source and cannot provide power to base load and critical load.

Source: SREDA

Review of Wind power generation based on option assessment framework (2/3)



Break-up of planned potential	
Govt. in govt. land	**45%**
IPP in govt. land	**25%**
Private in private land	**31%**

GoB's Target:

- GoB has set a target for development of 1320 MW of wind power plants in current 5 year plan with support from development partners.
- Target of 100 MW each for development of wind power plant by BPDB, APSCL, EGCB, NWPGCL, RPCL and CPGCBL.

Sustainability Aspects

- Wind firms generates electricity with no green house emission.
- Destruction of useful land is minimal and only footing area gets permanently used, other areas can be utilised
- Off-shore wind plants may hamper ecosystem and habitat of marine wildlife
- Collisions of birds and bats, displacement of natural habitats are some of the other concerns
- Locals population are often concerned with issues like noise, shadow flickers due to turbine movement, degradation of visual impact of the areas by the wind plants, etc.

Review of Wind power generation based on option assessment framework (3/3)

- Intermittent nature of wind at times cannot maintain load generation balance affecting the system stability. Site specific wind resource data collection provides certainty to the developer. Turbulence in wind and even a loss in wind speed can affect the moving components
- Generally, failure of key components like drive, generator can cause plant shutdown up to a weeks period in an year. However, highly reliable equipment's/technologies are available for monitoring maintenance requirement
- Wind turbines generally looses 1.6± 0.2% of their output every year reducing a wind farm output by 12% over a 20 year life time
- In case of line tripping, emergency outage due to fault, system experiences heavy current flow or voltage dip which can cause electrical & mechanical stress for the turbine components.

Estimated cost of generation for 15 MW wind firm at 80 Mtrs height : USD 0.15/kWh or BDT 12 kWh *(Source: SREDA estimate)*

Components	Shutdown duration per failure (days)	Frequency of failure (yearly)
Blades	6	0.2
Axle	6	0.15
Drive	8	0.11
Generator	9	0.12
Load bearing parts	5	0.1
Drivetrain	8	0.08
Mechanical brake	5	0.15

Interruptions in the T&D network hampers the energy generation:

- 900 kW Feni wind power plant failed to achieve target electricity production due to load shedding in supply line of BREB.
- Towers of 1 MW Kutubdia WPP were uprooted by cyclone & again renovated increasing generation cost.

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Low	Low	Low	Medium	Low

Wind generation option has low affordability, low reliability, low adequacy and medium sustainability. Hence, overall impact on energy security of Bangladesh is expected to be low.

Policy, regulatory and institutional arrangements can be put in place for incentivize and accelerate development of wind generation in Bangladesh and GoB appears to be committed towards this.

Section 2.11
Biomass, Biogas and Waste-to-Energy

Bangladesh has plans for developing Biomass, Biogas and Waste-to-Energy based electricity generating plants

Biomass

- Rice husk is viewed as a viable feedstock option while other feeding options are limited.
- More than 10 million tons rice husk are produced annually in the country, of which only 10% are located at large commercial rice operations which can feed to biomass plants.
- Ongoing developments:
  - Two rice husk based plants of capacity 250 kW (off-grid) and 400kW are proposed in Kapasia upazlia and Thakurgaon.
  - 1 MW combined heat and power plant (430kW power & rest heat) will be developed at Keraniganj, Dhaka based on modular type dry fermentation technology.
  - Currently ~40 biogas fired engines are operating in Bangladesh.

Source: SREP study

Biogas

- Poultry, cattle and cow manure is considered a possible options.
- Two Biogas based plants of 400 kW and 50 kW are in operations and four more plants of 25 to 100 kW is under construction
- Poultry and dairy farms have installed total 1,200 kW of small to medium engine biogas fueled generators (5 kW to 50 kW) under GIZ funding

Waste to Energy

- 13,383 tons of solid waste is produced daily in the country with highest production in Dhaka.
- BPDB in consultation with SREDA intends to start a 1 MW pilot waste-to-energy project.
- Plans to form a company (by the city corporations, municipalities and power utilities) with the objective of improved waste management & generation of electricity from waste.

Critical success factors in implementation

Technological aspects

- Various technologies have been developed like gasification, dry fermentation, wet fermentation or incineration of waste or preparation of refused derived fuel to generate energy.
- Dry fermentation technology will be one of option considering the organic nature and high moisture content of the waste.
- Gasification is a mature technology and a 250kW rice husk based gasifier plant was installed in 2007 in Kapasia Bangladesh having 75% efficiency.

Implementation aspects

- Typical project development timeline for a biomass plant is 18 months and waste to energy plant is 24 months.
- Waste management along with segregation and supply of waste & biomass are the key areas of concern.

Critical success factors

Review of Biomass, Biogas and Waste-to-Energy based on option assessment framework (1/2)

Biomass

- Potential Capacity: 274 MW

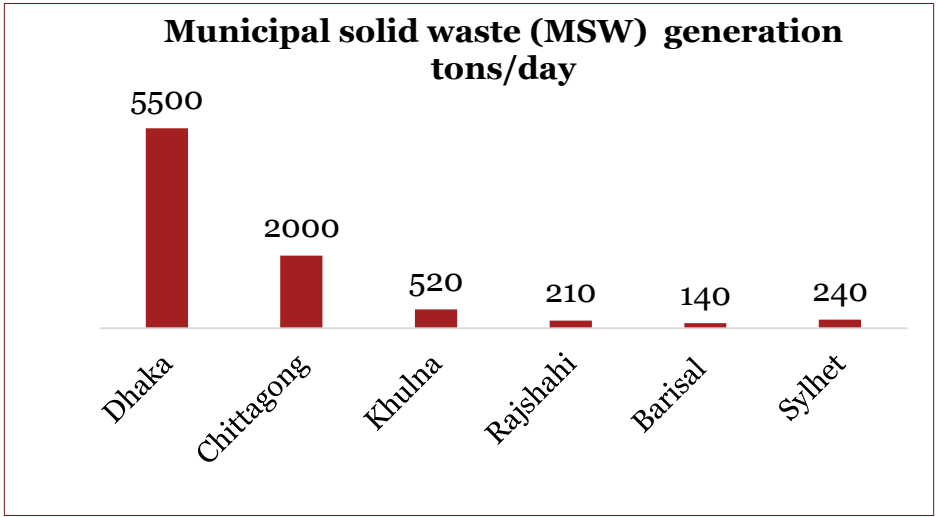
Biogas

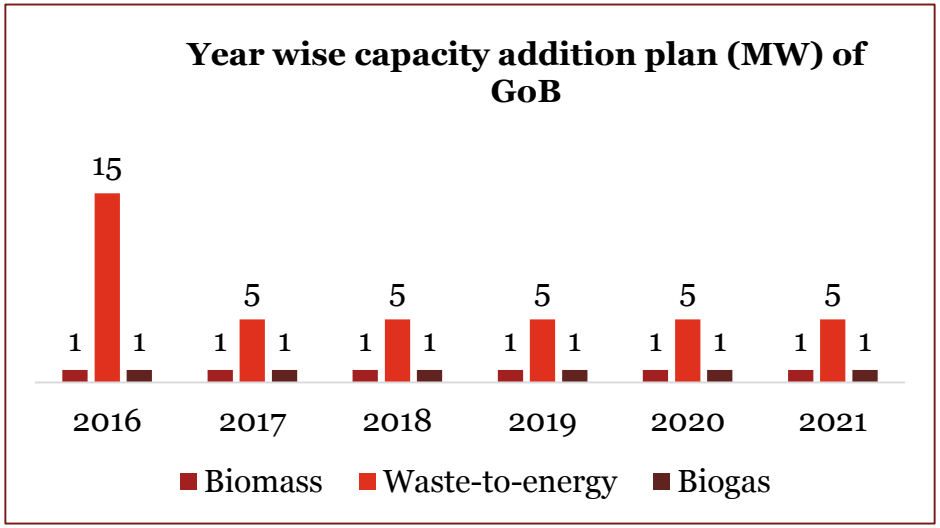
- Commercial Cattle & Buffalo: 1.3 MW
- Commercial Fowl & Duck: 8.1 MW

Waste-to-Energy

- Potential Capacity : 170 MW *

Calculated considering about 3 mn tonnes of waste generation per year





- 40-60% of wastes are not properly disposed or collected which increases the chance of not having sufficient availability of fuel.
- Reliability of biomass and municipal based power generation mainly faces three broad issues in terms of storage of raw materials, transportation of raw material and separation of waste.
- Efficient segregation of organic and inorganic waste will be needed at the source or the generation site depending on the technology e.g. dry fermentation needs separation of organic & inorganic waste.

Review of Biomass, Biogas and Waste-to-Energy based on option assessment framework (2/2)

- Lack of sufficient transport system to deliver adequate amount of waste from disposal sites can cause underutilization of the plant efficiency and generation potential from MSW.
- More efficient waste management initiatives needs to be taken by Dhaka City Corporation and Local Government Engineering Department to generate waste from energy.

City	Waste transported (tons/day)	Waste generated (tons/day)
Dhaka	2000-2400	5000–5500
Chittagong	500-550	2000
Khulna	240-260	420–520
Rajshahi	60-80	160–210
Barisal	30-40	100–140
Sylhet	60-80	200–240

Source: Chinese journal of engineering-Assessment of Municipal Solid Waste Management System in a Developing Country

- Clean technologies, with minimal impact on environment.
- Burning municipal solid waste generates energy and also reduces waste volume by up to 90%, leading to an environmental benefit.
- Key challenges:
  - Waste-to-Energy plants can be planned in the urban areas, but availability of land is a challenge.
  - Production of methane gas in the biogas plant can impact ozone layer.
  - Biomass unpleasant for humans and can attract pets, spread bacteria or infection.
  - Transportation of manure, biomass, waste has noise and emission impact.
  - Incineration of waste leads to emission of harmful gases like CO2, SO2, nitrogen oxides, etc.
  - Toxic materials contain trace metals like lead, cadmium and mercury present in the waste pose some environmental threat if they are released in to the air or dispersed in the ground.

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Low	Low	Low	Medium	Low

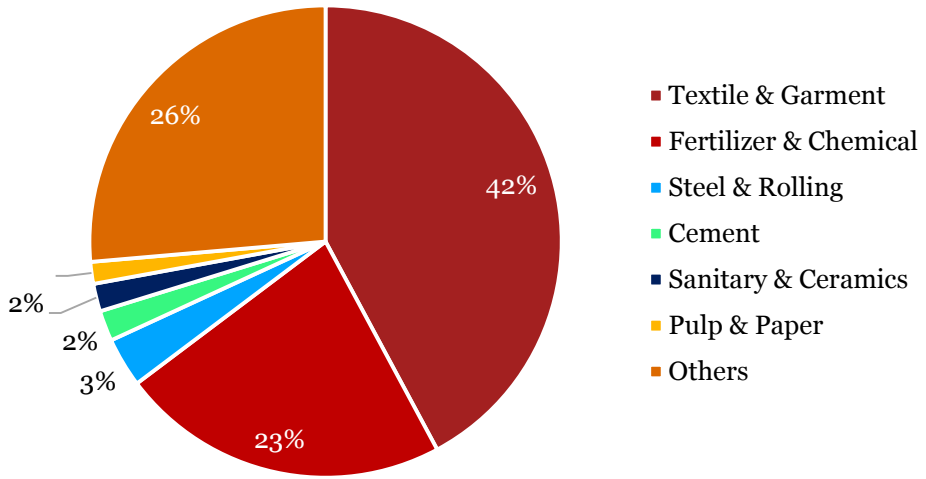
These options have low affordability, low reliability, low adequacy and medium sustainability. Hence, overall impact on energy security of Bangladesh is expected to be low.

However, GoB is committed to promote renewable energy and Biomass, Biogas and Waste-to-Energy are possible options. GoB is actively seeking the support of development partners to structure and implement such projects.

Section 2.12
Energy Efficiency and Conservation

Energy efficiency measures in gas consuming sectors are an imperative for efficient utilisation of this scarce natural resource

Industry sub sector wise consumption of natural gas (%)



- According to a survey of customer use efficiency by Titas Gas Distribution Company Ltd., modernization of the boilers used in industry alone can save 150 MMCFD of gas in Titas Franchise area alone.
- 100 mmscfd gas can be saved if domestic consumers in Titas Franchise area start using efficient gas cookers
- Most of the fertilizer companies are more than 35 years old and consume more than double the gas requirement for producing same amount of fertilizer as compared to private companies

Source: Energy Efficiency & Conservation Master Plan up to 2030, SREDA

- A recent survey estimated that **out of 2500 MMCFD use of gas, 400 MMCFD is wasted due to inefficient use in industries, power plants and residential sector** which can be used for generating about 3,000 MW power or supply of gas to other stalled power plants and thousands of new industries.
- Another 100 MMCFD gas can be saved if domestic consumers in Titas Franchise Area start using modern efficient gas cookers

Energy efficiency and conservation

Key opportunities

Industry	Existing energy consumption	EE&C case energy consumption	EE&C potential
Textile & garment	30.0%	17.6%	31% (3.6 Million toe/year)
Chemical Fertilizer	13.2%	8.4%	
Steel making & re-rolling	5.7%	3.8%	
Cement grinding	2.9%	2.0%	
Cold storage	0.5%	0.2%	
Chemical	2.5%	2.2%	
Others	45.2%	34.8%	

Fuel efficiency of old gas power plants operating in Bangladesh varies between 23% to 30%. Estimated saving in gas consumption by conversion to combined cycle is ~38 mmscfd which has a potential to generate 235 MW

Computation of estimated savings in gas consumption by way of conversion to combined cycle (1/2)

Sl. No.	Plant	Unit No.	Unit type	Installed Capacity (MW)	Present derated capacity (MW)	Total Annual Electricity Generation (kWh)	Efficiency (%)
1	Ghorashal	3	ST	210	170	1489200000	30.18
		4	ST	210	180	1576800000	30.18
		6	ST	210	190	1664400000	shut down from last 6 years
2	Shahjibazar	1	CT	35	35	306600000	25.79
		2	CT	35	31	271560000	25.79
3	Baghabari	1	CT	71	71	621960000	27.14

Source: BPDB – Annual Report, 2014

Computation of estimated savings in gas consumption by way of conversion to combined cycle (2/2)

Sl. No.	Plant	Unit No.	Gas consumed (cu.ft/kwh)	Gas consumed (cu. MT/kwh)	Energy consumed (kcal/kwh)	Efficiency after conversion (%)	Heat Rate at new efficiency (kcal/kwh)	Gas consumption at new efficiency (cu MT./kwh)	Savings in Gas consumption (cu MT/kwh)	Annual savings in gas consumption (cu. Mt.)
1	Ghorashal	3	11.9	0.34	3174.68	50	1720	0.18	0.15	229969377
		4	11.9	0.34	3174.68	50	1720	0.18	0.15	243496987.4
		6	0	0.00	0.00	50	1720	0.18	-0.18	-303903184.7
2	Shahjibazar	1	13.93	0.39	3716.24	50	1720	0.18	0.21	64973314.43
		2	13.93	0.39	3716.24	50	1720	0.18	0.21	57547792.78
3	Baghabari	1	13.24	0.37	3532.17	50	1720	0.18	0.19	119649160.5

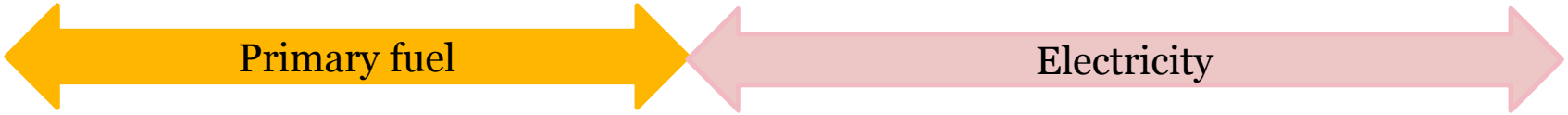
Assumptions
1 cu MT = 35.31 cu ft
GCV of gas=9420 kcal/kwh
1 kwh=860 kcal

Total Annual savings in Gas Consumption (cu. Mt)	**411733447.3**
Total savings in Gas Consumption (mmscfd))	**38.07**

Source: BPDB – Annual Report, 2014

Energy efficiency and conservation

Typical end-use energy efficiency measures in industries relevant to Bangladesh



Sectors	Waste heat recovery	Vapor Absorption system	Condensate steam recovery	Efficient steam management	High efficiency motors	Variable speed drives	Efficient distribution transformers	Efficient lighting systems	Compressed air MgMT.
Textiles	√	√	√	√	√	√	√	√	√
Readymade Garments					√	√	√	√	√
Steel rerolling	√	√			√	√	√		√
Food and beverages	√	√	√	√	√	√	√		√
Cement (clinker grinding)					√	√	√		
Light engineering					√	√	√		
Sugar			√	√	√	√	√	√	
Paper and pulp	√	√	√	√	√	√	√		√
Poultry								√	
Chemicals	√	√	√	√	√	√	√		√
Plastics					√	√	√		√

Option analysis
Overall assessment

1. Affordability, Reliability, Adequacy, and Sustainability analysis results:

Affordability	Reliability	Adequacy	Sustainability	Overall Assessment
Low	Low	Low	Medium	Low

Energy efficiency and conservation option has high affordability, high reliability, medium adequacy and high sustainability. Hence, overall impact on energy security is expected to be high.

Bangladesh has substantial energy conservation potential with respect to gas power plants and major energy consuming industries like textile, fertilizers etc. GoB has already taken steps and is actively seeking support of the development partners to convert some of the low efficiency open cycle plants to combined cycle, having estimated gas saving potential of 38 mmscfd, which can contribute to 235 MW of additional generation capacity.

Section 2.13
Other Options

Overview of Tidal potential in Bangladesh

- The coastline of Bangladesh has a tidal range of 2-8 meters and tidal energy can be generated by applying low head and medium head tidal movements.
- Dams or barrages with water turbines can be built across river mouths or inlets to generate electricity from the movement of tides.
- Low head tidal movements which uses tides of height 2-5 meters can be used in areas like Khulna, Barisal, Begarhat, Satkhira & Cox-Bazar regions.
- High tidal movements uses tides of more than 5 meters & may be explored in Sandwip.
- Some of the benefits of tidal energy generation are that it helps in preventing flooding and brings in benefits for coastal irrigation. Further, it is an emission free generation source. On the other hand, there are some negative impacts on water life.

Some other key characteristics of tidal power plants are as follows:

- Production of electricity from is for 24 hours a day and 365 days a year and has high efficiency (80%) compared with other power sources.
- Predictable and consistent generation source.
- Probable life of 40 years.
- Capital cost to develop a tidal energy plant is high, but the O&M costs are low.

Bangladesh has a tidal range of 2-8 meters, which may be too low for tidal power to be a viable option. In addition to the low resource potential, limited international experience—only seven tidal power stations are in operation—make this technology impractical for Bangladesh at this time.

Overview of Geothermal potential in Bangladesh

- Several locations in Bangladesh with potential geothermal resources, but due to lack of adequate studies, technical potential is not known.
- A study of Bottom Hole Temperature (BHT) of 13 deep wells drilled for petroleum exploration in northeastern part of Bangladesh measured temperature gradient in each well at depths of 3,000 to 15,000 m. Results show that 11 of these locations have temperature gradients of at least 30°C per km. Extensive investments in studies and well drilling are necessary to confirm the resource adequacy of these sites.
- A private company namely Anglo MGH Energy has initiated a project to set up the country's first geothermal power plant close to Saland in Thakurgaon district.
- Noise pollution, disposal of geothermal fluids which may contain low levels of toxic materials, and release of hydrogen sulfide (at low concentrations) are some of the detrimental effects.

Some other key characteristics of geothermal power plants are as follows:

- Capacity factor of 90-95%.
- CO2 emissions of about 14g/kWh (compared to 453 g/KWh for natural gas, 906 g/kWh for oil and 1042 g/kWh for coal based power plants).
- Provide very reliable base load; some plants can increase production to supply peaking power.
- Higher initial installation cost, however, such costs can be recovered by 10 years through energy savings.
- Costs $1,400 to $1,500 per kW, including exploration and drilling; for a binary plant, the total cost is about $2,100 per kW

Based our discussions with stakeholders, we understand that most of the potential geothermal sites are of religious significance in Bangladesh potential is not known; hence, in the current context, the potential of geothermal sources appears low for Bangladesh.

Overview of Nuclear Energy

- Worldwide, nuclear power has over 380 MW of installed capacity in 31 countries and additional 64 MW are under construction. #
- Countries like India and Pakistan are leading nuclear power generation in South Asia region
- Recent disaster caused due to tsunami has raised concerns over development of nuclear power plants
- Bangladesh is also planning to developing a Nulcear power plant at Rooppur since long with an installed capacity of 2400 MW (1200MW x2) by 2024 and further extended it to 4000 MW by 2030. Intergovernmental agreement between Russia and Bangladesh for set up of this plant has been signed.
- ROSATOM, the Russian state owned nuclear organization is developing the project
- Russia will supply the fuel for the projects
- Russia has also extended the state export credit (USD 500 million) for the preparatory stage work

- A general contract of USD 12.65 billion (90% as loan) has been signed between Bangladesh & Russian Federation for establishment of Nuclear Power Company of Bangladesh under Nuclear Power Plant Act.
- Indication of uranium reserves were found at Harargaj anticline of Moulavi bazar, Mitapukur of Rangpur and sand bars of Brahmaputra
- Typical project development timeline for a nuclear power plant is typically 5 years.

Critical success factors

#Source: https://www.euronuclear.org/info/encyclopedia/n/nuclear-power-plant-world-wide.htm

Development of Nuclear power plant involves various critical considerations such as govt. policy, fuel security, safety, environmental & social impact, international policies/obligations.

Section 2.14
Summary of Option Analysis

Summary of analysis of option (1/3)

Option	Option analysis result	Remarks
Conventional imported LNG	High	• LNG based power plants can cater to base load of Bangladesh and provide a reliable source of electricity. • Building the enabling infrastructure shall be critical to ensure accessibility of RLNG to these demand centers.
Small scale LNG	High	• Lower capital costs, modular nature and quicker turnaround time strengthens the case to explore Small Scale LNG as an option for 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.
Fuel diversification to LPG	High	• 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
Intensifying domestic E&P efforts	Medium	• 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 PSC may 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.

Summary of analysis of option (2/3)

Option	Option analysis result	Remarks
Imported coal	Medium	• Can cater to base load of Bangladesh & provide reliable source of electricity • Multiple imported coal fired power plants planned - sourcing & logistical arrangements are critical to ensure generation of uninterruptable power.
Domestic coal	Medium	• Can cater to base load of Bangladesh & provide reliable source of electricity • Key requirements - institutional strengthening & regulation to bring global standards, - standardization of exploration and resource classification, - exploiting domestic coal at larger depth through CBM/UCG.
Power Import	High	• Regulatory procedures, mechanisms and institutional arrangements needed • Bilateral engagement for agreements and consents on various aspects
Domestic Hydropower	Low	• Limited potential limited experience in development & operation of projects.
Energy Efficiency and Conservation	High	• Substantial energy conservation potential with respect to gas power plants and major energy consuming industries like textile, fertilizers etc. • Estimated gas saving potential of 38 mmscfd, which can contribute to 235 MW of additional generation capacity, by conversion of some of the low efficiency open cycle plants to combined cycle.

Summary of analysis of option (3/3)

Option	Option analysis result	Remarks
RE- Solar	Medium	• Policy, regulatory and institutional arrangements to incentivize & accelerate development.
RE-Wind	Low	• Policy, regulatory and institutional arrangements to incentivize and accelerate development
RE - Biomass, Biogas and W2E	Low	• GoB commitment to promote renewable energy • GoB is actively seeking support of development partners to structure and implement such projects.
RE-Tidal	NA	• Tidal range of 2-8 meters limits viability of option. • Limited international experience - only 7 tidal stations in operation - limit technological practicability at this time.
RE-Geothermal	NA	• We understand most potential geothermal sites are of religious significance • Hence, in current context, geothermal potential seems low.
Nuclear	NA	• Nuclear power caters to base load • Long gestation period and associates E&S concern • GoB undertaking actions to develop 1st Nuclear Power plant at Rooppur with Russia support.

Section 3
Ensuring Energy Security – Way Forward

Way forward on ensuring energy security (1/2)

- Development of LNG infrastructure and market in Bangladesh (discussed in Section 2.1)
- Step-wise assessment to evaluate SSLNG's feasibility in Bangladesh (discussed in Section 2.2)
- Development of a comprehensive LPG Master Plan with policy & institutional interventions and investments required to increase LPG usage in Bangladesh (discussed in Section 2.3)
- Regulatory and policy changes in the existing PSC to ensure foreign participation in future bidding rounds (discussed in Section 2.4)
- Putting in place a comprehensive Project Management Office for NOCs to accelerate their E&P efforts (discussed in Section 2.4)
- Energy saving by conversion of some of the low efficiency open cycle plants to combined cycle (discussed in Section 2.12)

Way forward on ensuring energy security (2/2)

Policy and institutional changes for coal (both imported and domestic) sector development

Addressing issues related to coal sourcing and logistics

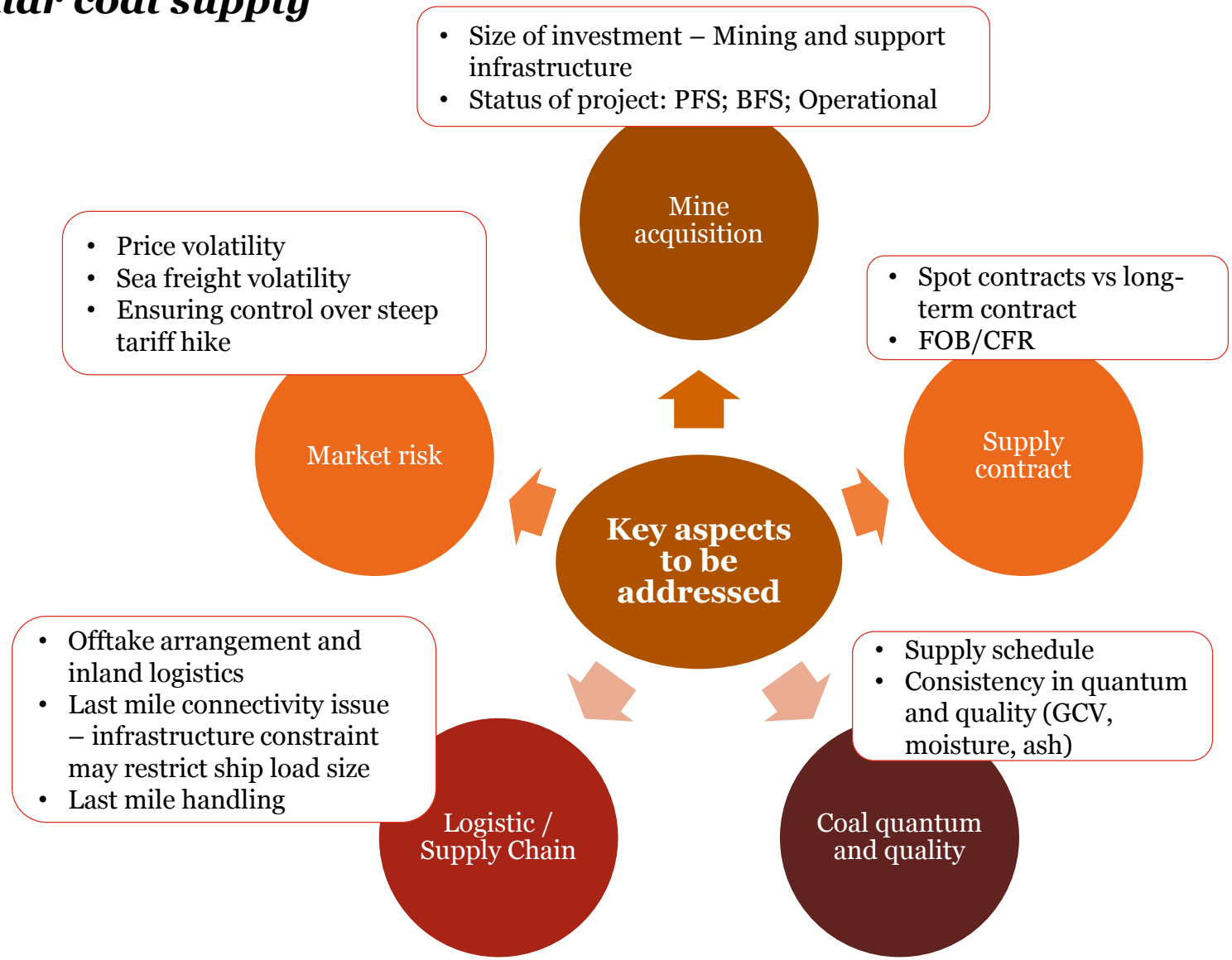
Policy and institutional interventions to facilitate cross border power trade

Feasibility assessment for pilot projects in the areas of solar roof top, feeder segregation, etc.

Due diligence/ feasibility study of a selected project (imported coal based or cross border transmission system, or solar, etc.)

Section 3.1
Coal Sector Development

Need for a national agency for coordinating coal import and ensuring regular coal supply



Coal supply chain arrangement

Key issues in coal source arrangement and logistics for further analysis

- Coal availability (coal sourcing countries) of desired quality on a long-term basis.
- Inland logistics arrangements and viability in the sourcing countries.
- Regulatory conditions defining the boundary conditions for coal export from these source countries.
- Size of vessel for required volume of coal.
- Availability of vessels in the market.
- Vessel freight and Bunker (Fuel price) variations.
- Further logistics arrangements, if required, after the vessel enters Bangladesh waters.
- Unloading arrangements at the Plant site.

Need for an integrated energy policy for development of domestic coal sector

Policy framework	• Resource allocation, sector administration, government support for approvals and clearances • Internationally acceptable licensing policy • Offtake mechanism reflecting open market pricing of coal, bidding of coal blocks
Pre-development activities	• Detailed exploration • Internationally acceptable exploration & resource classification framework • Detailed techno-economic and financial feasibility studies, data repository and management
Institutional development	• Nodal agencies for development of sector and monitoring • Key coordinating unit between different ministries • Skill development, training
Investment attraction	• Investment policy, framework and government support for FDI/Private investment • Roll out incentives in the form of tax holidays, waiver of local taxes, reduction in import duties on equipment

Proposed institutions for domestic coal sector development

Proposed Institutions	Functions
National Mines and Minerals Council	▪ It will be an apex body to approve the plans and strategy for development of the mines and minerals sector
The Ministry of Mines and Mineral Resources	▪ Two set –ups, namely: ○ Corporate Affairs Division- To deal with Coal Mining companies, other mining companies, Bangladesh Petroleum corporations, Gas companies ○ Energy and Mineral Resource Division – To deal with Dept. of Mines & Minerals and working on exploration license, mining lease, etc., Exploration through GSB, Mining & Minerals Institute, Inspectorate of Mines and Explosives Department
Corporate Bodies (Coal Bangla & Khani Bangla)	▪ Development of coal sector ▪ Development of other minerals including hard rock, lime stone, ordinary stone and gravels, etc.
Coal Sector Development Unit	▪ Key coordinating unit between different ministries to ensure development of coal sector by integrating the work plans and budgets of all the ministries

Section 3.2
Facilitating Cross Border Power Trade

Policy and institutional interventions required (1/3)

CBET Framework & Policies

- **SAARC Framework Agreement** for Energy Cooperation (Electricity) (Nov 2014) provides overarching framework for promoting CBET in SAARC region
- **Bilateral frameworks** also prevalent (e.g. PTA between Nepal and India)
- Govt. of India is in process of **formulating CBET policy** and amending Electricity Act 2003 to facilitate CBET
- Amendments to Bangladesh laws/policies?

Institutional Structures

- **Forum of Electricity Regulators** - to formulate common rules & regulations, codes & standards, etc. to facilitate CBET
- **Forum of National System Operators** - To formulate detailed guidelines for grid operation, market operation (scheduling & dispatch, energy accounting & settlement, congestion management etc.)
- **Forum of National Transmission Utilities** - To co-ordinate and plan cross-border links

Transmission Pricing and Access

- Transmission **pricing framework** and **access rules** to be defined for Intra-country network and Cross-border links
- Initially, pricing could be based on postage stamp
- Access rules to define priority for allotment and curtailment
- Duration of access for all links on the contract path - from injection point to drawal point - shall match with PPA tenure
- Congestion management - To begin with, define rules based on technical needs

CBET: Cross Border Electricity Trade

Policy and institutional interventions required (2/3)

Scheduling, accounting, Settlement	Standardised Commercial Terms	Regional Power Exchange

• Crucial to promote dispute-free CBET (specifically involving India)
• Define scheduling & despatch principles and timelines (aligned with IST)
• Treatment of losses
• To begin with, imbalance costs can be assessed and allocated to involved parties on certain pre-defined principles (later, DSM/UI kind of mechanism can be put)
	• PPA/TSA term
	• Tariff discovery (cost-plus / bidding)
	• Tariff structure (single-part/two-part)
	• Tariff recovery (fixed cost / variable cost)
	• Tariff escalation
	• Billing and payment
	• Payment currency
	• Payment security mechanism
	• Dispute resolution mechanism
		• **Option 1:** Extend operations of established Power Exchanges in India - Create separate bid area for each SAC or include SAC in nearby existing bid area
		• **Option 2:** Create separate Regional Exchange
		  • Bids from SACs (other than India) AND
		  • Separate direct bids from Indian sellers and buyers OR only uncleared sell bids and sell bids from Indian PXs

DSM: Deviation Settlement Mechanism; UI: Unscheduled Interchange; PPA: Power Purchase Agreement; TSA: Transmission Service Agreement; SAC: South Asian Countries; PX: Power Exchange

Policy and institutional interventions required (3/3)
Next steps

Assessment of national laws, policies and regulations to facilitate cross-border trading and exemption from taxes & duties for import of power

Identifying appropriate institutional arrangements for

- undertaking power trading, transmission system planning, transmission system operation;
- infrastructure strengthening, training and capacity building of institutions

Developing regulatory guidelines for power procurement and sale, transmission planning, scheduling & dispatch, energy accounting & deviation settlement, transmission pricing and access

Developing model PPA and TSA for facilitating cross-border transactions

Strengthening and comprehensive planning of Transmission system of Bangladesh considering generation, imports, demand, system requirement

Assessing and preparing appropriate project development models for transmission system and investing in generation projects outside the country

Infrastructure strengthening, training and capacity building of power trading, transmission system planning and system operation function

Section 3.3
Renewable Energy Development and Energy Efficiency

Policy and institutional interventions required (1/4)

Interventions required	Examples	Impact
Reduction in VAT or other taxes and Import duty exemption.	• In Philippines, zero VAT is charged on purchase of local goods, properties and services for project development, this may be claimed throughout the process from exploring and developing of RE sources to sale of power. Also farmers engaged in cultivation of crops, trees used as biomass are entitled to duty free import of agricultural inputs, equipment . • In India, solar PV modules / cells are exempted from payment of import duties and all major imported items used for initial setting up of solar PV plant attract concessional custom duty @5.15%.	• Energy costs are capital intensive. Reduction in cost of import for key technologies through VAT and duty exemption help end user invest in equipment with high reliability and thus increase generation.
Tax credit on research and development on renewable energy sources	• 25% tax credit in Ireland • 30% tax credit in Spain	• Helps in technical development and increase indigenous development of equipment which in future can help in cost reduction and self sufficiency.

Policy and institutional interventions required (2/4)

Interventions required	Examples	Impact
Investment (or) Capital subsidy, grant and rebates.	• In India a 80% accelerated depreciation for investments made in solar projects; grant of INR 20 lakh/MW or 30% of total project cost , whichever is lower for Solar projects. • An AUD 200 mn Southern cross renewable energy fund formed by contribution of AUD 100 mn by government and another AUD 100 mn by Softbank China Venture Capital for development RE sources. • An outlay of INR 10,000 Cr for 2016-17 is created from National Clean Energy Fund (NCEF) and Internal & Extra Budgetary Resource (IEBR). A cess of INR 400/ton on coal, lignite and peat will be used to support development of RE projects in India.	• Accelerated depreciation enable higher deductions in the initial years and attract private higher investments in the market increasing competition. • Renewable energy producers to get cost-based compensation for domestic products through capital subsidy thus supporting the domestic ecosystem. • RE based funds help fund priority projects through VGF at a cheaper rate.
Introduction of Viability Gap Funding (VGF) as one time support to improve financial viability.	• In India solar power project developers, bid for viability gap funding requirement in INR/MW and the bidder quoting minimum VGF is awarded the project	• VGF reduces upfront capital costs through a capital grant and meets the funding gap by covering a portion of financing requirement for a project.

Policy and institutional interventions required (3/4)

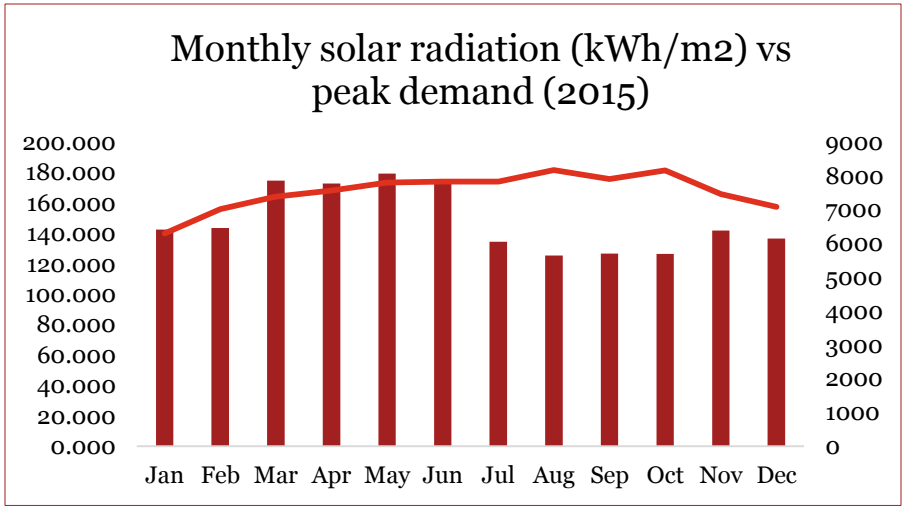
Interventions required	Examples	Impact
Feed in tariff and tradable REC's for different RE sources	• A budget ceiling for each RE sources is established &Feed in tariff granted for a certain period like 5, 12 or 15 years in Netherlands • In India, the distribution company is obligated to purchase REC (Solar and Renewable) from the market to comply with its renewable purchase obligation.	• FiT facilitates renewable energy producers get cost-based compensation by providing a price certainty over the PPA tenure and help finance renewable energy investments • Tradable certificates help developers get additional income and increase project viability.
Provision for generation based incentive (GBI) in addition to tariff for developers	• In India a GBI of 0.50 INR per kWh to developers for energy supplied and subject to a cap of 10 million INR per MW is provided in first 10 years of commissioning.	• GBI helps developers not availing accelerated depreciation under the IT Act to investment in wind sector and focus on energy generation rather than capacity addition.

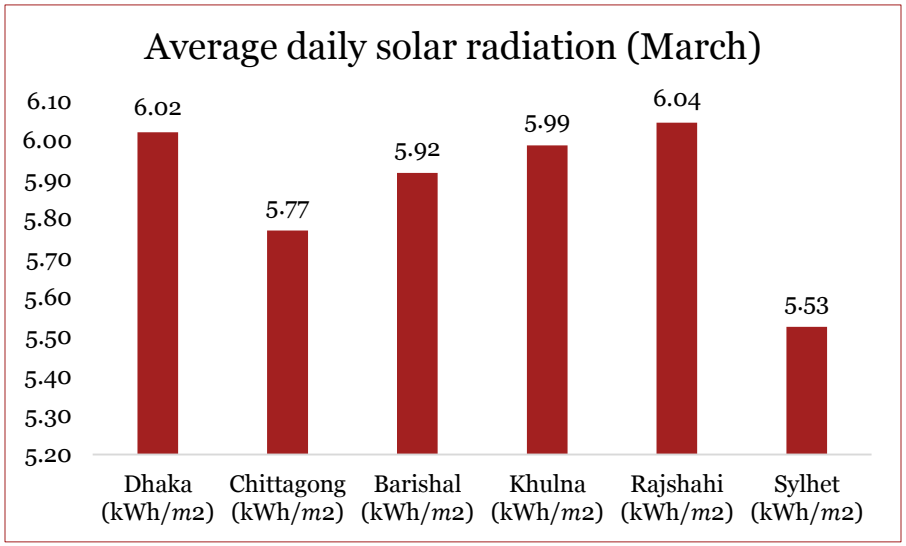
Policy and institutional interventions required (3/4)

Interventions required	Examples	Impact
Policy support for promotion of key renewable based projects and sectors – Solar roof tops, waste to energy production.	• European Unions waste management directive which covers collection & segregation of different types of waste, recycling of waste, landfilling and incineration waste etc and higher tax on landfilling in Sweden. • A National Tariff Policy, 2016 and regulatory framework in India actively promoting technology deployment and connectivity options for solar roof top project through Gross and Net metering arrangement.	• Such policy initiatives is garnering attention of both Government bodies and Private sectors participation in these sectors, making deployment models more efficient – Unlocks useful land space. • National Tariff Policy, 2016 obligates Discoms in India to procure 100% power produced from Waste-to-Energy plants in the State.

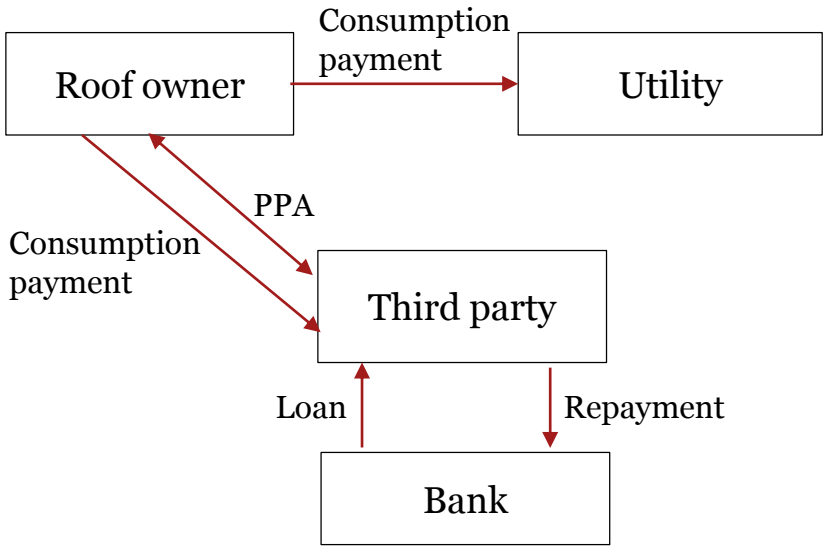
Concept: Utility Scale Roof-top Solar

- Solar radiation in the summer season is high and can help in meeting the rise in electricity demand.
- Further, during the summer season the level of ground water depletes, thus requiring higher amount of energy to draw water for agricultural purpose. Moreover the agriculture dominated divisions like Rajshahi, Dhaka, Khulna have high amount of solar radiation. Therefore, considering the same and existing electricity demand-supply situation, solar power can be used for irrigation purpose also
- However considering the land unavailability in agriculture dominated area, roof top solar is one of the feasible option and different third party model has been discussed subsequently.

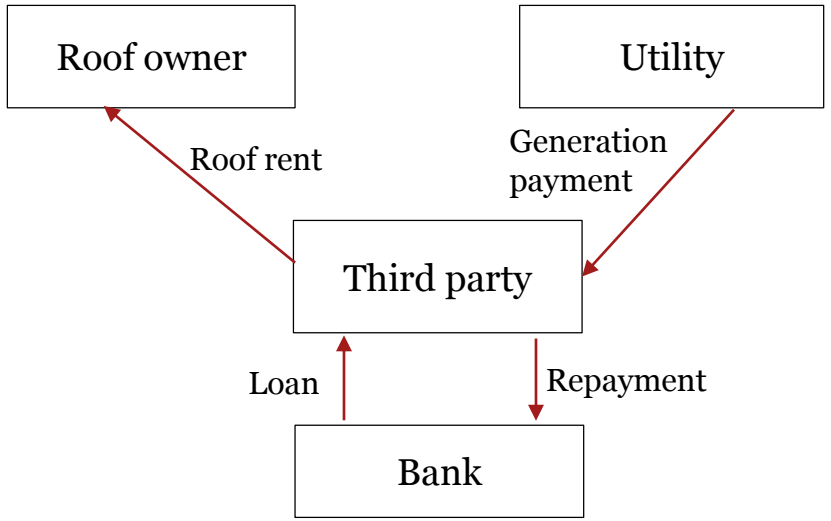




Roof top solar - Third party business model



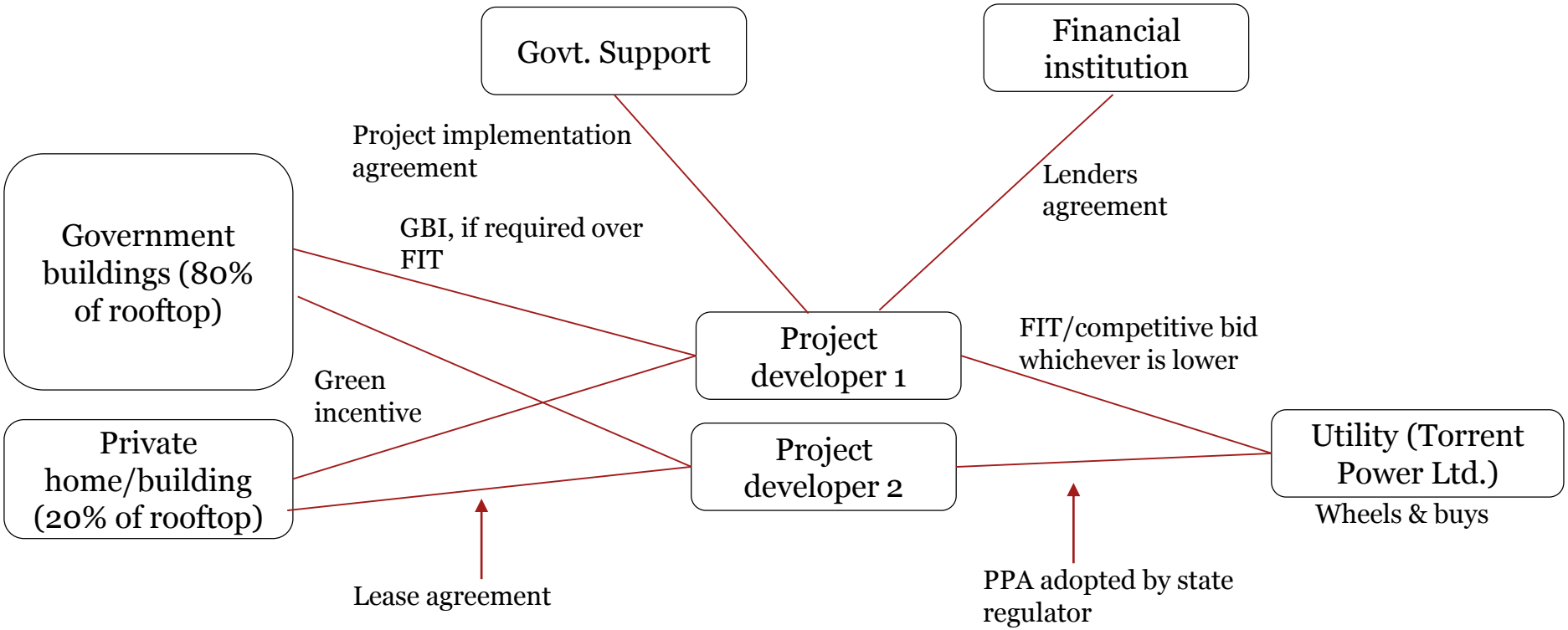
Net Metering - (Self-Consumption and Supply to Utility Grid) and Third Party Owned Model



Gross Metering - (Only sale of electricity to utility) and Third Party Owned Model

- Grid tied roof top solar can be developed both for personal use or can be leased to third party for development and provision of metering can be both gross or net depends on the willingness of the user.
- Considering the issue of land scarcity, third party utility scale roof top solar option will be the most viable option and can cover a larger roof top area and can adhere to benefits like economy of scale, centralised O&M network etc. Moreover subsidies or incentives applicable to utility scale parks can also be applicable to this model

Case Study - Gandhinagar (India) roof top pilot project



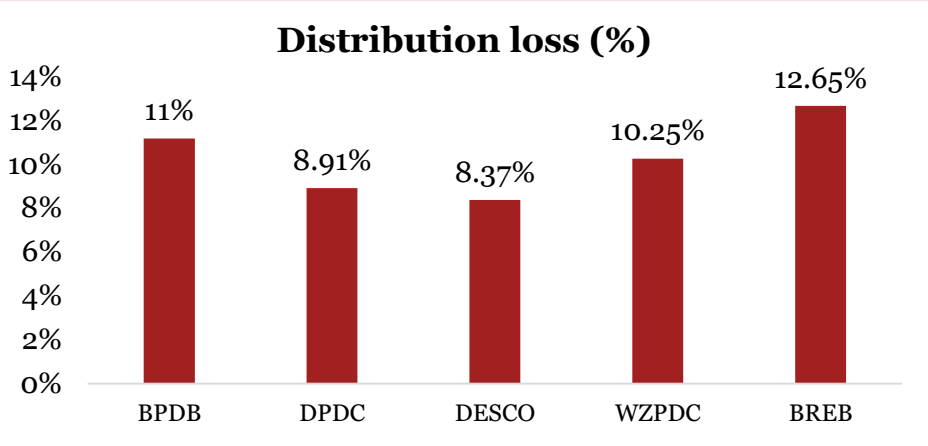
Govt. role: Provide access to roofs of buildings it owns, facilitate agreements with power procurer for electricity generated, and guarantee a subsidy if required

Project developer role: Identify private buildings that will participate in the project, producing solar power and delivering it to the grid

Incentive mechanism: Generation based incentive along with FIT to improve the investment attractiveness

Feeder segregation program

- Drivers: High loss and interruption levels of the distribution companies
- Most of the feeders are mixed feeder and cater different type of loads during a day – results in poor power quality and unstable supply of power affecting both residential and agricultural consumers
- Feeder segregation for residential, small rural industries and agricultural consumers can help in power quality improvement, loss reduction and subsequent improvement in agriculture production efficiency
- Also contribute to reduce the usage of diesel operated pumps reducing the cost and pollution



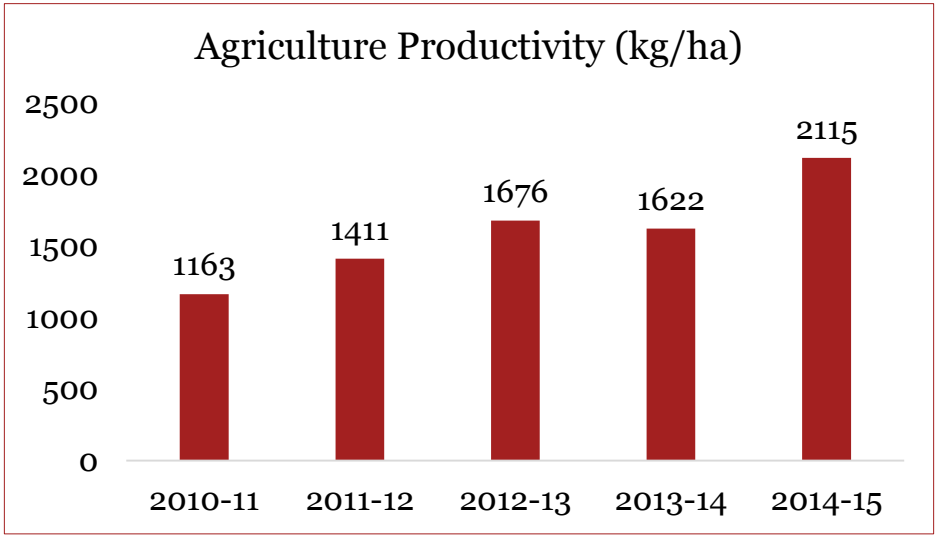
	BPDB	DPDC	DESCO	BREB	WZPDC
SAIFI	34	60	29	300	42
SAIDI	563	921	646	3500	731

Feeder segregation

Case study - India (Madhya Pradesh)

- Key objectives for segregation were 24 hour supply to domestic consumers, 10 hour supply to agriculture consumer and distribution system augmentation to reduce losses, pilferage and ensure better quality of supply
- Agriculture sector has got the real benefit, in terms of production and productivity, from the 10 hour power supply being provided
- Key reasons for increase in productivity – change in cropping pattern (single cropping areas to multiple cropping areas) and increase in the irrigated area (~16% in last five years)

	2010-11	2015-16	Increase %
33kV line (km)	38,867	48,069	**24%**
11kV line (km)	202,065	332,343	**64%**
33kV substation (no.)	2,685	3,324	**24%**
No. of DTRs	267,254	507,789	**90%**
Consumer in lakhs	91	122	**34%**



Section 3.4
Potential Projects for Due Diligence

List of upcoming imported coal based power plants in Bangladesh

Sr. No.	Description	Capacity (MW)	Ownership	COD
1	BIFPCL, Rampal, Coal Fired Power Plant (EXIM Bank of India)	1,320	BIFPCL	Dec'2019
2	Payra, Potuakhali 1200-1320 Coal Fired Power Plant (JV of CMC , China) (EXIM Bank of China)	1,320	NWPGCL	Dec'2019
3	Moheskhali 1200 MW Coal Power Plant (ECA)	1,200	BPDB	Jun' 2022
4	Moheskhali 1200 MW Coal Power Plant (Donar Funding)	1,200	BPDB	Dec'2024
5	Pekua, Cox'sbazar 1200 MW Coal power plant	1,200	EGCB	2023-24
6	Matarbari 1200 MW Coal Power Plant (CPGCBL) (JICA)	1,200	JV	Aug'2022
7	Matarbari 700 MW Coal Power Plant (CPGCL JV with SEMBCORP Singapore)	700	JV	Dec'2022
8	Matarbari 1200 MW Coal Power Plant (CPGCL JV with Sumitomo)	1,200	JV	Dec'2024
9	Moheskhali 1200 MW Coal Power Plant (BPDB JV with TNB, Malayasia)	1,200	JV	Jun' 2022
10	Moheskhali 1200 MW Coal Power Plant (BPDB JV with China Hudian Hong Kong)	1,200	JV	Jun' 2021
11	Moheskhali 1200 MW Coal Power Plant (BPDB JV with KEPCO Korea)	1,200	JV	Dec'2023
12	Khulna 630 MW Coal Fired PP (Orion)	630	IPP	Dec'2019
13	Maowa, Munshiganj 522 MW Coal Fired Power Project (Orion)	522	IPP	Dec'2019
14	Dhaka 635MW Coal Fired Power Project (Orion Group)	635	IPP	Jan'2020
15	Dhaka 282 MW Coal Fired Power Project (Orion Group)	282	IPP	Jun' 2020
16	Chittagong 282 MW Coal Fired Power Project (Orion Group)	282	IPP	Jun' 2020
17	Chittagong 612 MW Coal Fired Power Project(S.Alam Group)	612	IPP	Dec, 2019
18	Chittagong 612 MW Coal Fired Power Project(S.Alam Group)	612	IPP	Dec'2019
	TOTAL	**16,515**		

List of upcoming solar & wind power plants in Bangladesh (1/2)

Sl.No.	Project name	Capacity (MW)	Developer
1.	200 MWp (AC) Solar power plant, Teknaf	200	Sun Edison
2.	20 MW (+/- 10%) grid tied Solar power project, Teknaf	20	Joules Power Ltd.
3.	50 MW AC Solar Park, Sutiakhali, Mymensingh	50	Hetat-Ditrolic-IFDC Solar
4.	100 MWp Solar Park at Paikorati, Dharmapasha, Sunamganj	100	Haor Bangla-Korea Green Energy Ltd.
5.	200 MW Solar PV Power Plant, Panchagarh	200	Beximco Power C. Ltd.
6.	30 MW Solar power project, Gangachara, Rangpur	30	Intraco CNG Ltd & Juli New Energy Co. Ltd
7.	50 MW Solar PV project, Parbotipur	50	Shapoorji Pallonji Infrastructure Capital Company Private Limited, India
8.	135 MW Teesta Barrage Irrigation Canal Project	135	New Generation Power International
9.	240 MW only Offshore Wind Energy	240	Nordikraft AS, Norway
10.	18 MW Pilot Wind Solar Hybrid Project, Muhuri Dam, Feni	18	M/s. ReGen Powertech Private Limited
11.	8 MW Wind Power Project, Ukhia, Cox's Bazar	8	Trio Syndicate and PH-Consulting Group Inc. USA
12.	12 MWp Grid connected Solar PV Project, Buraburi, Tetulia, Panchagarh	12	Greenland Technologies Limited (a concern of GETCO group
13.	10 MW Grid Tied Solar Power Plant, Moulvibazar	10	Symbior Solar Siam & Holland Construction
14.	10 MW Grid Tied Solar Power Plant, Pangsha	10	Velcon Energy Mauritius Ltd
15.	15MWp Solar PV Power Plant, Lalmonirhat -01	15	Beximco Power C. Ltd.
16.	15MWp Solar PV Power Plant, Lalmonirhat -02	15	Hetat-Ditrolic-IFDC Solar

List of upcoming solar & wind power plants in Bangladesh (2/2)

Sl.No.	Project name	Capacity (MW)	Developer
17.	60 MW Solar Power Plant	60	Solar City Bangladesh
18.	10 MW Solar Power Plant (+/- 10%), Trishal, Mymensingh	10	AJ Corporation Ltd.
19.	100 MW Solar PV Power Plant	100	Bangla German Solar Power Dev.Co.Ltd.
20.	5+10% MWp Solar power plant, Sylhet	5	Sun Solar Power Plant Ltd.
21.	50 MW Solar park, Bhola Island	50	Elcon Bangladesh (UK) Limited
22.	24 MWp solar power plant, Daulatpur	24	CSA-UOL Consortium
23.	60 MW Solar power plant, Ishwardi, Pabna	60	SOWAREEN-GTR-PEN-LSE Consortium
24.	11 MWp grid tied Solar PV project, Panchagarh	11	Parasol Energy Limited
25.	100 MW Solar PV project, Bagherghat (60 MW) & Cox's Bazar (40 MW)	100	ENERGON Technologies FZE
26.	5 MW Solar PV power plant, Lalmonirhaat	5	Green Housing & Energy Ltd
27.	100 MWp Solar Plant, Nilphamari	100	ATN Solution Ltd
28.	20MW Hybrid Solar Plant using ECOGEN hybrid generator	20	Atlantic Power (Bd) Ltd
29.	50MW Solar Power Project	50	8minutenergy Holding, LLC
30.	35MWp Solar Plant, Manikganj	35	SPECTRA Engineers Limited and Shunfeng Investment Limited
31.	2x 25 MWp Solar Park, Pabna	50	CES-SUNSEAP-Consortium
32.	50 MW Solar PV power plant	50	Emizent Smart Technology Pvt. Ltd

Section 4
TA 8839 BAN: Study of Energy Security – Next Steps

Next steps for TA 8839 (1/2)

Energy security study and option analysis [Completed] → **Due diligence of priority projects [Next Steps]**

- 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. Such options are presented in the next slide.

Next steps for TA 8839 – key options

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 terms of reference, resourcing plan and timelines for the next step.

Appendix 1
List of Abbreviations

List of abbreviations (1/4)

ADB	Asian Development Bank
Apr	April
APSCL	Ashuganj Power Station Company Limited
Aug	August
AUD	Australian Dollar
BAN	Bangladesh
BCF	Billion Standard Cubic Fee
BCM	Billion Cubic Metet
BBIN	Bangladesh, Bhutan, India, and Nepal
BDT	Bangladeshi Taka
BERC	Bangladesh Energy Regulatory Commission
BHT	Bottom Hole Temperature
BIFPCL	Bangladesh India Friendship Power Company (Private) Limited
BOOT	Build–Own–Operate–Transfer
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
BT	Billion Tonnes
CAGR	Compounded Annual Growth Rate
CBET	Cross Border Energy Trade
CBM	Coal Bed Methane
CGD	City Gas Distribution
CNG	Compressed Natural Gas
CO2	Carbon Dioxide

CoD	Commercial Date of Operation
CPGCBL	Coal Power Generation Company Bangladesh Limited
CSR	Corporate Social Responsibility
cu. Mt	Cubic meter
Cu ft	Cubic Feet
Dec	December
DESCo	Dhaka Electric Supply Company Limited
DPDC	Dhaka Power Distribution Company Limited
DSM	Deviation Settlement Mechanism
DTRs	Distribution Transformers
E&P	Exploration & Production
EGCB	Electricity Generation Company of Bangladesh
EZs	Economic Zones
EPZs	Export Processing Zones
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EE	Energy Efficiency
EDR	Economic Demonstrated Resources
Est.	Estimated
E&P	Exploration and Production

List of abbreviations (2/4)

E&S	Environmental & Social
FDI	Foreign Direct Investment
Feb	February
FGD	Flue Gas Desulphurisation
FiT	Feed-in-Tariff
FoB	Free on Board
FSRU	Floating Storage Regasification Unit
FY	Financial Year
G2G	Government-to-government
GBI	Generation Based Incentive
GCV	Gross Calorific Value
GDP	Gross Domestic Product
GoB	Government of Bangladesh
GSMP	Gas Sector Master Plan
GHG	Green House Gas
GMS	Greater Mekong Subregion
GRID	Government Reforms and Infrastructure Development Sub-Business Unit of PricewaterhouseCoopers Private Limited
GW	Giga Watt

GWh	Giga Watt Hour
ha	Hectare
HFO	Heavy Furnace Oil
HPP	Hydro Power Project
HVDC	High-Voltage Direct Current
IEA	International Energy Agency
IEBR	Internal & Extra Budgetary Resource
IGCC	Integrated Gasification Combined Cycle
INR	Indian National Rupee
IOC	International Oil Company
IPPs	Independent Power Producers
Jan	January
JICA	Japan International Cooperation Agency
Jun	June
JV	Joint Venture
Kcal	Kilo Calorie
ktoe	kilotonne of oil equivalent
kV	Kilo Volt
kW	Kilo Watt
kWh	kilowatt hour
LNG	Liquefied natural gas

List of abbreviations (3/4)

LoI	Letter of Intent
LPG	Liquid petroleum gas
M	Meter
Mar	March
mn	Million
MMBTU	Million British Thermal Units
MMT	Million Metric Tonne
mmscfd	Million standard cubic feet of gas per day
MSW	Municipal Solid Waste
MT	Million tonnes
MTPA	Million Tonnes Per Annum
MW	Mega Watt
MWp	Mega Watt Peak
NCEF	National Clean Energy Fund
NCRE	Non-conventional & Renewable Energy Resources
Mar	March
NE	North East
No.	Number
NoC	No Objection Certificates
Nov	November

NWPGCL	North-West Power Generation Company Limited
O&M	Operation and Maintenance
Oct	October
oEM	Original Equipment Manufacturer
PPA	Power Purchase Agreement
PGCB	Power Grid Company of Bangladesh Ltd
PGCIL	Power Grid Corporation of India Ltd.
PLND	Planned
PoC	Point of Connection
PPP	Public Private Partnership
Proj.	Projected
PSC	Production Sharing Contract
PSMP	Power Sector Master Plan
PwC	PricewaterhouseCoopers Private Limited
PX	Power Exchange
R&D	Research and Development
R&R	Resettlement &Rehabilitation
RE	Renewable Energy
REC	Renewable Energy Certificates
RLNG	Regasified Liquefied Natural Gas
RoW	Right of Way

List of abbreviations (4/4)

RPCL	Rural Power Company Limited
S.	Serial
SAC	South Asian Countries
SAARC	South Asian Association for Regional Cooperation
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SAPP	Southern African Power Pool
SARD	South Asia Department
SARI/Energy	South Asia Initiative for Energy
SASEC	South Asia Subregional Economic Cooperation
SER	State energy registry
SPPs	Small Power Producers
SREDA	Sustainable and Renewable Energy Development Authority
SREP	Scaling Up Renewable Energy
SSLNG	Small Scale Liquefied Natural Gas
TA	Technical Assistant
TCF	Trillion Cubic Feet
TSA	Transmission Service Agreement
ToR	Terms of Reference

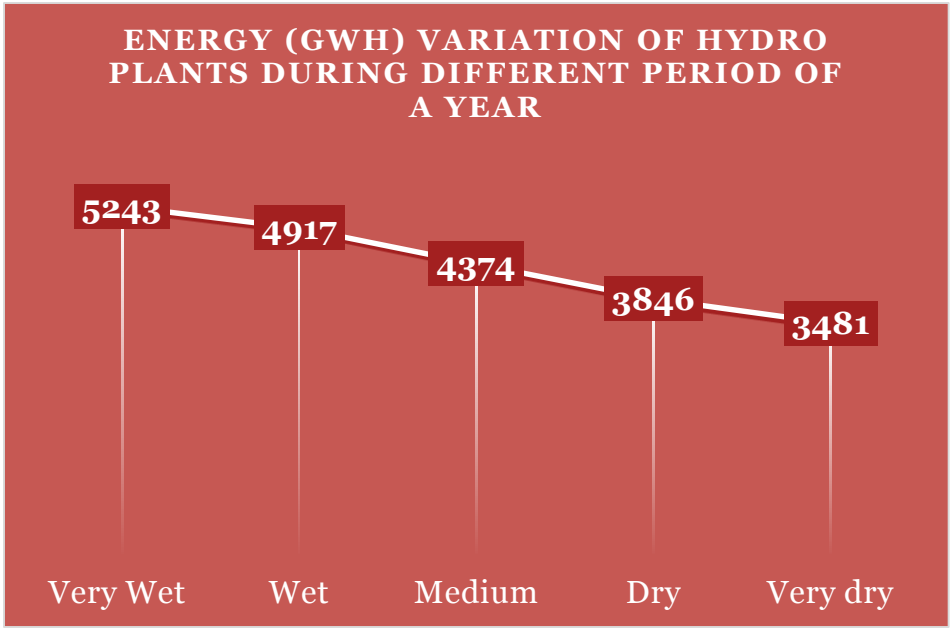
TWh	Terawatt-Hours
T&D	Transmission and Distribution
UI	Unscheduled Interchange
UNDP	United Nations Development Programme
US	United States
USAID	United States Agency for International Development
USD	United States Dollar ($)
VAT	Value Added Tax in Bangladesh
VGF	Viability Gap Funding
VSPPS	Very Small Power Producers
WB	The World Bank
WPP	Wind Power Project
WTP	Willingness to pay
WZPDC	West Zone Power Distribution Co. Ltd

Appendix 2
International Experience on Energy Security

Appendix 2.1
Sri Lanka

Need for energy security

Fuel diversification - Need of the hour



Fuel import (thousand tonnes)	2010	2011	2012	2013	2014
Diesel oil	1199	1402	1652	1199	1695
Fuel oil	423	368	564	177	348

Energy for diesel fired plants vary from LKR17/kWh - LKR25/kWh whereas coal power plant has average energy cost of LKR 8.5/ kWh

Large amount of oil import (Diesel oil import is almost 50% of total import in 2014)

+

Price volatility and huge energy cost for oil fired generation

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Large variation in the water availability and subsequent energy generation for hydro plants

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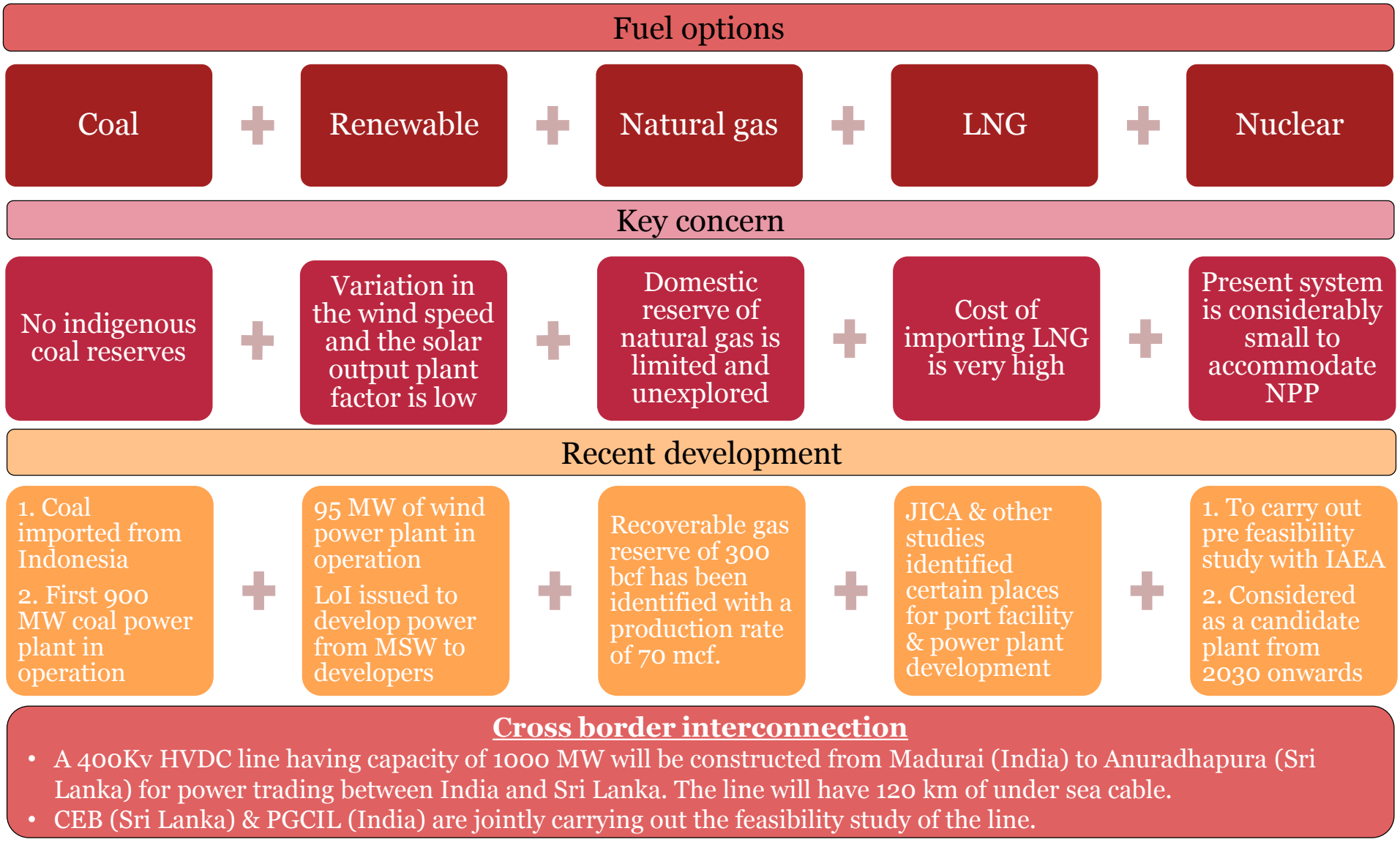
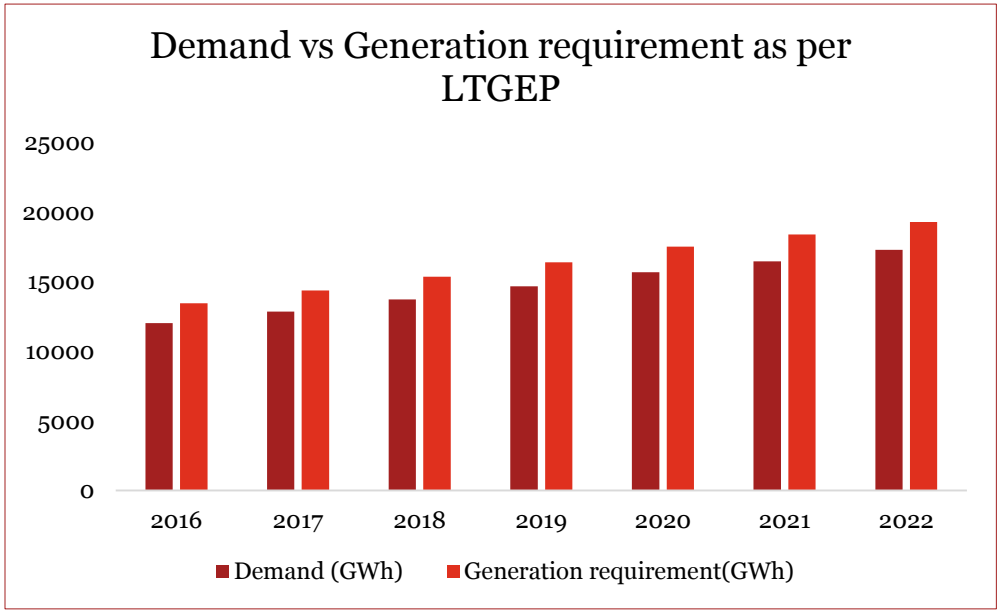
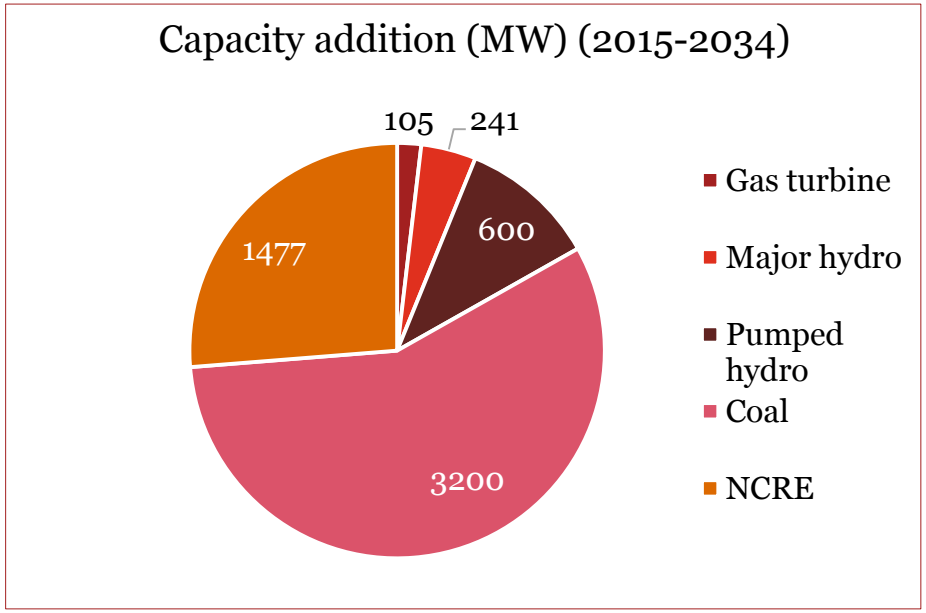
No indigenous coal reserves and natural gas exploration in nascent stage

Fuel diversification initiative and future action plan



Long term generation expansion plan (2015-2034)





Providing basic energy needs by improving rural energy access through on grid & off grid

Promoting energy efficiency & conservation through private sector participation

Promoting indigenous resources by adopting appropriate pricing policy, environment safeguard etc.

Ensuring energy security through fuel diversification and regional cooperation

Promotion of Non conventional & renewable energy resources (NCRE)

Key policy level interventions and institutional arrangement (1/3)

National energy policy

- Govt. will not entertain generation from oil, oil based products & fuel whose price is indexed to oil price
- No oil plant will be included in long term generation expansion plan unless there is technical limitation for development of other fuels
- Coal is decided as a third fuel after hydro & oil to ensure maximum possible security against price & supply fluctuation
- Non conventional renewable energy resources considered as fourth option with a target of 20% of supply by 2020
- Natural gas exploration in Mannar basin to be carried out
- Labelling of appliances and updation green building code made mandatory

Key policy level interventions and institutional arrangement (2/3)

Policy initiative to promote RE and energy efficiency

- Standardised PPA for RE project less than 10 MW which provide a non negotiable tariff for 20 years from CoD.
- The tariff has three components based on fuel type- fixed cost, escalable fuel cost and escalable O&M cost
- Net metering is allowed for consumers to promote RE development where the power export is set off against usage
- Low cost funding for mini hydro to expand rural electrification through Renewable Energy Rural Economic Development Project (World Bank & Global Environment Facility)
- National Energy Management Plan 2012-2016 plans to achieve energy saving of 20% of total energy consumed in 2010 by 2020.
- Soft loans are provided to commercial and industrial end users for energy efficiency improvement through Sustainable Guarantee Facility
- Sustainable Energy Authority introduced National Energy Efficiency Award to recognize their effort and to encourage end users to practice energy efficiency

Key policy level interventions and institutional arrangement (3/3)

Institutional Arrangement

Ministry of Power and Energy

- To formulate and implement policies and projects related to power and energy

Public Utilities Commission of Sri Lanka

- Economic, technical and safety regulator for electricity, petroleum and water industry
- PUSCSL is answerable to parliament

Sustainable Energy Authority

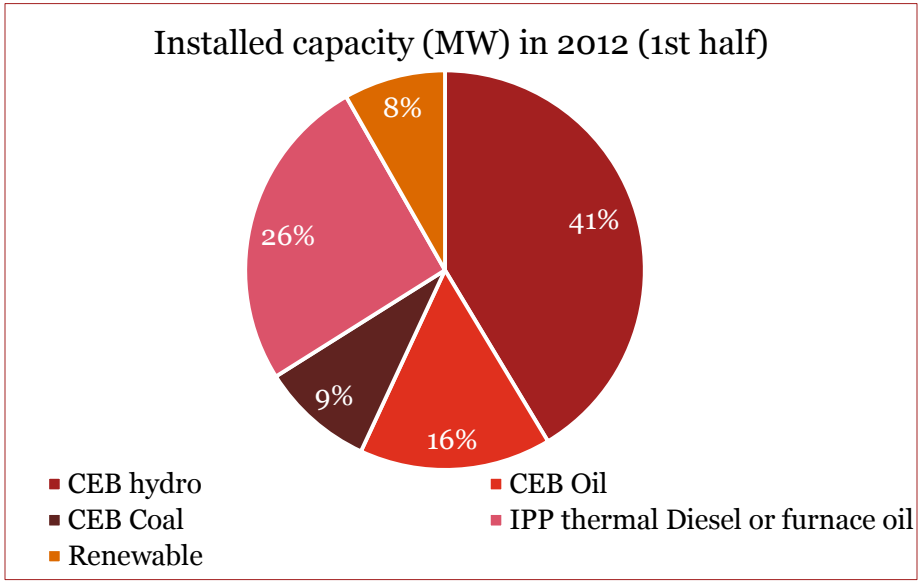
- To assist in National policy on energy
- To implement policy and promote development of RE and energy efficiency through private participation
- It functions under Ministry of Environment & Natural Resources

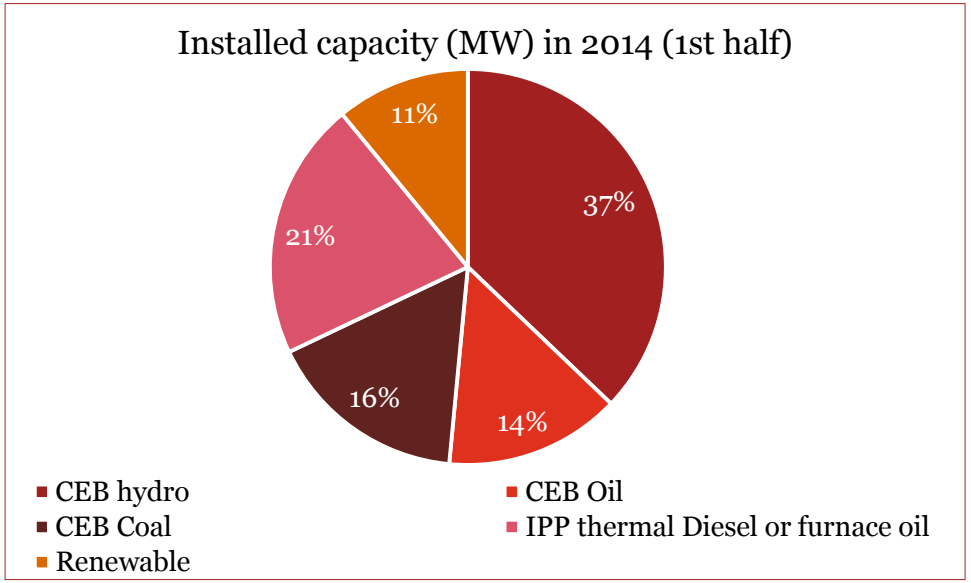
Ceylon Electricity Board

- It has major share in generation apart from IPPs
- It also looks after the transmission and distribution business

Progress till date and envisaged outcome

Change in electricity mix

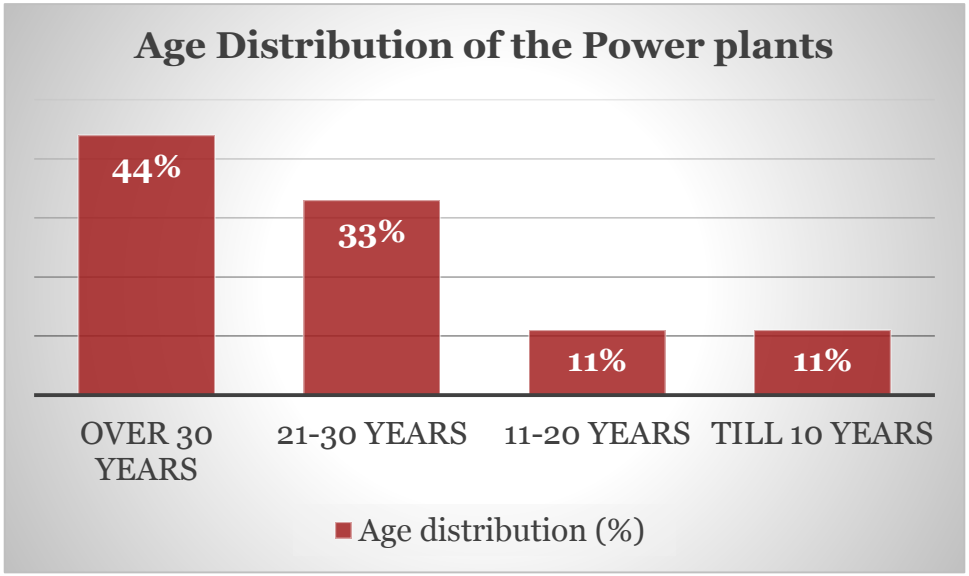


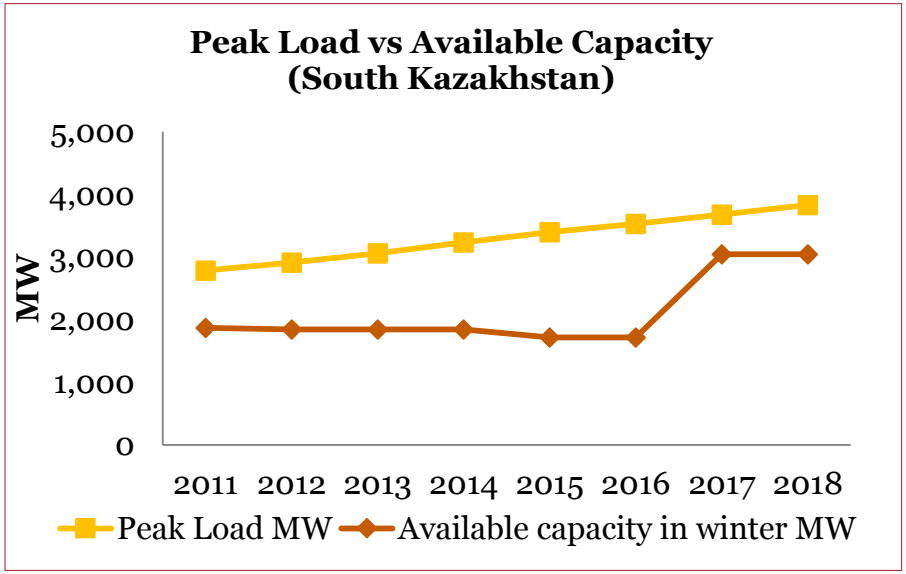


- The share of diesel and furnace oil based generation has decreased by 7% whereas the share of coal based generation has increased by 7%.
- Similarly the share of hydro based plants got decreased by 4% whereas as the share of Renewables have increased by 3%
- The decrease in share of hydro, the dominant in electricity mix is due to two reasons:
  a. Further exploitation of hydropower is limited
  b. Variability of both southwest & northeast monsoon rains and rains of convectional origin has increased which impacts water availability for hydro generation

Appendix 2.2
Kazakhstan

Need for energy security





Ageing of generating assets leading to inefficient supply

+

Transmission bottleneck between north & south leading to power deficit in southern part

+

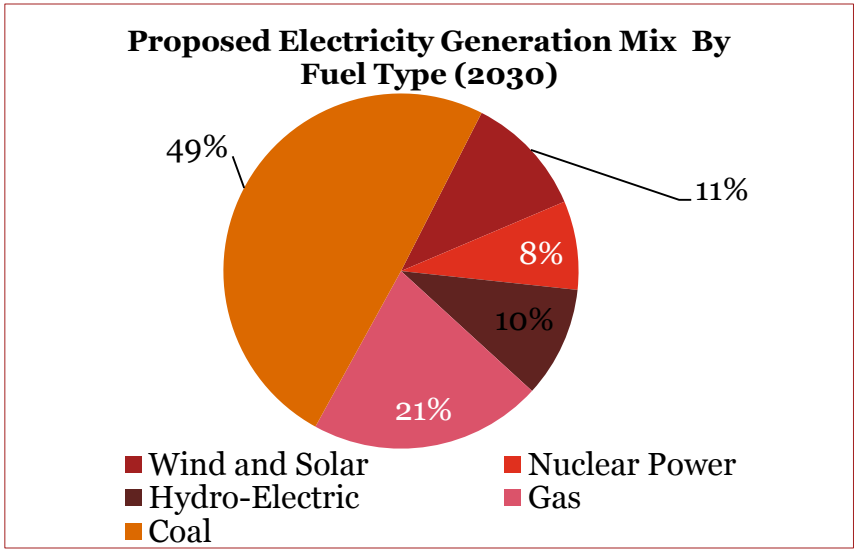
Limited internal gas pipeline network that does not connect production & demand centres.

+

High GHG emission due to thermal generation, gas flaring

Fuel diversification initiative and future action plan (1/2)

Kazakhstan 2030 strategy



- Kazakhstan will be spending 1% of its annual output on increasing power generation from green resources until 2050.
- The overall cost of the program from the period it starts until 2050 will be USD3.2 billion, approximately 1% of the country's GDP
- Share of renewable energy in electricity generation to be 3% by 2020 rising to 30% by 2030 and 50% by 2050

Key objectives of KEGOC vision 2025

Strengthening of electricity transmission network + Parallel operation with power system of neighbouring countries + Establish financial settlement center to support RE sources + Support tariff policy & electricity legislation improvement

Fuel diversification initiative and future action plan (1/2)

Kazakhstan Green Economy Concept Policy 2013

Phase I: 2013-2020	• During this period the main priority of the government will be optimization of the resources, improvement of environmental performance, as well as the creation of "green" infrastructure;
Phase II: 2020-2030	• In the second phase on the basis of the established "green" infrastructure it is envisaged that the national economy will be transformed , focusing on the careful use of water, encouragement and stimulation of the development and adoption of renewable energy technologies • Construction of structures on the basis of high standards of energy efficiency;
Phase III: 2030-2050	• The transition of the national economy on the principles of the so -called " third industrial revolution" , requiring the use of natural resources, subject to their renewability and sustainability.

Key policy level interventions and institutional arrangements (1/3)

Initiatives to promote renewable energy

- Feed-in-tariff for renewable energy sources. Tariff to be revised every three years & is indexed to inflation rate
- A single access point (Investors' Service Centre) is provided for investors involved in priority investment projects. Generation is de-licensed
- Investment security is created by power purchase agreements between regional grid operators and renewable energy facilities. Grid losses are compensated up to 50%
- Capacity Development Trust Fund Agreement between The Economic and Social Commission for Asia and the Pacific and the Kazakh Ministry of Foreign Affairs has been signed to support development of biogas-based renewable energy
- The Green Bridge Partnership Programme, a Kazakh initiative which brings together several countries, from Germany to Mongolia, to promote technology transfer and innovation in energy
- Renewable energy facilities to receive state grant up to 30% of project costs. Foreign investors may apply for tax exemption like land & property tax
- A joint project between UNDP and the Kazakh Electricity Association offers pre-feasibility studies for potential wind farm investment projects

Key policy level interventions and institutional arrangements (2/3)

Initiatives to promote energy efficiency

- Energy intensity of gross domestic product should be reduced by at least 10% by 2015 and 25% by 2020.
- Introduction of energy efficiency labelling of buildings and domestic appliances. Ban on the use and production of incandescent light bulbs
- Promotion of energy saving and energy efficiency, including the use of energy efficient equipment and materials
- Legal entities of State energy registry (SER) that consume more than 1500 tons of oil equivalents per year are required to establish, implement and organize the work of the energy management system in accordance with ISO 50001
- Development of training centers in the field of energy auditing and energy management
- Voluntary agreements on energy saving with the large industrial enterprises

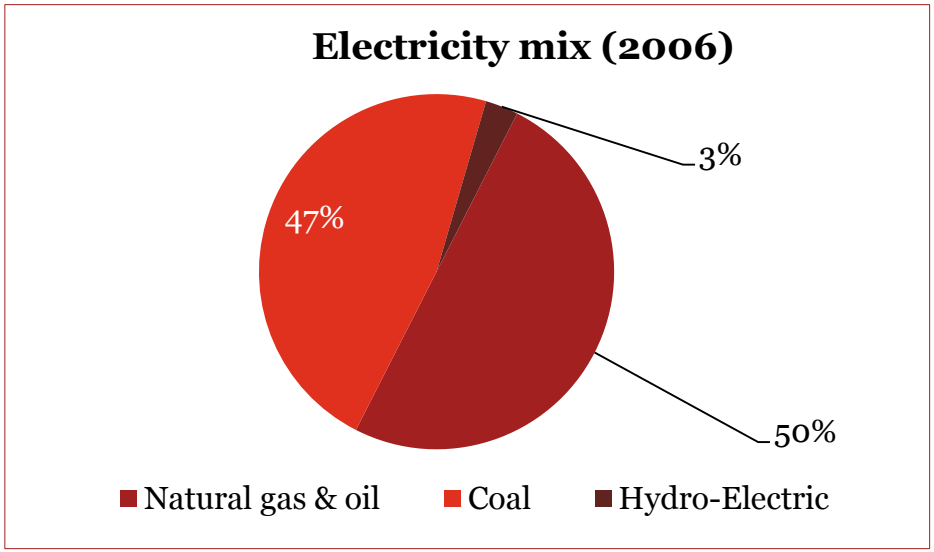
Key policy level interventions and institutional arrangements (3/3)

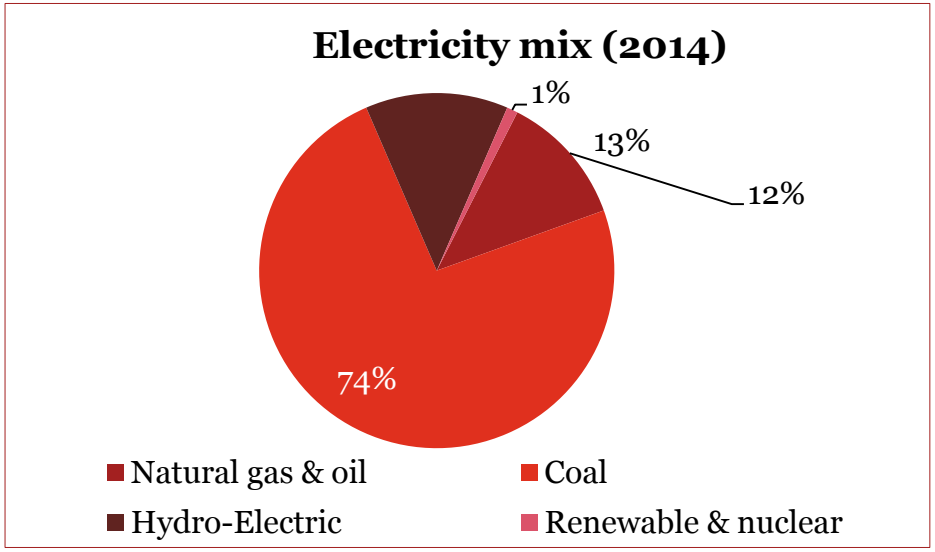
Institutional arrangement

Ministry of Investment & Development	• Carries out state investment policy and the policy fostering investments, creation of a favorable investment climate • Carries out management of mineral resources, except for hydrocarbon raw materials;
Ministry of Energy	• Pursue the state policy in the areas of oil & gas petrochemical industries, & transportation of raw hydrocarbons • Develop and approve policy documents, normative legal acts except for technical regulations, the oil & gas industry
Agency for regulation of natural monopolies	• Carries out state regulation of activity of natural monopolies, & prices for goods works, services of market entitie • Define tariff methodology and set transmission, distribution & heat tariff
Samruk Kazyna	• Develop & ensure implementation of regional, national and international investment projects • To support national producers
Kazakh operator of electric energy & power market	• Operates centralised electricity trading market • Operates both day ahead & forward auctions
IPP, KEGOC & DISCOMs	•Generation - (87% by IPPs & 13% by Samruk energy) •Transmission – KEGOC (state owned) •Distribution – 21 DISCOMs with 2 state owned

Progress till date and envisaged outcome

Change in electricity mix





Focus shifted on increasing oil & gas export

+

Increased hydropower generation to cater demand of southern part

+

Increase in coal based generation to reduce dependence on oil & gas

+

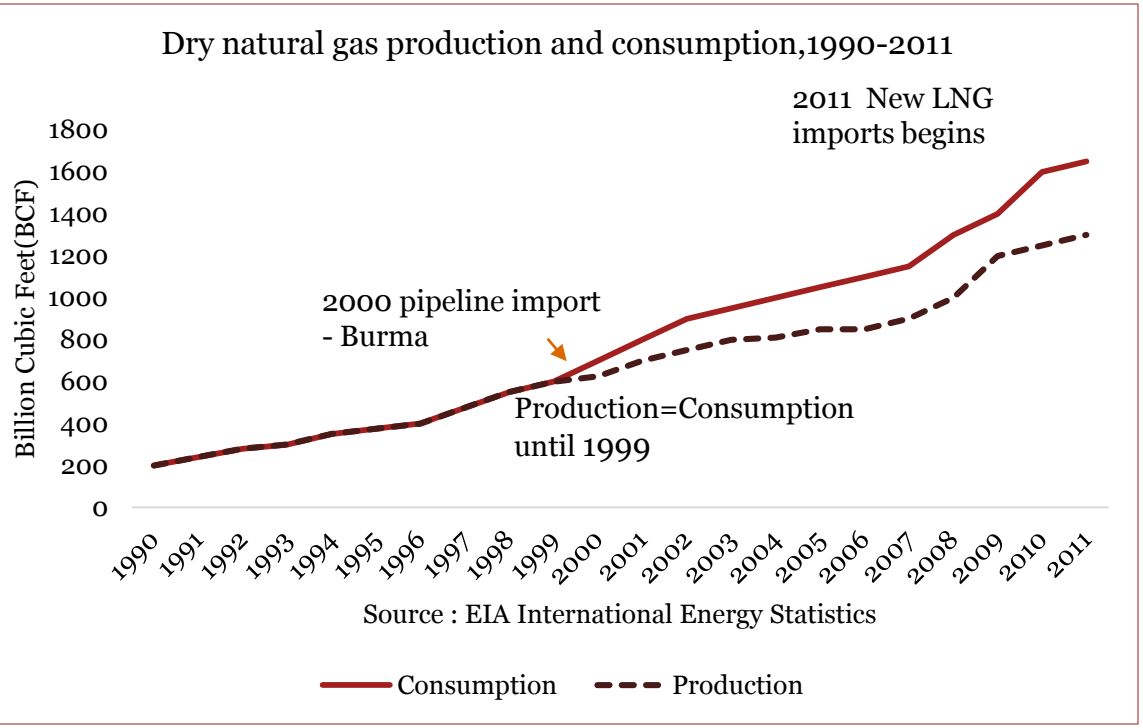
Focus on renewable & nuclear to reduce energy intensity & utilise uranium reserve

Kazakhstan also carry out power trading with neighbouring countries like Kyrgyz Republic and Russia to cater the seasonal variation. For example, in summer Kazakhstan import cheaper hydropower from Kyrgyz Republic

Appendix 2.3
Thailand

Need for energy security

Fuel diversification – need of the hour



Primary energy supply	Domestic production (ktoe)	Import (ktoe)	Export (ktoe)
Coal & its products	4459	10852	7
Crude oil & NGL	7363	43322	1606
Natural gas	36405	10470	
Electricity	--	1071	109
Renewable	9993	--	--
Biomass & waste	1609	125	29

Key reasons for fuel diversification

Depletion of natural gas reserve & increase in LNG import → Huge quantity of crude oil import → Power import uncertainty, hydro dry in lean season, project delay etc. → Low quality coal leading to social & environmental concern → Increase in CO_2 intensity

Fuel diversification initiatives and future action plan (1/2)

PDP 2015 – Key principles

Rationale for formulation of PDP

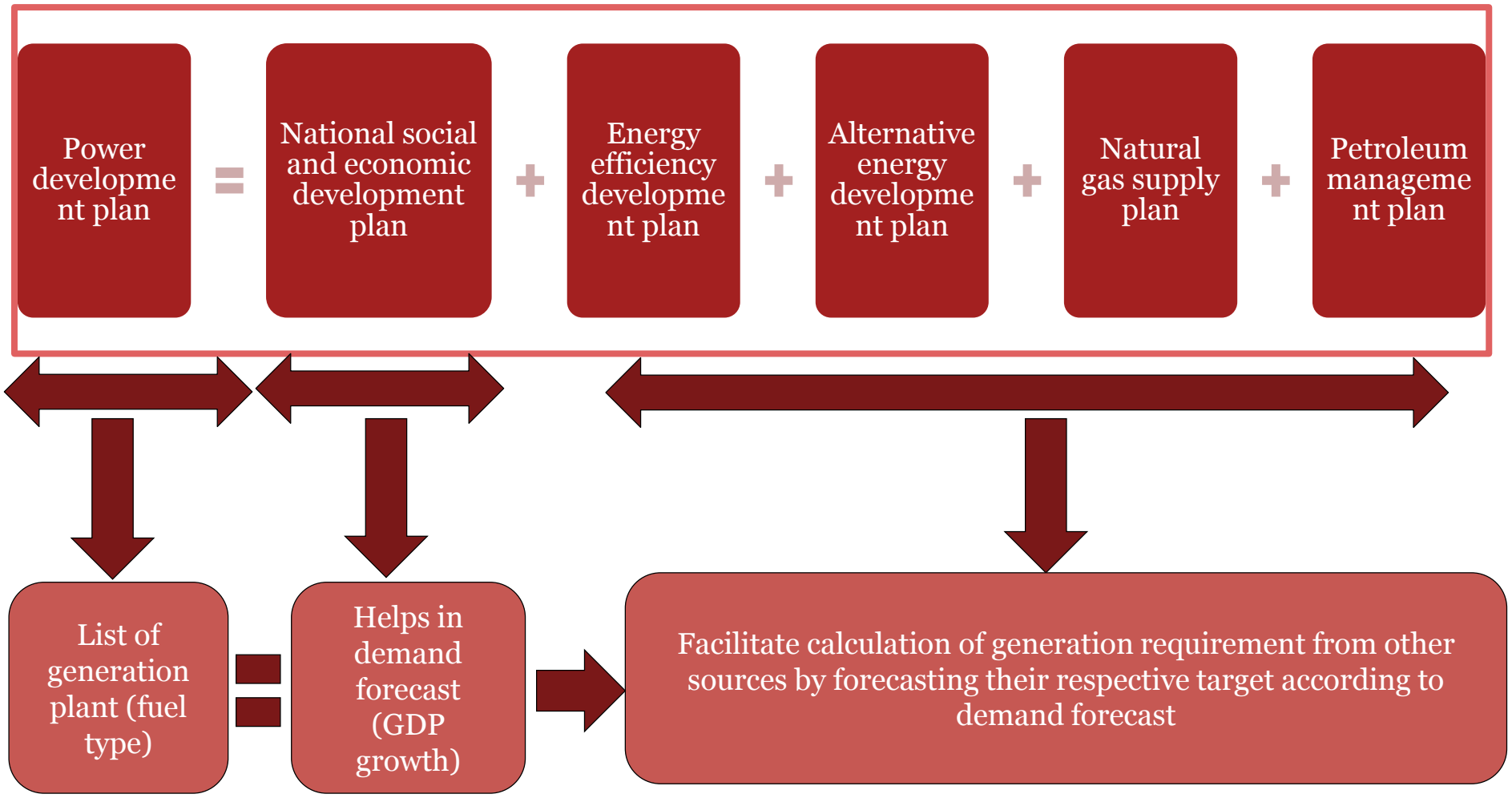
- Energy security – Fuel diversification
- Economy – Appropriate cost and energy efficiency
- Ecology – Reduced social & environmental impact

Steps to be taken for fuel diversification

- Reducing natural gas generation
- Increase in coal power generation (clean coal technology) for low cost of generation and high coal reserves
- Power import not more than 20% considering price and development potential
- Encourage RE generation considering transmission system capability
- Maintaining nuclear power plant considering its low environmental impact and relatively low cost

Fuel diversification initiatives and future action plan (2/2)

Integration of key plans



Key policy level interventions and institutional arrangements (1/3)

Promotion of Very small power producers (VSPPs)

- Facilitate small community owned or small private owned RE generation by allowing it to connect to grid and sell excess electricity to utilities
- Export to grid is limited to 10 MW and Feed-in-tariff is allowed for RE production
- VSPPs can use fossil fuel as supplementary fuel but the total thermal energy must not exceed 25% of total thermal energy used for electricity generation in that year

Promotion of small power producers (SPPs)

- SPP projects include non conventional sources with cogeneration projects must use 10% of energy output for thermal application
- SPPs can deliver 60MW for Sale to EGAT with a maximum of 90 MW
- Retail prices are offered for their output and connection to the national grid
- PPAs expiring during 2017-2025 will be renewed for 3 to 5 years with tariff reflecting real operational cost

Key policy level interventions and institutional arrangements (2/3)

Promoting energy efficiency

- Reduce energy intensity by 30% in 2036 compared to 2010
- Revision of energy price subsidies to create the market price
- Introducing tax incentives or ESCO fund to promote use of energy efficient appliances
- Defining energy efficiency resource standard for generation and distribution utilities. Building , industry and factory energy code to be under obligation
- Monetary support in terms of grant , soft loan to promote use of energy efficient high efficiency appliances

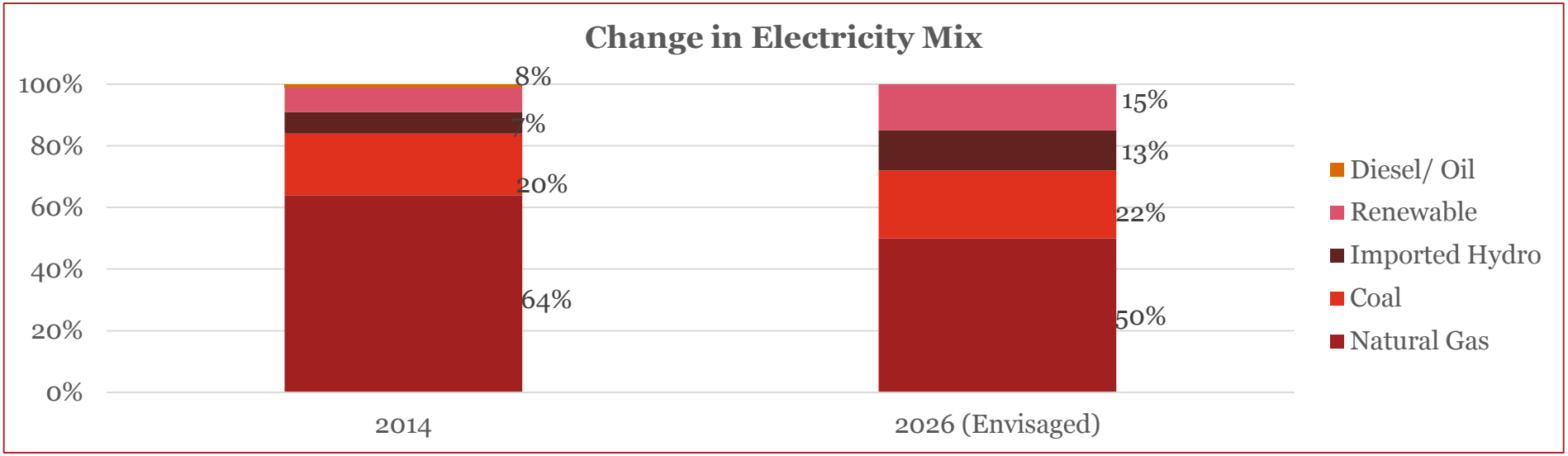
Key policy level interventions and institutional arrangements (3/3)

Institutional arrangements

Ministry of Energy	• Plan, propose, advise & monitor compliance with energy related policies • It has four dependent departments namely, Department of Energy Business, Mineral Fuel, Alternative Energy and policy & planning office
National Energy Policy Council	• Recommend national energy policies and national energy management and development plans to the cabinet • Evaluate the implementation of national energy policies & development plans • Set rules and conditions for prescribing energy prices in accordance with national energy policies
The Energy Conservation Fund Committee	• Propose to the NEPC guidelines, criteria, conditions and priorities for the disbursement of funds in accordance with Section 25 of the Energy Conservation Promotion Act • Prescribe regulations on the criteria and procedures for submissions, grants allocations or subsidies from the Fund
Energy Policy Committee	• Provide comments on the energy-related programs and projects of various agencies and suggest priorities • Recommend policies and measures on energy pricing and monitor tariff adjustments • Set petroleum prices and premium rates to be collected for the Petroleum Fund

Progress till date and envisaged outcome

Power Development Plan 2015



- The increased consumption of natural gas and inability to meet the demand solely from domestic production has shifted the focus of the government to diversify its fuel source. It is evident from the fact that share of natural gas for power generation will be reduced to around 50% in 2016 and share of other alternate sources will increase.
- Adequate focus has been given to renewable and power import which contribution will increase by almost 15% in the total mix which will facilitate to curve out the increased dependency on gas for electricity generation
- Various energy development plans like petroleum, natural gas etc. were integrated to consider power, gas, energy efficiency, alternate energy (solar, wind, waste to energy, biomass), to form the best possible electricity generation mix

Appendix 2.4
Key Learnings

Key learnings

- Fuel diversification undertaken to reduce the impact dependency on single fuel and high cost of imported fuels like oil, diesel etc.
- Power sector development plan formulated considering the availability, affordability, reliability and sustainability of various fuel sources including imported fuel options
- Cross border power trading has been considered as an option to import or banking of cheaper power wherever available
- Policy level interventions has been undertaken to encourage fuel diversification, use of renewable energy and energy efficiency (pricing policy, incentives, grants etc.)
- Improvement in rural electricity access through on grid and off grid to cater to basic energy needs

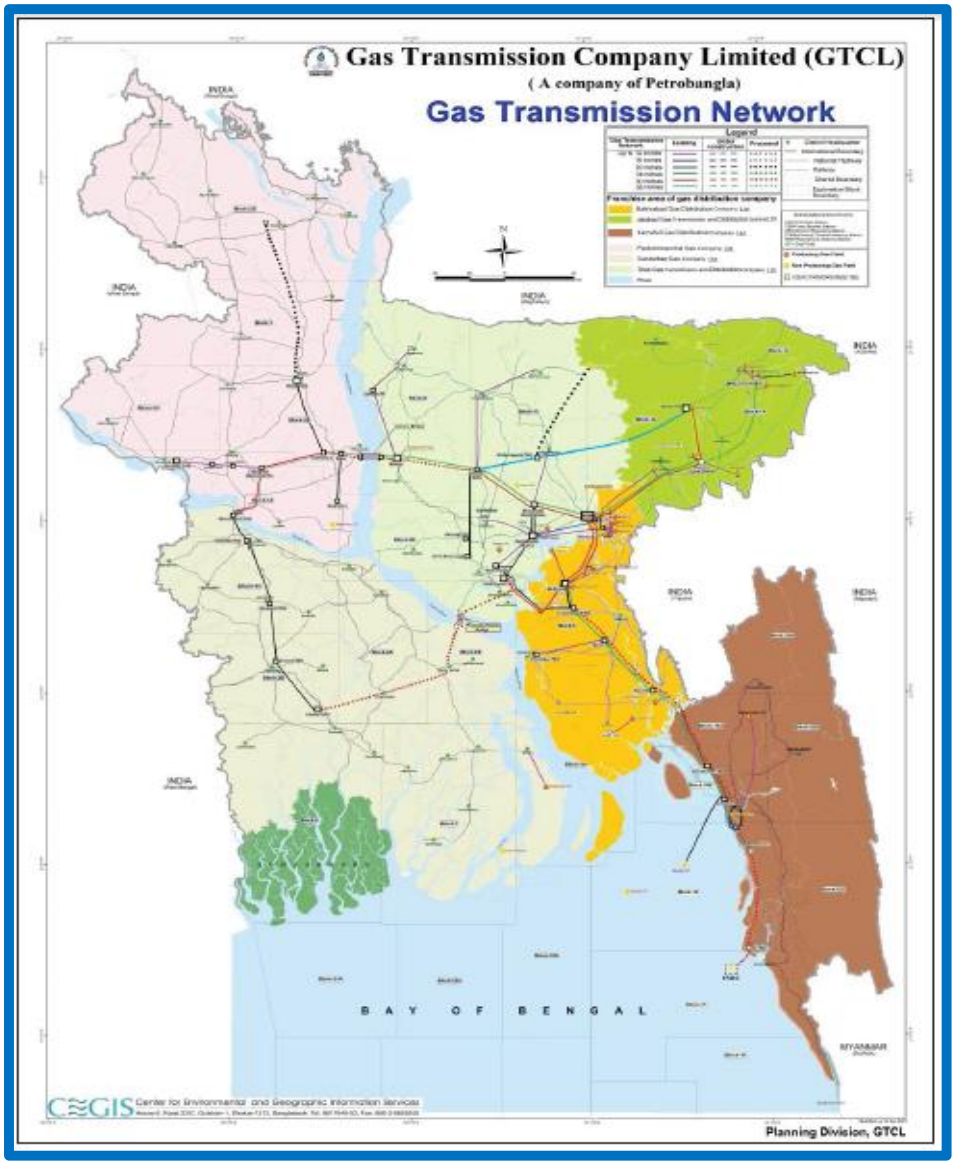
Appendix 3
Existing LPG Infrastructure in Bangladesh

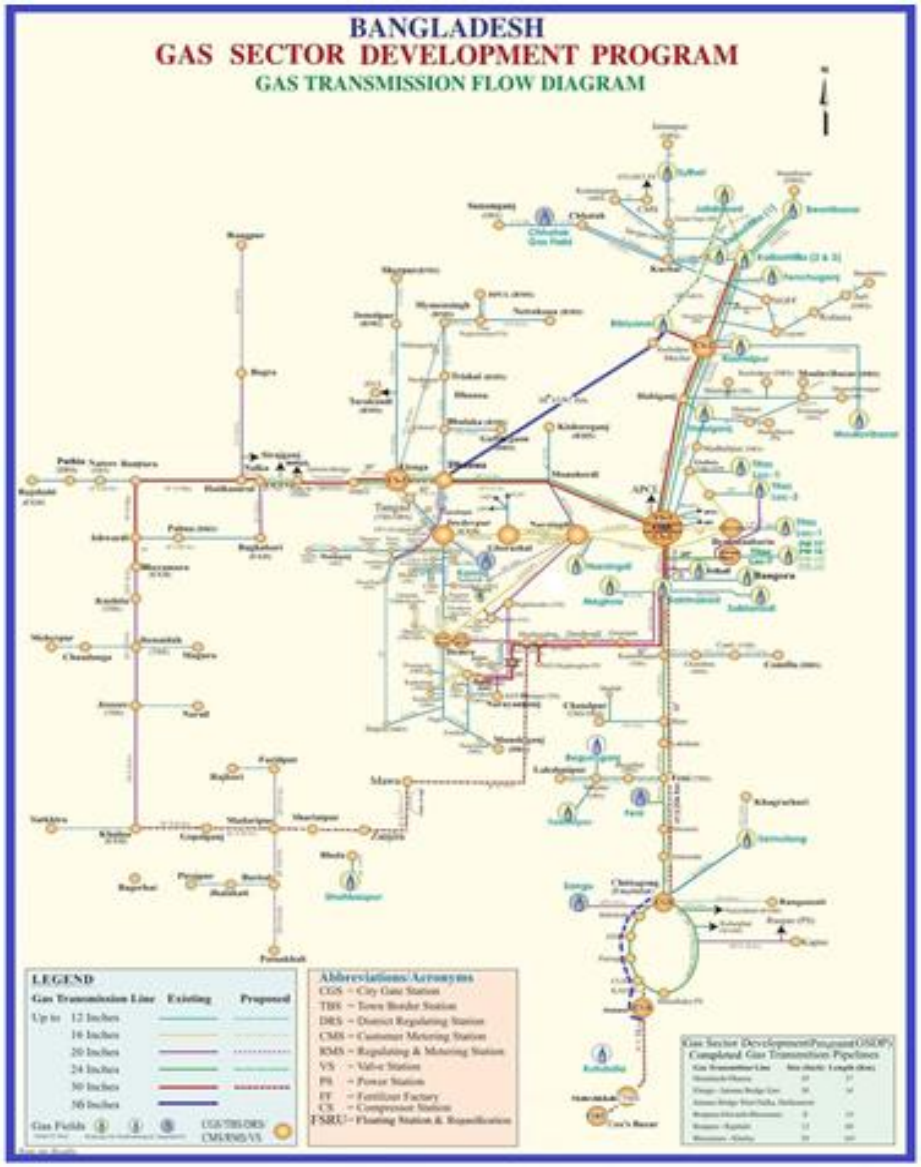
Snapshot of existing LPG infrastructure in Bangladesh

Company	Infrastructure	Location	Capacity
BPC	Storage Tank	Chittagong	1210 MT storage capacity
	Bottling Plant	Chittagong	10000 MT per year
	Bottling Plant	Sylhet	7000 MT per year
Omera Petroleum	Mother Plant	Mongla	3600 MT storage capacity
	Satellite Plants	Bogra, Ghorashal, Chittagong	400 MT storage capacity
	Cylinder manufacturing Plant	Habiganj	500000 MT per year
BM Energy	Floating terminal & Bottling Plant	Chittagong	3000 MT storage capacity
	Regional Distribution Units	Dhaka, Khulna, Bogra	--
Bashundhara LP Gas	Mother Plant	Mongla	3000 MT storage capacity
	Satellite Plants	Chittagong & Bogra	70 MT & 90 MT resp.
Jamuna Spacetech	Mother Plant	Mongla	2650 MT storage
	Satellite Plant	Bogra	200 MT
TotalGaz	Import Facility	Chittagong	--
Petredec Elpiji Ltd	Import Facility	Mongla	1800 MT storage

Appendix 4
Gas Pipeline Infrastructure in Bangladesh

Gas pipeline infrastructure in Bangladesh





Appendix 5
Affordability Analysis - Assumptions

Appendix 5.1
Gas Affordability Analysis

Assumption sheet for affordability analysis

Plant Capacity(MW)	450
Capital Cost(Taka)	69,125,000,000
Debt as percentage of capital cost(%)	80
Return on equity(%)	12
Interest on Long term Loan(%)	4.0
Working Capital Norm (No of months receivable)	2
Interest on Working Capital(%)	12
Depreciation(%)	4
O&M Cost(% of Capital Cost)	3
Plant Load Factor(%)	80
Auxillary Consumption(%)	4.5
Station Heat Rate (Kcal/kWh)	1,720
1 MMBTU=Kcal	252,000
1 USD= Taka	79
GCV of domestic natural gas (Kcal/scm)	8,450
Maximum Bulk Power Tariff in Bangladesh (Taka/kWh)	4.90

Assumption sheet for affordability analysis

GCV of Domestic Natural Gas (Kcal/scm)	9,420
GCV of Coal(Kcal/Kg)-Considering imports from NE India	6,500
GCV of HSFO (million BTU/ barrel)	6.287
GCV of Diesel (million BTU/barrel)	5.755
GCV of LPG (million BTU/ barrel)	3.565
GCV of Motor Spirit (Million BTU/ barrel)	5.101
GCV of Kerosene (Million BTU/ barrel)	5.670

Retail Price of Natural gas for Power sector (Taka/m3)	2.82
Retail Price of Natural gas for Captive Power sector (Taka/m3)	8.36
Retail Price of Natural gas for Fertilizer sector (Taka/m3)	2.58
Retail Price of Natural gas for Industrial sector (Taka/m3)	6.74
Retail Price of Natural gas for Tea estate sector (Taka/m3)	6.45
Retail Price of Natural gas for Commercial sector (Taka/m3)	11.36
Retail Price of Natural gas for Transport sector (Taka/m3)	35.00
Retail Price of Natural gas for Domestic(metered) sector (Taka/m3)	7.00

Retail Price of Motor Spirit (Taka/L)	96.00
Retail Price of Diesel (Taka/L)	68.00
Retail Price of HSFO (Taka/L)	60.00
Retail Price of Kerosene(SKO) (Taka/L)	68.00
Retail Price of 12. 5 Kg Subsidised LPG (Taka)	700.00
Retail Price of Subsidised LPG (Taka/kg)	56.00
Retail Price of 12. 5 Kg Non-Subsidised LPG (Taka)	1,400.00
Retail Price of Non-Subsidised LPG (Taka/kg)	112.00
Retail Price of Fuel Wood (Taka/Kg)	8.00
Retail Price of Coal (USD/ton)	112.00

Assumption sheet for affordability analysis

1 MMBTU= Kcal	252,000
1 barrel= Liter	159
1 ton= Kg	1,000
1 USD= Taka	76.61
1 USD= Indian Rupees	66.25
1 USD= Pakistan Rupees	103.71

Density of LPG (Kg/L)	0.557
Density of CNG (Kg/m3)	0.679

Subsidised Rates for LPG assumed only for Domestic Sector
Market rates for LPG assumed for all sectors except Domestic sector

Fuel Efficiency of Petrol Engines (Km/L)	15
Fuel Efficiency of Diesel Engines (Km/L)	18
Fuel Efficiency of CNG Engines (Km/Kg)	19

Appendix 5.2
Affordability Analysis Assumptions for Other Options

Affordability analysis - Imported Coal

Assumptions

Particulars	Assumptions
Plant Capacity	1200 MW
Useful life	30 yrs
Plant Load Factor	80%
Plant Heat Rate	2,100 kcal/kWh (41% Efficiency)
Auxiliary Consumption	6.5%
Capital Cost	USD 1.15 mn / MW
O&M Cost	USD 0.024 mn / MW
Escalation in O&M Cost	6.3%
Coal GCV (Kcal/kg)	5500
Landed Price of coal	USD 85/ton
Escalation in coal cost	5%
Debt : Equity Ratio	80:20

Particulars	Assumptions
Interest on Loan	4%
Loan Repayment Tenure	15 years
Return on Equity (Pre tax)	12%
Salvage value	10%
Depreciation Rate	1st 12 yrs - 5.28% 13th year onwards – 1.48%
Working Capital	Coal – 1 month Spares – 20% of O&M Receivables – 1 month O&M Expense – 1 month Secondary Fuel – 2 month
Interest on Working Capital	13%
Discount Factor	12%
Corporate Income Tax rate	35%
Tax Exemption	100% for First 15 yrs

Estimated levelized cost of generation: USD 0.077/kWh or BDT 6.03/kWh.

Affordability analysis – Domestic Coal

Assumptions

Particulars	Assumptions
Plant Capacity	600 MW
Useful life	30 yrs
Plant Load Factor	80%
Plant Heat Rate	2,100 kcal/kWh (41% Efficiency)
Auxiliary Consumption	6.5%
Capital Cost	USD 1.15 mn / MW
O&M Cost	USD 0.024 mn / MW
Escalation in O&M Cost	6.3%
Coal GCV (Kcal/kg)	6100
Landed Price of coal	USD 130/ton
Escalation in coal cost	5%
Debt : Equity Ratio	80:20

Particulars	Assumptions
Interest on Loan	4%
Loan Repayment Tenure	15 years
Return on Equity (Pre tax)	12%
Salvage value	10%
Depreciation Rate	1st 12 yrs - 5.28% 13th year onwards – 1.48%
Working Capital	Coal – 1 month Spares – 20% of O&M Receivables – 1 month O&M Expense – 1 month Secondary Fuel – 2 month
Interest on Working Capital	13%
Discount Factor	12%
Corporate Income Tax rate	35%
Tax Exemption	100% for First 15 yrs

Estimated levelized cost of generation: USD 0.097/kWh or BDT 7.65/kWh.

Affordability analysis - Blended Coal (Import - 70% & Domestic – 30%)

Assumptions

Particulars	Assumptions
Plant Capacity	1200 MW
Useful life	30 yrs
Plant Load Factor	80%
Plant Heat Rate	2,100 kcal/kWh (41% Efficiency)
Auxiliary Consumption	6.5%
Capital Cost	USD 1.15 mn / MW
O&M Cost	USD 0.024 mn / MW
Escalation in O&M Cost	6.3%
Coal GCV (Kcal/kg)	5680
Landed Price of coal	USD 99/ton
Escalation in coal cost	5%
Debt : Equity Ratio	80:20

Particulars	Assumptions
Interest on Loan	4%
Loan Repayment Tenure	15 years
Return on Equity (Pre tax)	12%
Salvage value	10%
Depreciation Rate	1st 12 yrs - 5.28% 13th year onwards – 1.48%
Working Capital	Coal – 1 month Spares – 20% of O&M Receivables – 1 month O&M Expense – 1 month Secondary Fuel – 2 month
Interest on Working Capital	13%
Discount Factor	12%
Corporate Income Tax rate	35%
Tax Exemption	100% for First 15 yrs

Estimated levelized cost of generation: USD 0.084/kWh or BDT 6.56/kWh.

Affordability analysis - Small Hydro

Assumptions

Particulars	Assumptions
Plant Capacity	10 MW
Useful life	30 yrs
PLF	40%
Auxiliary Consumption	1%
Capital Cost	USD 2.1 mn / MW
O&M Cost	USD 0.06 mn / MW
Escalation in O&M Cost	5.72%
Debt : Equity Ratio	70:30
Interest on Term Loan	6%
Repayment Tenure	9 yrs

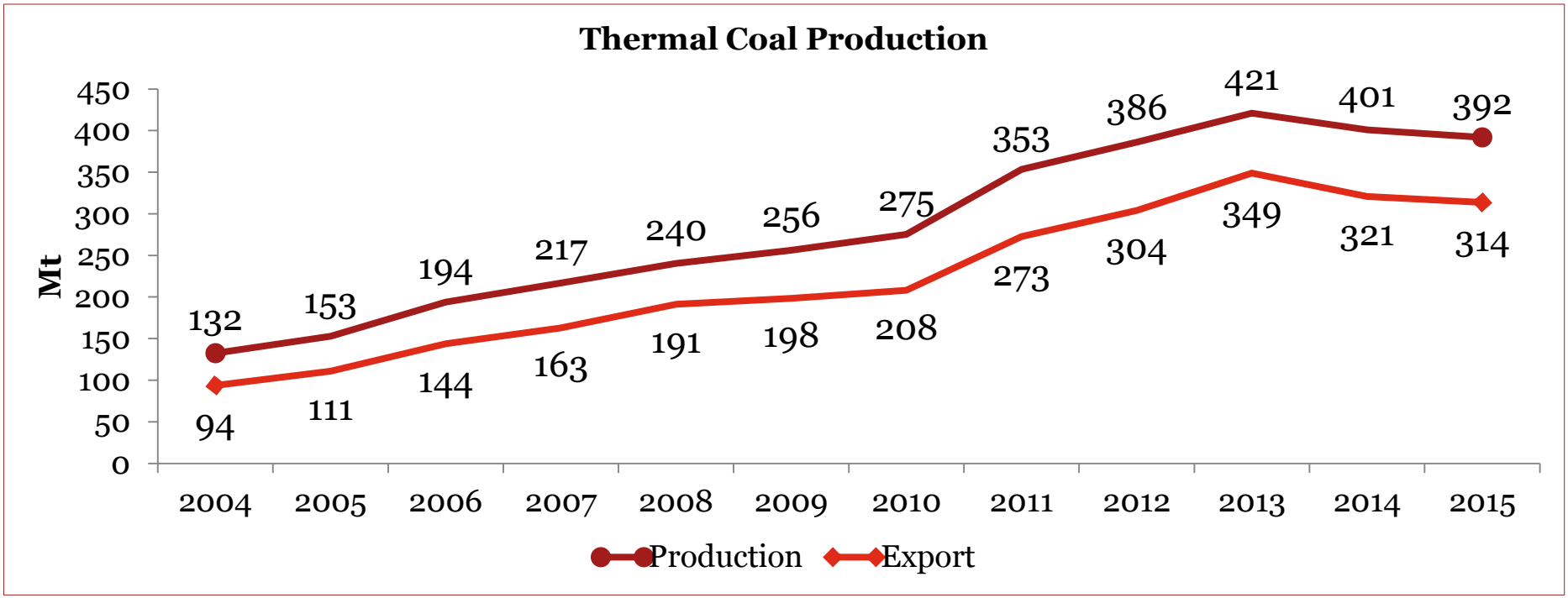
Particulars	Assumptions
Return on Equity (Post tax)	15 %
Interest on Working Capital	13%
Corporate Income Tax rate	35%
Tax Exemption	100% - First 5 yrs 50% - Next 3 yrs 25% - Next 2 yrs
Depreciation Rate	15%
Salvage value	10%
Discount Factor	12%

Estimated levelized cost of generation: USD 0.104/kWh or BDT 8.16/kWh.

Appendix 6
Global Coal Reserves and Production

Indonesia - coal reserves and production

- According to BP Statistical Review, proved reserves of coal at the end of Dec'14 in Indonesia are 28.02BT
- Recoverable coal reserves in Indonesia are primarily located in **South Sumatera, East and South Kalimantan.**
- Thermal coal production tripled between 2004 and 2014, increasing at a CAGR of 12.3%, though declined during past 2 years, due to capped coal production and Export License introduced in 2014.
- In long term, export is expected to increase.



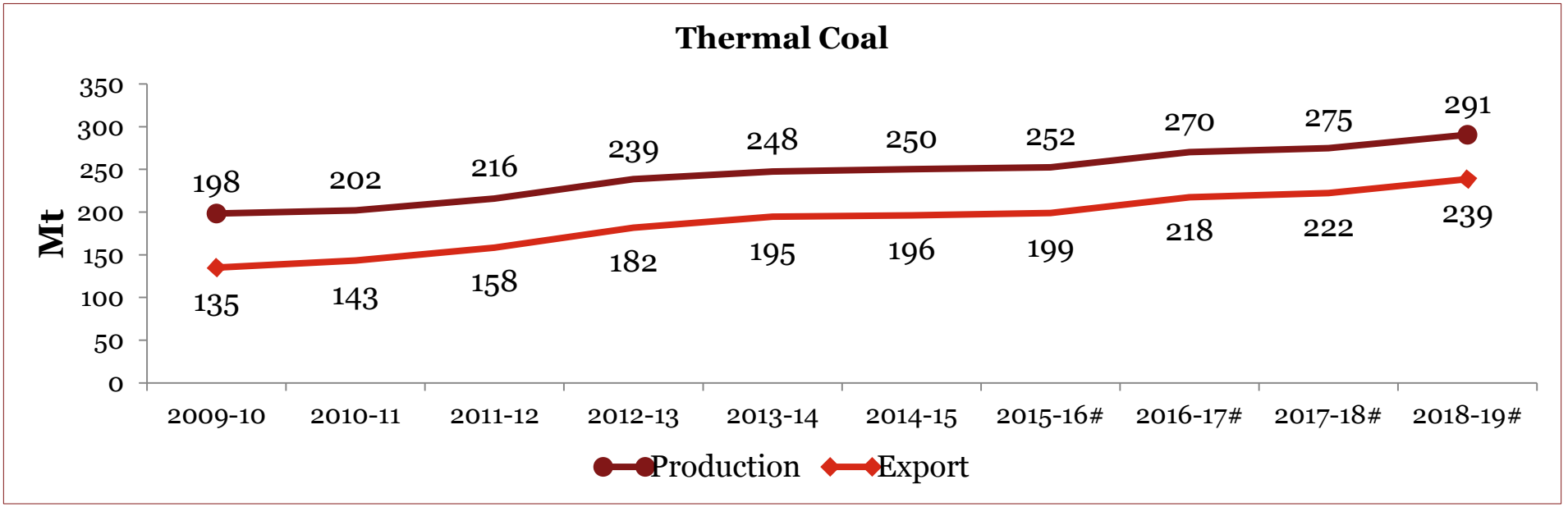
Australia - Coal reserves

- As per BP statistics, 76.4 BT proved coal reserves as on Dec'2014 are located in Australia.
- Coal resources in Australia are mainly located in **Queensland** and **New South Wales**.
- Major coal basins in Queensland are Bowen basin, Galilee basin, Surat-Moreton Basin.
- Major coalfields in New South Wales are Sydney Basin and Gunnedah Basin

Coal basin	Location within Queensland	Economic Demonstrated Resources (EDR) , Mt, Dec 2012	
		In situ	Recoverable
Bowen basin	Central Queensland	22,678	12,854
Surat - Moreton basin	South east Queensland	2,428	2,118
Galilee basin	Western- Central Queensland	800	450
Sydney basin	New South Wales	21,234	11,001
Gunnedah basin	New South Wales	972	637

Australia – Coal production

- Australia produced 248 Mt of thermal coal and exported 195 Mt in 2014.
- In the past five years, thermal coal production has increased at a CAGR of 4.5% while export has increased at a CAGR of 7.6%.
- Over the medium term, Australia's thermal coal production is projected to increase at an average annual rate of 3.0% to 291 MT in 2018-19.

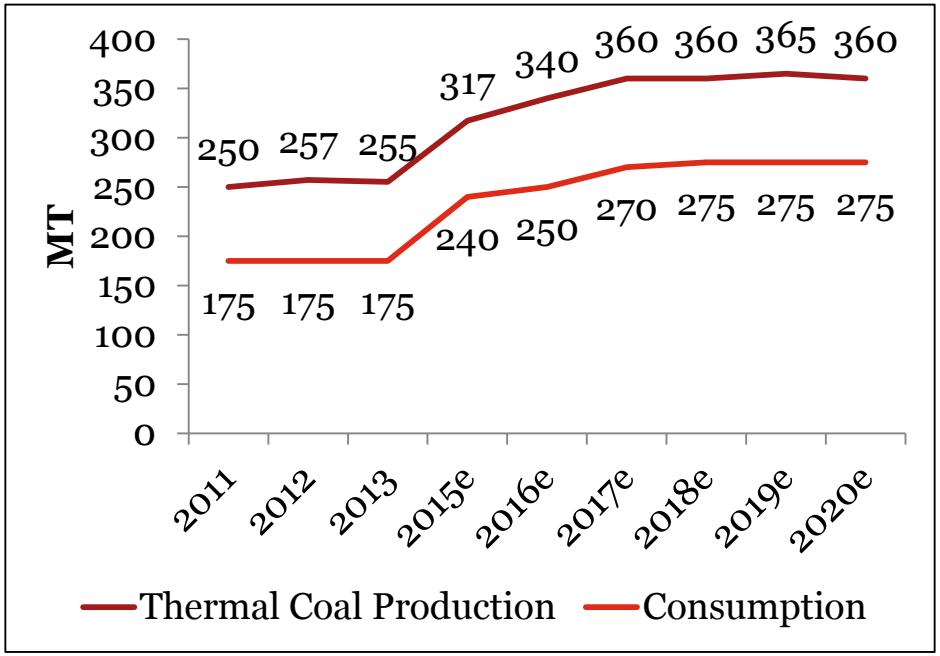


South Africa – Coal reserves and production

- Has 30.15 BT of proved coal reserve as on Dec'14.
- Ranks 9th in terms of amount of recoverable coal reserve.
- Holds 95% of Africa's total coal reserve.
- Most of the thermal coal for export comes from the Witbank, Highveld, and Ermelo coal fields.

Coal Field	Reserves (MT)
Witbank/ Secunda	11,344
Highveld	10,182
Ermelo	4,924
Klip River	1,056
Utrecht	598
Vryheid	91
South Rand	569
Sasolburg	1,960
Free State	4,920
Springbo k Flats	3,250
Ellisras	14,677
Mopane Tshipise Pafuri	344

- More than 99% of the total coal produced is thermal coal. Anglo American, BHP Billiton Energy Coal South Africa and Glencore International Plc. are major producer of thermal coal in South Africa.
- According to Wood Mackenzie, South African coal production will increase to 319 Mt by 2015, and 359 Mt by 2020.
- Domestic coal demand will increase to 275 MT by 2020.



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