Power Sector Strategy for the Perspective Plan

[Document subtitle]

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**Power Sector Strategy for the Perspective Plan**

# Introduction and Background

Power shortages became the number one constraint to economic growth during 2005-2009, with no new generation capacity added over almost one decade. For a long period during 2001-2008, due to lack of serious attention and decisive policy actions, no new power plant was installed and older and inefficient gas-based power plants also started to suffer from frequent breakdowns and shortage of gas supply. With a power sector which is almost entirely dependent on natural-gas fired generation, Bangladesh was confronting a simultaneous shortage of natural gas and shortage of electricity generation capacity. Nearly 800 MW of power with fully installed capacity could not be availed from the power plants due to shortage of gas supply. During this 8-year period installed capacity was hovering at 5202 MW and actual peak production was 4130 MW. As the demand for electricity continued to surge with economic activity measured in terms of real GDP growth at 6% or more, power shortage became more acute and load shedding became wide spread. In all forms of indicators such as Doing Business or Global Productivity Index—based on perception surveys of business entrepreneurs—power shortage came out as the number one constraint limiting investment and business operations in Bangladesh. Electricity shortage has high economic costs. The World Bank estimated that load shedding represented a loss of 0.5 percent in GDP and a $1 billion loss in terms of industrial output a year. There are also significant financial and environmental costs of owning generators to compensate for power outages.

The Awami League government which came to power in 2009, made power generation as the number one economic priority of the government by adopting short-, medium- and long-term strategies for the power sector in the context of the Power Sector Master Plan (PSMP) 2010. Because of the government’s strong commitment to the power sector, Bangladesh has made commendable progress in electricity generation during the last eight years (2009-2017). According to Bangladesh Power Development Board (PDB), installed generation capacity including captive power as of December 2017 amounted to (13,846+2,200) = 16,046 MW, which was more than 3 times greater than the volume eight years back. More than 80% of households have now access to electricity compared with less than 50% in 2009. As a result, per capita power consumption has doubled to about 450 kWh over this period, but still Bangladesh’s per capita power consumption remains one of the lowest among the South Asian countries.

Despite the impressive progress, Bangladesh power sector faces numerous challenges over the long term. The challenges are and will continue to be arising from diverse sources such as:

* Improving efficiency in power sector operations to ensure adequate power supply at affordable and competitive prices and ensure financial sustainability of the major expansion currently underway;
* Diversification of primary fuel for power generation from its continued dependence on natural gas as domestic gas reserves are declining rapidly;
* Projected rapid growth in power demand in line with the projected acceleration of real GDP over the medium and long term and consistent with the government’s objective to become an upper middle-income country by FY31 and a high income country by FY41;
* Determination of the optimum production mix (gas, coal, hydro, import of power from regional countries, and renewable sources), taking into account, logistical considerations for handling coal and LNG, potentials for trade in power with regional countries and environmental considerations/commitments; and
* Mobilization of financing for the massive amounts of investment that would be needed to realize the targeted generation capacity expansion and associated transmission and distribution network.

In order to address the challenges in a systematic manner, the government had prepared the Power System Master Plan (PSMP) 2010, and much of the implementation during the Sixth Five Year Plan (covering FY10-14) was in line with the strategy underpinning the PSMP 2010. On the basis of the lessons learned during the Sixth Plan period, the PSMP was revised by the Ministry of Power and the new PSMP 2016 has been adopted by the government. The PSMP 2016 was however prepared by the Ministry of Power before the GDP growth targets for the Perspective Plan FY41 were finalized. Since power sector plays a critical role in supporting economic growth, capacity expansion in power generation and distribution would be critical for realizing the growth targets under the Perspective Plan (PP) FY41. We also believe that the underlying elasticity of growth in power demand with respect to real GDP growth might have been understated in the PSMP 2016. Both these factors appear to have contributed to a much lower demand for power under the PSMP 2016, compared with what we believe would be needed in support of the ambitious growth targets required for Bangladesh to become an upper middle-income country by FY31 and a high-income country by FY41.

The objective of this study is to determine the medium-and long-term energy needs of Bangladesh, from which sources these growing demands are expected to be met, and what should be the strategy to ensure that supply of power grows in line with the demand without becoming a constraint to growth potential of the country. As part of the strategy to meet the power sector challenges, the study will cover size of potential investment requirement in the power sector, the potential financing mix between the public and private sectors, challenges and risks involved in such financing, risk mitigation strategies, etc.

The remainder of the paper covers the following issues. Section II, discussed Bangladesh’s recent performance in the power sector and how this performance compares with the Sixth Plan and Seventh Plan targets and also compared with the PSMP 2010. Where Bangladesh currently stands in terms of power tariff, energy mix, infrastructure and logistics for handling coal and LNG, state subsidy and other constraining factors are to be discussed in this section. Power generation targets to support the growth/income objectives envisaged under the PP and the related requirements for investment are discussed in Section III. The following section (Section IV) identifies the key challenges in ensuring primary fuel supply due to the rapid dwindling of natural gas reserves to achieve the PP and PSMP 2016 Objectives. In particular, this section focuses on the prospects for domestic gas supply, logistical and other problems with increased reliance on coal and LNG based power plants. Section V highlights the key opportunities and challenges in realizing the potential for trade in electricity, investment in regional power generation projects, and trans-national grids in electricity covering the regional countries. The following section (Section VI) covers other emerging long-term challenges and opportunities in non-renewable power generation and nuclear technology. Issues related to mobilization of financing needed for implementation of the power sector objectives under the PP are discussed in Section VII. In particular, this section covers issues related to financing requirements, financing mix, and the role of domestic and international financial institutions. Some concluding observations are provided in the final section (Section VIII).

# Bangladesh’s Recent Performance in the Power Sector

With the rapid growth in electricity generation, per capita consumption of energy has more than doubled and has also helped sustain the rapid GDP growth in Bangladesh in recent years. Supply of electricity was also boosted by alternative solutions such as increased electricity imports from India. Although the installed capacity was a little behind the original PSMP 2010 objective, the tripling of generation capacity within an 8-year period was certainly impressive. Maximum power generation has also almost tripled to 9,500 MW over this period, although the gap between installed capacity and maximum generation has widened significantly over the years. This raises questions about efficient utilization of the installed capacity and consequently the issue of return on capital in the power sector.

#### Table 1: Power Situation in Bangladesh at a Glance

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2009 | 2017 | Achievement  (2009-2017) |
| Installed capacity of electricity (MW) | 4942 | 15829  (with captive power) | +10879 |
| Maximum generation (MW) | 3268 | 9507 | +6239 |
| Per-capita electricity generation (kWh) | 220 | 433  (with captive power) | +213 |
| Power Import (MW) | ---- | 660 | +660 |
| Access to electricity (% of households) | 47 | 80 | +33 |
| System loss (%) | 16.85 | 12.19 | -4.66 |
| Total Subsidy (billion Tk.) | 25.1 | 55 | +25.1 |
| Average Tariff Rate (Tk. per unit): |  |  |  |
| Households (0-400units) | 2.8 | 5.2 | +2.4 |
| Commercial | 5.77 | 10.6 | +4.83 |
| Small Industries | 4.28 | 8.47 | +4.19 |

***Source: Bangladesh Power Development Board (PDB), Power Division***

The rapid growth in power generation was also reflected in per capita electricity consumption, which almost doubled to 433 KwH in 2017. Despite this impressive growth in power consumption in per capita terms, Bangladesh’s per capita electricity consumption still continues to remain one of the lowest in South Asia and among the developing countries. Access to electricity has also increased with 80% households having access to electricity in 2017 compared with only 47% of households in 2009. At this pace, Bangladesh is firmly on track to achieve its stated objective of providing electricity to every household by 2021. The quality of electricity supply however is still very poor due to poor transmission and distribution networks and frequent load shedding across the country.

Bangladesh also made remarkable efficiency gains in terms of reduction of transmission and distribution (T&D) losses. The T&D losses fell from a high of 32 percent in FY00 to 17 percent in FY2009. It declined further to 12.2 percent in 2017. A part of the T&D loss reflects power leakage, which has been substantially curtailed. Improvements have also been made in reducing the incidence of power outages, increasing the efficiency of billing and collections and reducing the backlog of accounts receivable.

##### Figure 1: Transmission and Distribution Losses (in percent)

***Source: Power Development Board***

Progress with transmission and distribution system has also continued under the Sixth Plan and beyond, although much more investment will be needed in this area. Some nine development & renovation projects have already been completed and another five development projects are in progress. The total infrastructure projects that were added to transmission network by the end of Sixth Plan are shown in Table 2.

#### Table 2: Major Transmission Programs Implemented in the Sixth Plan

|  |  |
| --- | --- |
| **Investment Project** | **Actual Implementation** |
| 400kV Transmission Line | 154.7 ckt. Km |
| 230kV Transmission Line | 381 ckt. Km |
| 132kV Transmission Line | 433 ckt. Km |
| 400kV HVDC Station | 500 MW |
| Substations Capacity 132/33kV | 2400 MVA |
| Capacitor Banks installation at Grid substation at 33 level | 600 MVAR |

***Source: Power Division***

These impressive gains however did not come without costs to consumers and taxpayers. In particular, electricity tariffs were adjusted upwards repeatedly and despite the tariff increases the budgetary subsidy for electricity generation increased rapidly.

***Power Tariff and subsidies***

**Electricity pricing policy:** The establishment of the Bangladesh Energy Regulatory Commission (BERC) in FY04 improved power tariff setting mechanism. Tariffs now get adjusted fairly regularly in accordance with established BERC guidelines. Nevertheless, the gap between the average cost of electricity production and the average selling price remains large, leading to a rapid growth in budgetary subsidy for the power sector.

**Electricity subsidy:** The average cost of power generation in Bangladesh increased by a galloping 23 percent per annum. BERC responded by increasing the bulk average tariff at regular intervals, but the average selling price of electricity fell significantly short of the average cost of production. The resulting financial losses have created substantial pressure on the national budget **(Figure 2),** with the electricity subsidy bill increasing from Tk. 44.86 billion in FY13 to a record high level of almost Tk. 90 billion in FY15. However, because of aggressive tariff adjustments and the sharp decline in liquid fuel prices in the world market, the subsidy bill sharply declined to Tk. 26 billion in FY16 and thereafter estimated to have increased to Tk. 55 billion in FY17 primarily due to a partial recovery in liquid fuel prices in the world market and volume growth due to coming on stream of a new liquid-fuel based power plants.

The availability of even flow of electricity is dependent on expensive imported machineries and maintenance equipment. As a result, the government continues to subsidize a significant share of the power tariff in Bangladesh. At present, both implicit and explicit subsidies in electricity transmission and distribution by the government allow the bulk of retail tariff rates to be set below the supply cost of electricity. As a result, the subsidy bill on account of the power sector is likely to continue to remain sizable. The recent decline in international fuel oil prices provided some relief for the Budget. Yet, in view of uncertainties of international oil prices, electricity pricing and subsidy will continue to pose substantial policy challenges during the Seventh Plan.

##### Figure 2: Power Subsidies and Cash loans (Taka billion)

***Source: Ministry of Finance***

**Developments in electricity tariff structure:** Electricity tariffs in all six customer categories have become almost doubled during the last 7 years. With a view to containing the budgetary subsidy in an environment of rapidly growing domestic supply and demand, the government had to raise the electricity tariff rates across the board. The huge supply constraints in electricity generation--along with the rapid increase in power generation through the high cost quick rental power plants using furnace oil (as well as diesel) as the feedstock--has resulted in tariff increases for all categories of consumers (households, businesses and industries) in recent years. Nevertheless, the industrial and commercial sectors pay higher tariffs while domestic and agriculture sectors pay lower subsidized tariffs. Thus, the domestic and agriculture sectors are partially cross-subsidized by the industrial and commercial sectors.

#### Table 3: Electricity Tariff Increase (March 2010 – December 2017)

|  |  |  |  |
| --- | --- | --- | --- |
| Customer Category: | March 2010  (Per-unit average rate in Tk.) | December 2017  (Per-unit average rate in Tk.) | Increase in tariff (%) |
| Residential (0-400units) | 2.95 | 5.2 | 76% |
| Agriculture | 1.93 | 4 | 107% |
| Small Industries | 4.6 | 8.47 | 95% |
| Medium Industries (11 KV) | 4.9 | 8.56 | 103% |
| Heavy Industries (33 KV) | 4.69 | 8.45 | 114% |
| Commercial | 6.03 | 10.6 | 90% |

***Source: PDB and DESCO***

Bangladesh’s average household electricity tariff is now US cents 9.84 (Tk. 8.14) per unit (1 kilowatt-hour), which is US cents 12.5 in India, US cents 15.48 in Nepal, US cents 17.36 per unit and US cents 11.05 per unit in Sri Lanka and in Pakistan respectively, all of which are higher than in Bangladesh, as shown in Table-4.

Table 4: Summary of Electricity Tariff Rates   
(Average Unit price in equivaent US cents per Kwh)

***Source: DESCO, Public Utility Commission of Sri Lanka, India Power Corporation, Islamabad Electric Supply Company, Nepal Energy Authority***

There are many reasons that account for tariff rate differences. The price of power generation depends largely on the type and market price of the fuels used in power generation, level of government subsidies, government and industry regulations including schemes to cross-subsidize the poor households, and even weather patterns. Although Bangladesh used to have the lowest electricity tariff rates with about 85% electricity generation from domestic natural gas in the past, the cost of generation has risen dramatically with the depleting domestic gas reserves and installation of oil-fired rental and quick rental power plants over the past several years. To provide electricity on an emergency basis, the government signed 3- to 5-year contracts with private suppliers operating diesel or furnace-oil fired 'quick rental' power plants. While these plants came on-line rapidly, use of liquid fuel is always costly and these plants are much less fuel-efficient than large coal or gas-fired power plants.

**Energy mix:**

The Government has undertaken lots of activities to improve primary energy mix in electricity generation, thus shifting its reliance on depleting natural gas power plant to various other alternatives.

##### Figure 3: Installed Capacity by Fuel Type (Sept 2017)

***Source: Bangladesh Power Development Board (PDB)***

##### Figure 4: Fuel Wise Net Electricity Generation (Jan 2017)

***Source: Bangladesh Economic Review, MoF***

Thus, we can see that furnace oil and diesel is accounting for a significant share of power generation in recent years, followed by power import and coal. Additionally, the government has taken various initiatives to enhance installation and power generation from the private sector and from regional power trade.

#### Table 5: Power Generation and Installed Capacity (2017)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Public | Private | Power Import | Total |
| Installed Capacity (Feb’17) | 6985 MW  (53%) | 5535 MW  (42%) | 659 MW  (5%) | 13179MW  (100%) |
| Power Generation (Jan’17) | 14817 MkWh  (45%) | 15475 MkWh  (47%) | 2634 MkWh  (8%) | 32926 MkWh  (100%) |
|  |  |  |  |  |

***Source: Bangladesh Economic Review, Mof***

At present, the private sector is producing more electricity than the public sector due to inefficiencies and poor productivity in the old public sector power plants. Power trade has also flourished significantly in order to meet the growing electricity consumption. However, there is a huge discrepancy between installed capacity and maximum generation, and the trend is deteriorating.

#### Table 6: Surplus Capacity (FY2010 – FY2016)

|  |  |  |  |
| --- | --- | --- | --- |
| Fiscal Year | Installed Capacity (derated) (MW) | Maximum Generation (MW) | Surplus Capacity (MW) |
| 2009-10 | 5823 | 4606 | 1217 |
| 2010-11 | 7268 | 4890 | 2378 |
| 2011-12 | 8716 | 6066 | 2650 |
| 2012-13 | 9151 | 6434 | 2717 |
| 2013-14 | 10416 | 7356 | 3060 |
| 2014-15 | 11534 | 7817 | 3717 |
| 2015-16 | 12365 | 9036 | 3329 |

***Source: Bangladesh Economic Review, Mof***

Although having sufficient generation capacity, actual demand of electricity could not be served to the consumers due to transmission and distribution bottlenecks. The shortage of gas supply and other fuel requirements is another main constraint for not being able to utilize full capacity of power generation. Nevertheless, the power sector reform programs have taken various measures like continuous performance monitoring of the utilities, reforms and target-oriented measures to reduce the system loss. The system loss in both transmission and distribution has come down to 13.10% in FY2015-16 from 15.73% in FY2009-10 mainly because of more private involvement during these years.

**Power subsidies:**

Since the international prices of crude and refined petroleum products were higher than their domestic selling prices, Bangladesh Petroleum Corporation (BPC) incurred losses until FY15, which used to be covered through government subsidies to pay for import of petroleum products. The amount of subsidies given to BPC by the government to recover from losses is shown below:

#### Table 7: Government Subsidies to Bangladesh Petroleum Corporation and Power Development Board, FY10—FY17

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fiscal Year | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | 2016-2017 ® |
| Subsidy to BPC (in billion Tk.) | 9 | 40 | 85.5 | 135.5 | 24.8 | 6 | 0 | 0 |
| Cash loan to PBD (in billion Tk.) | 9.9 | 40 | 63.6 | 44.9 | 61 | 89.8 | 27.9 | 55 |

***Source: Ministry of Finance***

However, the sharp reduction of petroleum prices in the international market helped to recover the losses in the recent years, leaving the subsidy figure in FY16 to zero. However, cash loans to PDB, which cover operating costs and essentially amount to subsidy, continued to remain high since FY11.

The fact that actual average generation is far less than the installed capacity, due to constraints in transmission and distribution systems along with inefficiencies resulting from inadequate gas supplies and other irregularities, poses a major problem for financial sustainability of PDB. Addressing the issue of such high unutilized capacity is a way to improve financial position of PDB and also to achieve un-interrupted power supply.

One of the foremost challenges the present government is facing with the power sector is that, despite some progress it is primarily dependent on natural-gas fired generation, which is in short supply. Thus, Bangladesh is confronting a simultaneous shortage of natural gas and electricity. The government decided to diversity the use of primary fuels to coal, nuclear and renewable energy sources. Planning and work on some major large power plants have already been initiated like the two coal-based 1200 MW each power plants with Japanese assistance at Materbari in Chittagong, the Bangladesh-India public sector joint venture 1200 MW coal-based power plant at Rampal near Mongla, and Ruppur nuclear power plant with 2,400 MW capacity with technical, financial, and other support from Russian Federation. Some rehabilitation of old PDB owned power plants are also being done largely by the government sector with financial support from bilateral official and multilateral sources. These developments notwithstanding, public sector alone will not be able to mobilize and implement the massive investment plan and private sector (foreign, domestic and joint venture), would need to finance more than half of the required investment in the power sector in the coming years.

The government has developed short, medium and long-term plans for the power sector. Under the **short-term plan**, Quick Rental Power Plants to produce electricity within 12-24 months have been installed using liquid fuels and natural gas as the primary fuel. In total, 1,653 MW of electricity is generated from quick rental power plants by this time. Some 300-450 MW gas based power plants have also been planned for setting up in Bibiana, Meghnaghat, Ashugonj, Sirajgonj and in Ghorashal. Under the **medium-term plan**, initiatives have been taken to set up larger power plants with a total generation capacity of 11,497 MW. The plants would primarily be gas and oil based. In the **long-term plan**, some large coal fired plants have already started construction, one in Rampal between Khulna and Mongla and two others at Matherbari in Chittagong, each having an installed generation capacity of 1200-1300 MW In the event, none of the large, medium and long-term plants could come into operation so far due to substantial delays in project design, financial closure, contracting out, and implementation problems. The government accordingly, continues to depend on small and medium-size quick rental power plants.

In the meantime, as the access to power is increasing rapidly and consumption of electricity per capita is accelerating, the demand for power is going to grow very fast. In recent years the demand for electricity has been rising rapidly in Bangladesh with growth in per capita income, increasing industrialization, and expansion of electricity use in agriculture and commercial sectors of the economy. Bangladesh witnessed a rise in electricity demand by 8-9% during 2010 to 2015, with implied elasticity of 1.2-1.5, which is not unusual for the state of development in Bangladesh.

***Performance under the Sixth/Seventh Five Year Plans***

A review of power sector performance under the Sixth and the ongoing Seventh Five Year Plans —based on the developments and considerations/issued noted above—can be summarized in the following manner:

* Government put the top most priority in the development of the power sector during the Sixth Plan and the ongoing Seventh Five Year Plan. The Power Division has been receiving the highest priority in ADP allocations through the annual budgets and the amount of resources allocated for the power sector has been increasing progressively. As a result, important successes were achieved in the power sector in terms of new installed power generation capacity and associated supply of power.
* The government has taken various investments initiatives to diversify the sources of primary fuels in the contexts of the Sixth and Seventh Plans. However, progress with diversifying and increasing the supply of cost effective primary fuel till now has been very limited.
* Power tariffs and subsidies have risen more than estimated, but the average power generation cost still significantly exceeds the average tariff rate, primarily due to high cost power purchases from new plants.
* Gas pre-paid meter is being introduced in some areas/households to conserve the rapidly depleting resources. Nevertheless, such efforts are inadequate and significant amounts of gas are being wasted in the household sector due to lack of proper metering of gas usages.
* In addition to conservation, Bangladesh urgently needs to focus on the exploration and development of its untapped potential natural gas resources.
* Improvements have been achieved in reducing the incidence of power outages. Access to electricity has risen, but demand-supply gap persists primarily due to transmission problems. Furthermore, quality of power, particularly in terms of uninterrupted supply continues to remain a major problem in industrial, business and rural areas.
* Although Bangladesh intends to increase its reliance on coal-based power generation, there is no national coal policy so far to enhance domestic coal mining along with addressing the environmental and social concerns related to coal mining. The required investments related to handling of coal import will be massive and are delaying the planned implementation of cost effective coal-based power plants.
* The main driving force for the power generation during the sixth plan was the Public Private Partnership (PPP) initiative in the form of guaranteed power purchase agreements. Bangladesh has so far gained significant power generation through IPP, SIPP, Rental, Quick Rental and Joint Venture policies under the PPP framework.
* The country attained impressive performance in terms of expansion of generation capacity. The growth in generation capacity alone, without the associated expansion of transmission and distribution networks, is contributing to under-utilization of generation capacity undermining the economic impact of power sector investment.
* System loss has reduced prominently, but there is scope for further improvement.

# Power Generation Targets to Support the Perspective Plan and Related Investment Plan

The main driver for growth in electricity demand in any economy is the underlying expansion of economic activity which is generally captured through the growth rate of GDP. The other major driver for growth in electricity demand is the elasticity of electricity demand with respect to real GDP growth or per capita real GNI. Because the PP aims to transform Bangladesh into a high income by FY41, the real GDP growth is projected under the PP is far higher than the GDP rates projected in the PSMP 2010 and PSMP 2016, which were probably not done in consultation with the Planning Commission and did not even reflect the growth objectives stated in the Seventh Plan.

While the PP projects Bangladesh’s real GDP growth rate to accelerate to 9.9 percent in the outer years of the Plan period, in order to reach High Income country status by FY41, the PSMP 2010 projected the average real GDP to be 7 percent throughout the projection period. It is surprising to observe that PSMP 2016 projected even lower GDP growth rate than PSMP 2010. In fact, the projected GDP growth rates in PSMP 2016 in the outer years are less than half that of PP GDP growth projection. Since real GDP growth rate is one of the major drivers of power demand in any economy, a much higher projection of real GDP growth under the PP certainly contributed to much higher power demand forecast under the PP scenario (see Box 1).

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| Box 1: Perspective Plan Projection vs. PSMP Projections/Assumptions The Power System Master Plans (2010 and 2016) and Perspective Plan (PP) of Bangladesh (2021-2041) have different projections on future power demand in Bangladesh. While all three projections are long-term covering broadly overlapping/similar timelines, the differences in forecasted power demand is rather sizable. In fact, the power demand forecasted for FY41 in the PSMP 2016 for FY41 is almost half of what is forecasted in the PP for the same fiscal year. This huge difference in power demand forecast is mostly attributed to the PP’s objective to achieve an upper middle-income (UMI) status by FY31 and high income country (HIC) status by FY41.   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Box Table 1. Perspective Plan Projection vs. PSMP Projection | | | | | | | | | | Fiscal Year | **Projection for Perspective plan** | | |  | **PSMP2010** | | **PSMP16** | | | **Real GDP growth** | **Forecasted Demand (MW)** | **Elasticity** | **Real GDP growth** | **Forecasted Demand (MW)** | **Elasticity** | **Real GDP growth** | **Forecasted Demand (MW)** | | FY16 | 7.1 | 9229 | 1.5 | 7 | 11405 | 1.5 | 6.30 | 8921 | | FY20 | 8 | 14054 | 1.4 | 7 | 17304 | 1.4 | 7.40 | 12949 | | FY21 | 8.1 | 15591 | 1.35 | 7 | 18838 | 1.35 |  |  | | FY25 | 8.5 | 23012 | 1.15 | 7 | 25199 | 1.15 | 7.40 | 19191 | | FY26 | 8.6 | 25189 | 1.10 | 7 | 26838 | 1.10 |  |  | | FY30 | 8.9 | 35371 | 1 | 7 | 33708 | 1.00 | 6.30 | 27434 | | FY31 | 9 | 38554 | 1 |  |  |  |  |  | | FY35 | 9.4 | 54924 | 1 |  |  |  | 5.30 | 36634 | | FY36 | 9.5 | 59881 | 0.95 |  |  |  |  |  | | FY40 | 9.8 | 85047 | 0.95 |  |  |  | 4.40 | 49034 | | FY41 | 9.9 | 92625 | 0.9 |  |  |  |  |  | | *Source: PRI Staff Projection, PSMP 2010 and PSMP 2016* | | | | | | | | |   The rationale behind this higher power demand forecast under the PP scenario is that Bangladesh would need rapid and sustained expansion of power generation, transmission and distribution to support the rapid growth in Industrial/Manufacturing, Service, and agriculture sector in line with the objective to reach the goal of becoming a High-Income country. The elasticity of electricity consumption with respect to real GDP/GNI is another major factor in power demand projection. The income elasticity of electricity demand is important, especially in the case of a rapidly developing country like Bangladesh. Cross country estimates indicate that the elasticity is very high for least developed counties like Bangladesh, and it is below unity for the industrialized countries. Current income elasticity for Bangladesh is 1.5, which has been used in the PP projection. In the earlier years the elasticity was even higher at close to 1.9. As the economy develops and per capita income of the households increase steadily, the elasticity is expected to fall over the long term. Accordingly, as Bangladesh becomes and UMY and HIC, the elasticity is projected to decline to 1.0 by FY31 and thereafter further decline to 0.9 by FY41. PSMP 2010 also had similar elasticity assumption over the projection period through 2031.  As seen in the Table below, the annual average electricity demand growth rate is assumed to be only 4.8% under the PSMP 2016. Such a low growth rate in generation capacity would not at all be compatible with the PP GDP average growth rate of more than 8%.  **Box Table 2. Projection of Primary Energy Supply Under PSMP 2016**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Primary Energy Sources** | **2014** | | **2041** | | **Annual growth rate (‘14-’41)** | | **ktoe** | **(share)** | **ktoe** | **(share)** | | Natural gas | 20,728 | (57%) | **49,783** | **(38%)** | **3.3% p.a.** | | Oil (Crude oil ＋ refined products） | 6,060 | (17%) | **32,162** | **(25%)** | **6.4% p.a.** | | Coal | 1,038 | (3%) | **25,401** | **(20%)** | **12.6% p.a.** | | Nuclear power | - | - | **12,029** | **(9%)** | **-** | | Hydro, solar, wind power and others | 36 | (0%) | **199** | **(0%)** | **6.6% p.a.** | | Biofuel and waste | 8,449 | (23%) | **4,089** | **(3%)** | **-2.7% p.a.** | | Power (Export) | 377 | (1%) | **6,027** | **(5%)** | **10.8% p.a.** | | Total | **35,880** | **(100%)** | **131,151** | **(100%)** | **4.8% p.a.** |   In the end, it comes down the differences in Goals and Visions of these plans that are reflected in the components of the forecasting model which contributed to a stark difference in power demand projections under the PP and the two Power Sector Master Plans. In order to fulfill objective of the Bangladesh government as envisaged in the PP, the growth projection of PSMPs must be revised upwards significantly. Certainly, Bangladesh is not aiming to limit its GDP target to 4%-5% over the long run and become an upper middle income and a high-income country over time as targeted under the PP. To meet the much higher power demand as projected in PP much more investment will be needed in the power sector and the associated investment plan would need to be revised upwards by the Ministry of Power. |

The income elasticity of power demand ranges from 0.7 for industrial countries to more than 1.5 for least developed countries like Bangladesh and Nepal. The income elasticity is higher in the case of a rapidly growing low-income country where one can expect to see large increases in income of households in the next decades and a corresponding increase in demand for electricity by the households, industries and businesses. Since this elasticity is below unity for industrial countries, income growth apparently results in a less than proportional increase in electricity demand in developed countries. Thus, Japan has a relatively high income and we can observe it has elasticity less than 1, which is 0.7.

#### Table 8: Elasticity between Per capita GNI and Electricity Consumption in Different Countries, Averages for 1991-2010

|  |  |  |  |
| --- | --- | --- | --- |
| **Countries** | **GNI Per capita (1991-2010 AVG) US Dollars** | **Electricity Consumption per capita (1991-2010 AVG)** | **Elasticity between Per capita GNI and Electricity Consumption (1991-2010**) |
| **Developed** |  |  |  |
| Japan | 37292.29 | 7847.80 | 0.74 |
| Australia | 29857.79 | 9968.97 | 0.6 |
| **Upper Middle Income** |  |  |  |
| China | 1443.24 | 1452 | 1.05 |
| **Lower Middle Income** |  |  |  |
| India | 647.62 | 436.22 | 0.77 |
| Pakistan | 788.41 | 449.25 | 1.09 |
| **Lower Income** |  |  |  |
| Bangladesh | 401.48 | 131.55 | 1.91 |
| Nepal | 336.74 | 66.72 | 1.5 |

However, in developing countries like Bangladesh and Nepal the elasticities for the period 1991-2010 were 1.91 and 1.5, respectively, which were much greater than 1. This shows that Bangladesh’s income elasticity for power is very high. Since electricity is a normal good (service), higher disposable income is expected to increase the consumption through greater activity and purchases of electricity-using appliances in both the short and long run.

In a typical developing economy, a one percent increase in GNI/GDP leads to 1.1-1.5 percentage point increase in electricity demand. This implies that even at the current average real growth rate of 7% percent, supply of electricity needs to grow at more than 8%-10% percent per annum. In the event Bangladesh achieves the targeted growth rates of 8% or more over the medium term, as envisaged in the government’s Seventh Five Year Plan (covering FY16-20), it would require about !0%-12% rate of growth in supply of electricity per year over the Seventh Plan period.

Since Bangladesh plans to become a high-income country by 2041, with the projected real GDP growth of 9.9% in FY2041, we have estimated the peak-power demand using the GDP-elasticity method for the following years.

#### Table 9: Projection for Electricity Demand in Bangladesh Under the PP, Fy16-41

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fiscal Year | FY16 | FY20 | FY21 | FY25 | FY26 | FY30 | FY31 | FY35 | FY36 | FY40 | FY41 |
| Real GDP growth (%) | 7.1 | 8 | 8.1 | 8.5 | 8.6 | 8.9 | 9 | 9.4 | 9.5 | 9.8 | 9.9 |
| GDP elasticity of power demand | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.3 | 1.3 | 1 | 1 | 1 |
| Change in Demand (%) | 10.65 | 12 | 12.15 | 12.75 | 12.9 | 13.35 | 11.7 | 12.22 | 9.5 | 9.8 | 9.9 |
| Forecasted Demand (MW) | 8921 | 13682.9 | 15393.3 | 24711.9 | 27899.7 | 45691.2 | 51037.0 | 80379.2 | 88015.3 | 127230.7 | 139826.5 |

***Source: PRI staff estimation***

The peak power demand according to PSMP 2016 was used as the baseline for forecasting the power demand. The baseline was derived by adding the base and intermediate load in summer and peak load in winter. The peak power demand in 2016 is thus estimated at 8,921 MW and the subsequent years’ demand is forecasted accordingly. As the country gradually shifts from low middle income to high middle-income country by FY31 and to a high-income country by FY41, the income-elasticity for power demand steadily falls from 1.5 to 1.0 by FY31 and thereafter to 0.9 by FY41, as shown above. On the basis of these assumptions, the projected peak power demand exceeds 92,000 MW with the GDP growth rate reaching a peak of 9.9% in FY41.

***Investment Requirements***

In order to meet such a high peak power demand, Bangladesh would need to invest massively in power generation and transmission in the coming years. If the power generation cost at current (2017) prices comes to about 100MW= US$100 million on average, by FY41 total investment in power generation would amount to about US$92 billion. After including the initial high cost of the Ruppur Power Plants, the estimated generation cost could exceed US$100 billion, We have to add additional investments associated with distribution and transmission to this US$100 billion plus amount. Thus, Bangladesh will have to invest about US$120 billion in the power sector, and public investment alone would not be sufficient to meet the required investment target. Bangladesh will need private investors and FDI to meet this massive investment challenge.

# Key Challenges in Ensuring Primary Fuel Supply to Achieve the Perspective Plan and PSMP 2016 Objectives

In order to implement the power sector road map over the medium and long term, the government should address a number of important challenges related to:

1. *Ensuring primary fuel supply to achieve the targeted electricity generation mix envisaged under the PSMP 2016 (see Box Table 2);*
2. *logistical issues relating to transportation of fuel and equipment and storage of fuel;*
3. *coping with and taking advantage of technological changes including the scope for rapid expansion in renewable energy and conservation of energy;*
4. *regulatory regimes to promote generation and distribution of power by private sector players and to promote regional trade in electricity at a broader scale;*
5. *financing of such a large investment plan for the electricity generation and the related new transmission and distribution system along with up gradation of the old network;*
6. *human resource development for the related activities.*

The remainder of this section primarily focuses on challenges in primary fuel supply in terms of composition of primary fuel and logistical challenges in handling new primary sources of power like import based coal, LNG, and nuclear power. Other related important issues like renewable power, trade in electricity, and financing of the power generation and transmission projects have been covered in the subsequent sections.

1. ***Enhancement of Gas Exploration and Production***

Bangladesh’s recent experience with discovery of new gas fields has been disappointing. No major new gas field has been discovered in recent decades and the rate at which the gas is extracted, the current stock of proven and recoverable natural gas would last for only about 10-13 years. The rapid loss of pressure in the offshore Shanghu field in the Bay of Bengal along with the absence of new gas field discoveries is forcing Bangladesh to face a major natural gas supply shock in the coming years from domestic sources.

Owing to the absence of new major discoveries and very extensive use, a burning issue for Bangladesh now is the growing shortage of natural gas. Petrobangla estimated in 2010 that the widening gap between demand and supply would be 7 to 9 TCF by FY2029 (Figure 5). Most recent data suggest that the current reserve will likely be depleted in less than 10 years. Out of the 27.1 TCF recoverable reserves, Bangladesh already used 12.3 TCF of natural gas by 2014. As a result,

##### Figure 5: Gas Demand and Supply Balance 2010-29

0

2000

4000

6000

8000

10000

12000

**MMCFD**

**FY**

Demand

Supply

***Source: Petrobangla***

some 14.8 TCF reserve remains for future consumption. If Bangladesh’s gas demand continues to grow at the current pace of 7% per annum, the current reserve will be completely depleted by FY2023 (Table 10), unless gas supply capacity is substantially added through new gas field exploration/development and gas imports.

#### Table 10: Reserve to Production (Supply) Projection from 2014

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** |
| Production (TCF) | 1.1 | 1.2 | 1.3 | 1.3 | 1.4 | 1.5 | 1.7 | 1.8 | 1.9 | 2.0 |
| Growth Rate | 7% | 7% | 7% | 7% | 7% | 7% | 7% | 7% | 7% | 7% |
| Cumulative Production (TCF) |  | 2.3 | 3.5 | 4.9 | 6.3 | 7.9 | 9.5 | 11.3 | 13.2 | 15.2 |

***Source: Ministry of Power, Energy and Mineral Resources and Petrobangla.***

As against this difficult current situation, the potential outlook is not necessarily bad. Bangladesh has abundant untapped gas resource. Despite its low R/P ratio, Bangladesh is very likely to have sizable unexplored/undiscovered gas resource. Although the survey was conducted more than 10 years ago, available data indicates that Bangladesh has at least 8.4 TCF of gas resources. If 50 percent of the 8.4 TCF becomes available for power generation (based on the current gas consumption pattern where Power Sector contributes a half of the total gas sales), it will support around 2,500MW highly efficient combined cycle power plants over their 30-years lifetime. It should be noted that the Petrobangla-USGS Survey indicates that the majority of unexplored/undiscovered resources are in on-shore, rather than highly costly and risky off-shore (see Table 11). This is a welcome prospect as this will allow Petrobangla to undertake most of the exploration on its own at relatively lower cost.

#### Table 11: Potential/Unexploited Gas Resource

| **Survey/Probability** | **95% POE** | **50% POE** | **10% POE** |
| --- | --- | --- | --- |
| Petrobangla and United States Geological Survey (USGS) 2001 Survey | 8.4 TCF   * On-shore: 6 TCF * Off-shore 2.4 TCF | 32.1 TCF   * On-shore:23.3 TCF * Off-shore: 8.8 TCF | - |
| Bangladesh’s Hydro Carbon Unit (HCU) and Norwegian Petroleum Directorate (NPD) 2003 Survey | 19 TCF | 42 TCF | 64 TCF |

***Source: Petrobangla***

POE stands for Probability of Exceedance. If POE is 95%, it means there is 95% or higher chance of exceeding this level.

In the past domestic exploration of gas field was constrained by lack of funding. To support BAPEX for undertaking seismic survey and exploration works, in 2009 the Government took the initiative to establish the Gas Development Fund (GDF), under which 15 percent of the gas tariff is to be utilized for upstream exploration and development activities. With this fund the BAPEX has resumed survey and exploration efforts and efforts have also focused on strengthening the technical capabilities of BAPEX.

1. ***Increased Reliance on Coal as Envisaged in the PSMP 2010 and PSMP 2016***

**Domestic Coal Development:** Despite various rounds of deliberations the government has not yet adopted the national Policy for Domestic Coal Development. Bangladesh has large quantities of high quality proven coal reserves; however, without a coal policy, initiatives could not be taken to utilize the domestically available coal for electricity generation purpose. Since the Master plan envisages that 25%-30% of electricity generation in Bangladesh will come from domestic coal supply in the long run, this issue needs to be addressed urgently to complement the PSMP 2016.

Because it will take about 10 years to develop a new coal mine and start production, coal production will begin in 2027 at the earliest even if it is decided now. Therefore, it is necessary to carry out the required preparation from a position of being able to do this now due to as much utilization of the excellent domestic resources as possible. Unfortunately, the production of Barapukuria coal mines in 2015 was 0.68 million tons and did not reach 1 million tons as planned. Nevertheless, the PSMP 2016 assumes that total domestic coal production will be 1.1 million tons by 2020, 5.7 million tons by 2030 and 11.2 million tons by 2041, considering the production scenario in which Dighipara and Kalaspir coalfields have high development possibility, including the Phulbari coalfield. The acquisition of coal mine technology by Bangladesh has also been highlighted in the PSMP 2016 through which Bangladesh can learn/acquire technologies related to mining, ventilation and mine safety for stable production in the Barapukuria coal mine. By acquiring such technology, Bangladesh will be able to develop new coal mines over time.

Coal Import (long term contract) and deep-sea port for coal handling: Because there is no visible movement on domestic coal development, the government has decided to move first on coal-based power generation through imported coal. Coal importation will however entail major investment challenges in the form of developing one or more deep sea ports (including the one in Materbari); long-term contracts with foreign coal mining companies/operators for supply of coal from abroad; and internal shipment of coal to power plants like Rampal. Large investments will be required on several fronts like development of deep sea ports, large ocean-going vessels to carry coal, and domestic transportation facilities. Progress on all these fronts are quite slow due to various reasons and there is currently no clear indication when Bangladesh will be ready to import coal after completion of necessary infrastructure.

The feasibility study for the CTT (Coal Transshipment Terminal) planned in the Matarbari area has already been completed *(Source: Preparatory Survey for the Construction and Operation of Imported Coal Transshipment Terminal Project in Matarbari Area in People's Republic of Bangladesh as a PPP infrastructure project).* In this plan, phased development for CTT was recommended to provide sufficient flexibility, i.e., to expand the CTT when the power generation program development and realistic commission operation date (COD) become certain. The first phase of the CTT will commence operation in 2025 (planned amount of coal: 10.4 million t/year); the objective of the second phase will include those power stations that commence operation by 2029 (amount of coal: 25.6 million t/year) and use the CTT.

**Cost efficiency of coal based plants**: The analysis presented in PSMP 2016—based on five alternative scenarios--shows that as the use of coal spreads in stages, the fuel expense will be slashed, helping curb increases in power generation costs. Thus, the power generation cost is estimated at 9 to 12 US cents/kWh for 2040, depending on the proportion of coal in the primary energy mix. In addition, a comparison of the power generation cost between the five scenarios for energy source ratio (P1 to P5) shows that the power generation cost becomes higher as the ratio of coal to all other energy sources becomes smaller *(Source: JICA Survey Team)*

1. ***LNG Import to meet the Growing Shortfall in Domestic Natural Gas***

Despite the reduction in the excessive dependence on natural gas in recent years and the envisaged further reduction on gas dependence over the long term, gas-based power generation will continue to remain the largest source of primary fuel. In view of the projected outlook for domestic gas output and the growing demand for gas in the domestic economy, LNG import is being considered as a new major source of primary energy in the coming years.

Two large floating storage and re-gasification units (FSRUs) each with capacity of 500 MMCF are currently under construction. The first LNG terminal with capacity of 3.75 million tons per year FSRU is being developed by US-based EXelerate Energy and it is expected to come into operation in April 2018. The second large FSRU, with similar capacity is being developed by Summit Group and expected to be commissioned by October 2018. Both FSRUs will be in Moheshkhali Island in the Bay of Bengal. Separately, Petrobangla is close to finalizing deals on three smaller FSRUs with capacity of 200 MMCF each. The selected firms will be responsible for building the FSRUs, import LNG, re-gasify the LNG, and supply the re-gasified LNG into gas transmission pipelines owned by the state-run Gas Transmission Company Ltd. (GTCL) at their own costs. Petrobangla will only purchase the re-gasified LNG from the contractors under long-term gas purchase agreements.

#### Table 12: LNG Import Projects Under Implementation and Consderation

|  |  |  |
| --- | --- | --- |
| Developer Companies | Types of Infrastructure | Anticipated Time of Construction |
| Excellerate Energy Bangladesh Limited (EEBL) | 500 MMCFD, FSRU | March 2018 |
| Summit Corporation Ltd. (SCL) | 500 MMCFD, FSRU | July 2018 |
| Reliance Power Ltd. (RPL) India | 500 MMCFD, FSRU | 2019 |
| China Huanqiu Contracting & Engineering Corp (HQC) | 1000 MMCFD | 2020 |
| In JV with China CAMC Engineering Company Ltd. | Land Based Terminal |  |
| Hong Kong Shanghai Manjala Power Ltd. (HSMP) | 500 MMCFD, FSRU | 2019 |
| JV with Global LNG Sdn Bhd, Malaysia |  |  |
| Petronet LNG Limited (PPL), India | 1000 MMCFD, Land Based | 2020 |

***Source: GTCL Presentation to Sector Leaders***

On the expectation that LNG will be available from April 2018, the government is also planning to replace oil-fired rental power stations with LNG from 2018 onwards. Given Bangladesh’s growing shortage of natural gas supply in the coming years, the demand for imported LNG is likely to increase rapidly and a number of other initiatives are also under active consideration for LNG import in the coming years. Accordingly, Petrobangla also plans to set up at least two onshore LNG terminals, each with capacity of 7.5 million tons per year by 2015. Bangladesh has already signed an agreement with Qatar’s RasGas to import 2.5 million tons of lean LNG annually for 15 years.

It is difficult to project the distribution of long term supply or gas between domestic and imported (primarily LNG based), given the uncertainty about new discoveries within Bangladesh territories (on shore and off shore). Nevertheless, given the demand outlook for gas and the PSMP 2016 projection that about 38% of domestic power generation would continue to depend on gas even in FY41, investment in LNG terminals and re-gasification plants, and large LNG container ships would be prerequisites for meeting the future primary fuel needs of Bangladesh.

1. ***Oil Import for Power Generation***

Bangladesh began expanding its oil-based power generation capacity in 2010, amid a natural gas deficit caused by depleting upstream reserves and rapid industrialization, bringing almost 40 new oil-fired power plants online by the end of 2016, with an initial tenure of three to five years. As a result, Bangladesh began to import oil for power generation from various Asian and Middle Eastern countries since 2010.

The reduction of oil imports for power generation will be gradual and it is still unclear how much will be displaced as a result of the retirement of the oil-fired power plants. However, over the medium term we should expect further increase in import of fuel oil because several new oil based power plants have been sanctioned recently and more approvals may be on the way (many of which are unsolicited). This development is disturbing because earlier it was expected that no new liquid fuel based power plants would be installed and the existing ones will be phased out over time. This development, which will continue to put pressure on electricity tariff, was perhaps due to long delays experienced in commissioning the coal based power plants and delays in putting in place the infrastructure needed for LNG import.

1. ***Safe Nuclear Technology***

Nuclear power is envisaged to take a bigger role in the power supply mix. The government has put the Nuclear Power Project at Ruppur under its fast track project list for speedy progress on this front. Agreements have been signed with Russian Federation for installing 2400 MW nuclear power project in Bangladesh. The government has already held preliminary discussions with the international nuclear oversight organization on matters related to safety and safe disposal of nuclear waste. Since FY15 budget allocations are also being made for initiating the project (see Section VI.2 for further on nuclear power generation).

1. ***Energy Conservation & Energy Efficiency Program***

The Government also accorded priority to the promotion of Energy Efficiency (EE) and Energy Conservation (EC) programs during the Sixth Plan. The “Energy Efficiency and Conservation Map” and “Energy Efficiency Action Plan” have been prepared, and preparation of “Energy Efficiency and Conservation Master Plan” with support from JICA is under process. Time-bound targets for energy savings have been set and program implementation is well underway. The energy saving targets through the Energy Efficiency Action Plan and specific programs that are being implemented is shown in Box 2. Successful implementation of these initiatives should help conserve resources and will be a positive step in implementing a sound energy strategy in Bangladesh.

###### Box 2: Energy Conservation Initiatives during the Sixth Plan

1. **Energy conservation targets**

* 10% of primary and secondary energy saving by 2015
* 15% by the 2021 and
* 20% by 2030

1. **Ongoing energy efficiency and savings programs**

* Closure of the shopping mall & market after 8 pm
* Holiday staggering program in commercial areas and markets.
* Operation of irrigation pumps from 11 pm to 5 am
* Maintaining the temperature of ACs not below 250 C
* Conversion of Simple Cycle power plant to Combined Cycle Power Plant
* Replacement of inefficient incandescent bulb with energy efficient CFL/ LED bulb.
* Use of CFL/LED in Government & semi-government offices.
* Conventional street lights will be replaced by LED and solar subsequently
* Replacement of single cycle plants by CCGT for base load operation
* Renovation of inefficient and old power plants for capacity & efficiency improvement
* Performance improvement of inefficient power plants
* Introduction of quality pre-paid and smart metering all over the country
* Use of Improved Rice Parboiling System in the rice mills
* Use of Improved Cooking Stoves in the rural areas and Improve gas stoves in the urban areas
* Use of energy saving Intelligent Motor Controller (IMC)
* Reduction of technical and non-technical system loss
* Incorporation of Energy Conservation issues in the academic curriculum of School/Madrasas/Colleges
* Include Energy Conservation and Energy Efficiency issues in the National Building Code

1. **Implementation of energy standard & energy star labeling program through BSTI**

* Refrigerator
* Ceiling Fan
* Electric motors
* CFL
* Electric Ballast
* AC

The Gas Use Efficiency is one of the critical issues that needs to be introduced. “Cheap gas” will not be available in the future and gas users need to enhance their efficiency to save the country’s indigenous gas resources. Both the Urea Manufacturing Sector and Power Sector are major gas users and have a significant impact on the overall gas consumption. Urea is manufactured from natural gas. The world benchmark efficiency for Urea Manufacturing is 25mcf/ton, while average efficiency in Bangladesh was 44 mcf/ton as of FY14, much higher than that of the international benchmark. Provided that the international benchmark is used in the country, 130 mmscfd of gas would be saved in manufacturing 2,375,000 tons of urea in 2014 and this figure would translate into the power plant equivalent of 1000 MW.

Gas Consumption for the Power Sector (under BPDB) was 337.4 BCF in FY 2014 while Power Generation Capacity was 8,340 MW and Generated Power was 42,200 GWh. From these figures, it is assumed that current power generation efficiency is around 38%. Provided that efficiency can be raised to 45%, which is considered the international benchmark for a gas based power plant, gas consumption in the power sector will be reduced to 285 BCF, and the difference of 52 BCF can be said to be wasted. This is equivalent to 1,300 MW in power plant annual operation.

In addition, it appears that power generation efficiency of Captive Power is not necessarily high enough. Further investigation is necessary but low gas efficiency is waste of resources and some penalty should be imposed. It is necessary to enhance the efficiency to the international level and a supporting legal framework and regulations need to be put in place to provide basic lighting and other services in areas where the grid is unlikely to reach for a long time.

1. ***Logistical issues relating to transportation of fuel and equipment and storage of fuel***

**Transportation of Fuel and Equipment:** For easy handling of coal and other primary fuel massive infrastructure investment will be needed in the following areas:

* Development of deep sea ports for handling of imported coal. The government has undertaken plans for building two deep sea ports at Materbari and Payra Bandar for handing the massive volumes of coal that would need to be imported to operate the planned and future coal-based power plants.
* Infrastructure Development by Railway and Roads & Highways to handle the distribution of primary fuel across Bangladesh. Completion of the Padma Bridge in 2019 will be a major step in this area, which will then be followed by establishing railway lines to south-western districts of Bangladesh including Payera Bandar.
* Dredging of River Routes by BIWTA will be important for carrying primary fuels in large vessels to coal based power plants (like Rampal), liquid based power plants across Bangladesh, and other processing/distribution facilities for fuel and LPG across Bangladesh.
* Handling capacity building of BPC, Railways, R&H and BIWTA. Massive investment will be needed in all these areas. Major R&H and Railway projects are currently under consideration or under implementation in all these areas.

**Infrastructure and logistics for handling coal and LNG**

* As discussed earlier, exploration of coal and LNG requires huge investments as well as the use of expensive imported machineries and maintenance equipment. Furthermore, getting licenses for the extraction of such domestically available resources such as coal, oil, gas etc. and ensuring safety mechanism for the flammable liquids from offshore drilling needs infrastructure and logistics development.
* Handling this massive volume of coal import will require huge port, rail transport and coal stocking infrastructure. However, so far there is only one on-going deep-sea port project in Matarbari island which will be able to cater ships having 80,000 tonnes capacity.

1. ***Human Resources Development***

Development of skilled manpower for adopting and operating new technologies will be important for operating and maintaining the new generation mega projects based on coal and nuclear technology. Bangladesh has an acute shortage of skilled manpower for these new types of mega power plants, and operations and maintenance of high voltage transmission lines which will be critically important for carrying out these massive investments, and operations and maintenance of these projects.

In the nuclear technology area, Bangladesh has no prior experience in running and maintaining even small (50-100 MW capacity) and medium-sized (200-600 MW) power plants. But the government is going to build mega-sized nuclear power units with 1200 MW capacity each. The leapfrogging of this scale is unprecedented and will require massive investment in developing a huge pool of experts in different aspects of nuclear power technology. Countries like India, has now developed the capability to maintain large size nuclear power generation units after experimenting with small, medium and larger size plants over the last 70 years. Achieving that kind of level with adequate number of national experts will certainly be a challenge. Bangladesh Government has already sent a large contingent of students to Russia for training/learning in nuclear energy technology, which is just the beginning.

The power sector is already suffering from an acute shortage of skilled manpower for the oil and gas-based small to medium sized power plants. As the large coal-based power plants start being built, the authorities should focus on how to train hundreds of power generation and distribution engineers for employment in these plants and projects.

# Trade in Electricity—Opportunities and Challenges

**Background:** Bangladesh is exploring alternative solutions to power generation such as increased electricity imports from the neighboring countries and LNG trade. Initiatives are underway to enhance cross border trade of electricity through bilateral/regional cooperation initiatives with Nepal, Bhutan and Myanmar and India. Trade in power between Canada and the USA is a very good example of trade in electricity between two neighbors. Trade in electricity is also widely practiced in Europe among the European Union economies and beyond. Investment and trade model is also being practiced between Bhutan and India, under which Indian Government and private sector invest in hydro power projects in Bhutan and import the power to India under long-term power purchase contracts.

Electricity trade was already considered to be an element of the PSMP 2010 and Bangladesh is already receiving about 450MW-500MW of power from India under a Government-to-Government deal. As part of the Plan, Bangladesh also expects to receive another 500MW of power from India under private sector to private sector or private sector to Government deals. The interconnector between Baharampur of West Bengal (India) to Bheramara of Bangladesh has already been constructed with ADB financing.

##### Figure 6: Regional Power Exchange Possibilities



Beyond the 1000MW power trade agreement, there is also the possibility of getting an additional 250MW power from the Indian state of Tripura once the interconnector between Pallatana in Tripura to Comilla in Bangladesh is constructed. The process is currently underway to construct the interconnector between Pallatana and Comilla. A number of other possible interconnectors for increased power import from India and other neighbors like Bhutan are currently under consideration with support from the Indian Government. Some of these other possibilities include Silchar to Fenchuganj for 750MW, Aliduarpur to Bogra 1000MW and Purania to Barapukuria 1000MW. In addition, Bangladesh Government was also discussing with the Government of Myanmar to import 500MW of hydro power from a hydro power project in the Rakhyn state of Myanmar to Chittagong in Bangladesh.

**Medium-term initiatives and outlook:** All these possibilities mentioned above could only be the beginning of a much broader regional power trade initiative. Beyond the possible initiatives mentioned above, which alone could potentially add 3,000MW of electricity to Bangladesh national grid, there could be other major regional initiatives encompassing Bhutan, Nepal and North-Eastern India which have very large hydro power potentials. Both Nepal and Bhutan are interested to receive long-term investment in their hydropower projects and export their surplus hydropower to Bangladesh. The Government has already actively engaged in economic diplomacy with India for joint venture investments in large hydropower projects in Nepal, Bhutan and North- Eastern India. Although new hydropower projects would take more than one decade to materialize, the lifelong low cost supplies would ensure cheaper and environmentally friendly power for Bangladesh for decades to come. Electricity trade was not appropriately emphasized in PSMP 2010 but has received more attention in PSMP 2016, where it is envisaged that by FY41 at least 5% of domestic power demand will be met through import of power from regional countries.

BIMSTEC Secretariat has finalized a draft deal to set up power grid connections for electricity trade among its seven member countries -- Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka and Thailand. Bangladesh is also currently negotiating to import at least 3,500 MW more electricity through bilateral, regional and sub-regional joint venture initiatives from India, Myanmar, Nepal and Bhutan by 2030.The BIMSTEC deal is almost similar to SAARC Framework Agreement for Energy Cooperation signed in Kathmandu on November 27, 2014 to set up a South Asian regional grid for cross-border trade of electricity. This covered trans-border power exchange and grid interconnection, hydropower development and energy security of the region. The deal will pave the way for all member countries to buy and sell energy as per their necessity through private or public companies. It will ease power generation, distribution and trading between the BIMSTEC states. The relevant BIMSTEC bodies are responsible for identifying regional and sub-regional projects in the area of power generation, transmission and power trade, including hydropower, natural gas, solar, wind and bio-fuel, and implementing them with top priority to meet the increasing demand for power in the region. The seven member states have the potential of generating around 260,000 MW of hydropower, including 150,000MW by India, 40,000MW by Myanmar, at least 30,000MW by Bhutan and Nepal each, 500MW by Bangladesh and Thailand each and 1,000MW by Sri Lanka.

**Trans-national power grid and pricing issues:** It has become increasingly difficult for Bangladesh to develop its existing domestic thermal coal mining capacity. This reflects social opposition to the compulsory land acquisition requirements as well as resistance to the inevitable water, particulate and air pollution along with all the associated negative health effects. With rising surplus power capacity in northeast India, an opportunity came up for Bangladesh to relatively quickly increase the importation of cost-competitive coal-fired electricity.

In 2014/15 the cost of imported electricity from India was Tk5.62/kWh, 10% below the Tk6.28/kWh average across the Bangladesh system. India-Bangladesh currently have 600 MW of grid connectivity. According to BPDB, 2634 mkwh of electricity was imported until January 2017. BPDB is working with India to double the capacity of the 500 MW Baharampur-Bheramara lines (commissioned in September 2013) to 1,000 MW by June 2018 at an estimated project cost of US$180 million.

A second expansion plan involves doubling the new 100 MW Tripura-Comilla line capacity (commissioned in March 2016 at a cost of US$26 million by Korean contractor GS Engineering and Construction) to 200 MW. A second Tripura-Comilla upgrade to 500MW is in BPDB’s forecasts for 2021. Since 2010, Adani Power Ltd of India has been working on a 1,600 MW coal-fired power plant in Jharkhand with Terms of Reference being finally agreed in August 2016 that paves the way for approval for potentially 100% of this output to be transmitted to Bangladesh by a dedicated power transmission line. Such a buildup of international grid connectivity could be highly beneficial, as it would also facilitate export of India’s growing solar-generation capacity as well as providing greater grid flexibility and stability. Greater interconnectivity of electricity grids is likely to be key to the growth of renewables across the sub-region comprising North-Eastern India, Bangladesh, Bhutan, Myanmar and Nepal.

However, challenges Bangladesh faces in trans-national grids appears more in the form technological aspects rather than environmental aspects. These imported powers from India though are assisting to meet the immediate power demand, they also come at a higher cost. GoB has agreed to import electricity from Adani Group at a price Tk. 6.89 (8.61 US cents) per kWh from its 1600 MW mega plant that will be setup in Jharkhand, India. According to Power Division, as per the rate fixed for Adani, the country will have to pay an additional cost of nearly Tk. 300cr to the Indian company over the next 25 years as compared to other coal-based power plants. Total cost of this import is far higher than the price of electricity from the local private coal based plants. The main challenge here lies in importing the power at a competitive rate.

# Other Long-Term Challenges and Opportunities in the Power Sector

This Section intends to illustrate the long-term environmental and technological challenges and opportunities that the Bangladesh will face in the areas of Renewable Power Generation, Nuclear Technology, Power Transmission, and Rural Electrification.

1. **Renewable Power Generation**

**Background:** The Government has given priority to the implementation of renewable energy, energy efficiency as well as energy conservation programs during the Sixth Plan. The Renewable Energy policy was approved in 2008. Through this policy, the Government is committed to facilitate both public and private sector investment in renewable energy projects to substitute indigenous non- renewable energy supplies and scale up contributions of existing renewable energy based electricity productions. The Policy envisioned 5% of total generation from renewable sources by 2015 and 10 percent of the same by 2020.

Dedicated funding support has also been extended through government financial institutions like Bangladesh Bank and IDCOL as well as through private commercial banks. Moreover, Government has extended fiscal incentives including duty exemption on certain renewable energy products, e.g. solar panel, solar panel manufacturing accessories, LED light, solar operated light and wind power plant. These facilitated a significant success in the area of solar energy that has delivered 150 MW equivalent of power primarily through a highly successful Solar Home Lighting System (SHS) program. Some 4 million SHS units have been delivered by 2016 primarily to households outside the national power grid. However, various environmental and technological challenges are associated with solar power generation and expansion in Bnagladesh.

The potential environmental impact such as land use and habitat loss, water use, and the use of hazardous materials in manufacturing can vary greatly depending on the technology, which includes two broad categories: photovoltaic (PV) solar cells or concentrating solar thermal plants (CSP). Depending on their location, larger utility-scale solar facilities can raise concerns about land degradation and habitat loss. Total land area requirement varies depending on the technology, the topography of the site, and the intensity of the solar resource. Estimates for utility-scale PV systems range from 3.5 to 10 acres per megawatt, while estimates for CSP facilities are between 4 and 16.5 acres per megawatt which, for a densely populated country like Bangladesh is very complicated as it will not only cause habitat loss but also will impact agricultural production since there is less opportunity for solar projects to share land with agricultural uses unlike wind power.

Solar PV cells do not use water for generating electricity. However, as in all manufacturing processes, some water is used to manufacture solar PV components. CSP plants on the other hand, use wet-recirculating technology with cooling towers withdraw between 600 and 650 gallons of water per megawatt-hour of electricity produced. CSP plants with once-through cooling technology have higher levels of water withdrawal.

The PV cell manufacturing process includes a number of hazardous materials, most of which are used to clean and purify the semiconductor surface. These chemicals, similar to those used in the general semiconductor industry, include hydrochloric acid, sulfuric acid, nitric acid, hydrogen fluoride, 1,1,1-trichloroethane, and acetone. The amount and type of chemicals used depends on the type of cell, the amount of cleaning that is needed which exposes the workers to tremendous health hazard. Moreover, thin-film PV cells contain a number of more toxic materials than those used in traditional silicon photovoltaic cells, including gallium arsenide, copper-indium-gallium-diselenide, and cadmium-telluride. If not handled and disposed of properly, these materials could pose serious environmental or public health threats. Furthermore, the cost associated with solar power generation is also much higher compared to other non-renewable sources of power. Considering the lack of availability of land and other technical and environmental challenges, Micro solar projects like rooftop solar projects in small industries and houses in both rural and urban areas that usually require less space and less cost should be encouraged more.

**Bangladesh as Renewables Innovator: Vision 2041**

Despite the somber assessment regarding the prospects for renewable power in Bangladesh noted above, it must be noted that the Global Renewables Revolution continues to exceed expectations driven by falling production costs for Solar PV and Wind driven energy combined with greater emphasis on Green Growth by governments. As the chart below from the IEA’s World Energy Outlook 2017 illustrates, this trend is likely to persist in the coming decades with global energy production capacity addition being dominated by renewables.

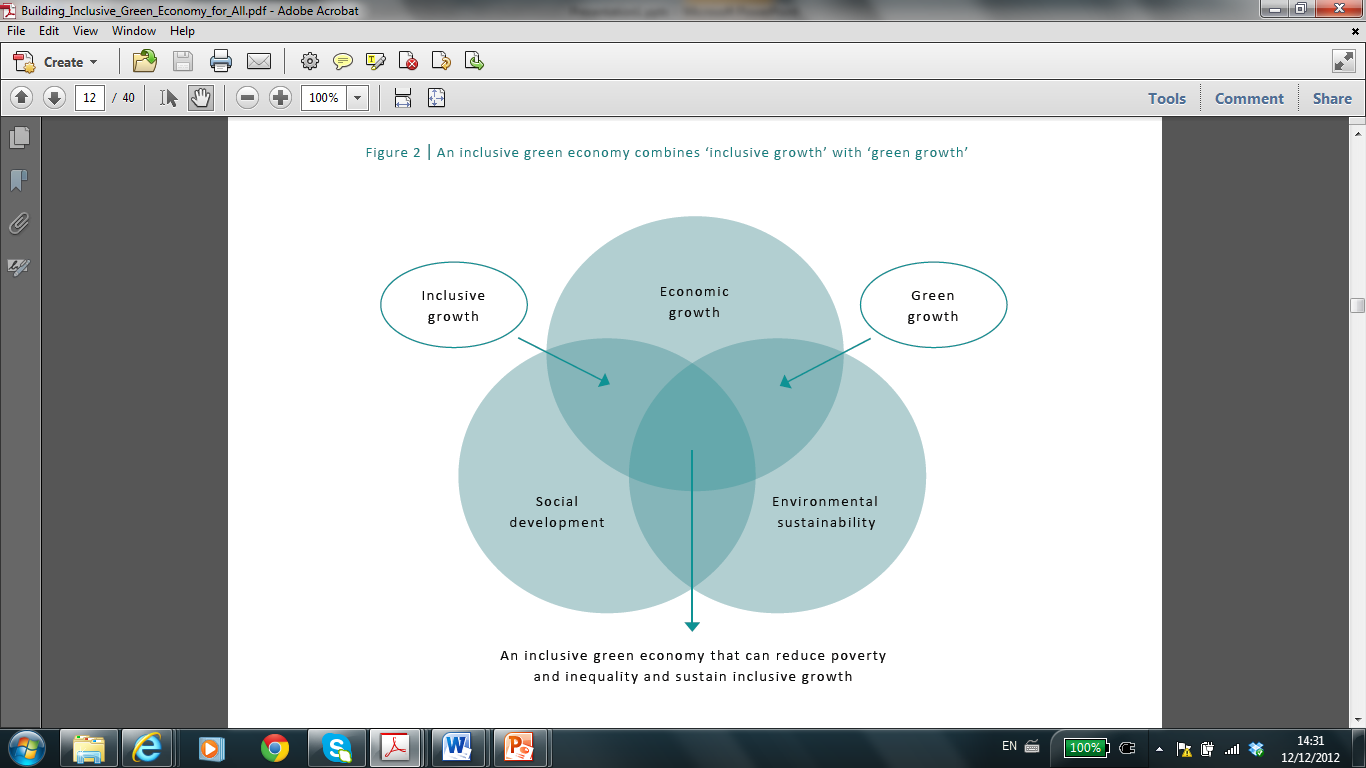
##### Figure 7: Global Capacity Addition by Primary Energy Sources



***Source: IEA World Energy Report 2017***

China has been far and away the global leader in renewables. From being one of the biggest casualties of industrial pollution, the Chinese government has made Green growth a central component of its 5-year economic plans. Environmentally sustainable economic growth was made a primary objective including a rapid shift to non-fossil fuel energy production.

##### Figure 8: Green Growth Encompassing Social Development and Environment



The results have been dramatic as illustrated below which shows explosive growth in solar energy production.

##### Figure 9: China’s Solar Capacity Expansion and Outlook



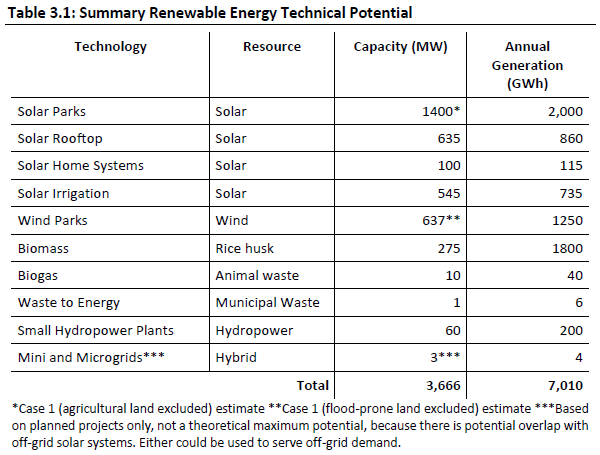
Like China, we believe Bangladesh can achieve a similar Renewables/Green Growth revolution in the face of pressing necessity. It is the largest MVC (Most Vulnerable Country) to Climate Change given that about 75% of Bangladesh is less than 10 meters above sea level. Dhaka one of the five most vulnerable cities in the world and some estimates have suggested that by 2050 Bangladesh could lose 15% of its land area at a time when the population may increase from 160 million currently to 200 million. The country is particularly vulnerable to flooding from monsoons and sea- level rise. Rising temperatures have already begun to reduce crop yields.

Bangladesh has already been a world leader in one area of solar – namely off grid small Solar Home Systems (SHS). Of the 6 million SHS installed globally Bangladesh accounts for 75% or 4.5 million approximately. Assuming an average of 4.5 dependents in each household, this suggests it has brought electricity to around 20 million people, clearly a huge social as well as economic impact. However, the total of all the SHS only still amounts to 100 MW. To achieve the government goal of 2000 MW of renewables by 2021, clearly much more needs to be done.

The Government of Bangladesh has issued more than 1000 MW of LOI/PPA for utility or larger scale solar projects in 2016-2017. But there has been little effective implementation in most of these projects. A major issue is land, which is understandable given that Bangladesh is one of the most densely populated countries in the world. Jeff bezos, the founder of Amazon, famously noted that “frugality drives innovation” – in the case of Bangladesh, the “frugality” is defined by the scarcity of land which necessitates a different approach to leveraging new technologies and thinking to spur the next phase of the country’s Renewables revolution.

The Table below from the PSMP 2016 shows forecasts for Renewables with Solar energy production dominating.

#### Table 13: Summary Renewable Energy Technical Potential



***Source: PSMP 2015***

We believe that Bangladesh can achieve a much more ambitious target of 5,000 MW of solar within 5 years (by 2023) by emphasizing new innovations and technologies on smaller scale solar projects like the ones discussed below.

**Rooftop Solar:** We agree with the PSMP 2016 optimism on rooftop solar. The RMG sector is likely to feel increased pressure to shift to renewable energy sources given that H&M, the largest RMG buyer in Bangladesh, has announced a target of being a zero carbon company by 2030 and carbon positive by 2040. Many other RMG buyers are likely to follow which will mean that those RMG factories that stick to conventional power sources will increasingly be at a competitive disadvantage when seeking orders. Solar production of 400-500 MW can be achieved from RMG factory rooftops alone. When this is extended to other industries and the public sector including hospitals, rooftop solar can make an important contribution.

**Solar irrigation pumps:** Bangladesh has more than 2 million irrigation pumps powered by electricity and diesel. This can be replaced by 300,000 solar powered irrigation pumps. IDCOL is already actively promoting and irrigation pumps and there is currently a 50% grant incentive to switch to solar.

**Agri Solar:** We believe the greatest potential growth area for renewables is in combing with new innovations in Agri-tech. specifically by embedding solar panels into greenhouses, we believe Bangladesh can benefit from an Agri Solar revolution that will see a significant jump in organic farming with higher yields and a wider variety of potential produce. In a pilot study done in Africa, a 1 MW Agri Solar greenhouse built on 1.8 hectares of land produced 490,000 kg of fresh produce, 1,700 MW hours of power, 83,000 tonnes of CO2 emission savings and 100 new jobs.

Bangladesh can also combine Agri solar and solar irrigation pumps. If we target 10,000 farmers each in all 64 districts of Bangladesh, some 640,000 farmers, with a 10kw solar irrigation pump and greenhouse, that would amount to 6,400 MW of solar power and potentially billions of dollars of new agricultural output providing greater incomes and a new means of livelihood. Moreover, any surplus electricity could be sold either as a mini grid for local consumers of electricity or even back into the national grid.

**Economic Zones:** In terms of utility scale or larger solar projects, we believe targeting the 100+ new economic zones for solar production could be another area of focus. But in addition, there are there are a number of potential other areas to target where land is not being used effectively. One sector is tea estates where out of the million acres of tea gardens, it is estimated that less than 500,000 acres is used for tea production. The rest is used as rice paddy or fallow land and could be utilized for solar energy production.

**Water Bodies:** Another potential area, given that Bangladesh is a riverine country with a large number of water bodies, is floating solar projects. Japan was the first country to set up floating solar in 2006 in Chiba province. In 2017, the Chinese city of Huainan, famous for coal production, has launched the largest floating solar plant in the world. The 40-megawatt power plant consists of 120,000 solar panels covering an area of more than 160 American football fields. The $45-million investment could help power 15,000 homes. The ADB has established a Tk. 1 billion fund to finance a floating solar park in Kaptai Lake and this can be a template for a wider range of floating solar power generation projects.

**Reclaimed Land:** Another potential source of new land for solar is from reclaiming land from dredging. One estimate suggests that if rivers that are currently as much as 15 km wide in Bangladesh are reduced to 1.5-2.5 km optimal width as envisaged the Delta Plan 2100, this could create up to 100,000 acres of new reclaimed land, which could be used for a combination of smart cities/townships, solar parks and Agri solar.

**Longer Battery Life:** Finally, the collapsing price of Lithium batteries--as a result of the rapid technological development in electric car technology such as Tesla--presents new renewable opportunities for Bangladesh. It may now be economic to get rid of all of the diesel backup generators in Bangladesh and replace with Lithium Ion batteries. These batteries can be charged either from solar energy or even conventional grid power. The potential savings in terms of fossil fuel burning, CO2 emissions and imported fuel costs will be considerable.

1. **Nuclear Technology**

**Current Status and Issues:** Gas and oil based thermal power generation, by virtue of its ability to respond quickly and flexibly to ever-changing power demand, supplies middle and peak load. Nuclear power, power import, hydropower, and coal-based thermal power generations are considered as base load energy. This combination of different types of power sources is commonly referred to as the best mix of power sources. In PSMP 2016, nuclear power generation plays an important role in providing a stable base load. The government has put the Nuclear Power Project at Ruppur under its fast track project list for speedy progress on this front. The FY15 budget allocated TK 2,000 crore (about $300 million) for initiating the project. It is assumed that the first unit of 1,200 MW is to start operations by 2024 and the second unit of 1,200 MW by 2025 (PSMP 2016). These figures are preconditioned in the power development planning without alternative cases, which means nuclear power is assumed as one of the Fixed Factors in terms of generation capacity in the simulation, considering the government’s nuclear power project planning.

**Nuclear safety is a global issue.** There are many instruments for achieving high level of nuclear safety on a global basis, such as IAEA safety standards, safety review services provided by the IAEA. The IAEA safety standards provide a system of safety fundamentals, Safety Requirements and Safety Guides for ensuring safety. They reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. The IAEA safety standards are applicable throughout the entire lifetime of facilities, to activities (existing and new) utilized for peaceful purposes, and to protective actions to reduce existing radiation risks. For proceeding with the nuclear power project, like most other countries Bangladesh should follow the IAEA safety standards. Greenhouse gas emissions from nuclear fission power are much smaller than those associated with coal, oil and gas, and the routine health risks are much smaller than those associated with coal. However, the potential catastrophic risk arising from overheated fuels melting and releasing large quantities of fission products into the environment could wipe out the benefits and can lead to a near extinction of all the living being of that particular area and areas nearby. The most long-lived radioactive wastes, including spent nuclear fuel, must be contained and isolated from the environment for a long period of time which is a very expensive and a delicate task. The government has already held preliminary discussions with international nuclear oversight organization on matters related to safety and safe disposal of nuclear waste.

**Public awareness about nuclear program:** Many kinds of programmes, such as meetings and seminars with journalists and local people, have been arranged till now, and Bangladesh has established Nuclear Industry Information Center in 2013. These kinds of activities should be continued and enhanced for the public knowledge which will be the basis for public acceptance. However, in a recent study in 2015 on public acceptance / awareness for nuclear power project it was found that concrete public opinion for nuclear power generation has not yet formed in Bangladesh since accurate information on nuclear generation technology has not became widely and correctly known. Therefore, the government has to do more in supporting enlightenment activities to enhance accurate technical knowledge on nuclear generation including assessment of risks and safety issues.

**Legal and implementation framework:** All legal and implementation framework shall be established, and even be in an active form before a commissioning of the first nuclear power generation unit at Ruppur. The legal requirements are as follows: (i) Meeting IAEA safety standards; (ii) Establishment of fuel cycle management; (iii) Proper knowledge about nuclear safety and public acceptance; (iv) Participating international framework; and (v) Ratification of the international law and standards.

**Long-term plan for nuclear power projects**: In total six nuclear power units are envisaged in the PSMP 2016. Out of the six, four units would be in Ruppur and the remaining two units are to be located in a separate place. The first two units at Ruppur are expected to come into operation by 2025 and the other two units at Ruppur are projected to be completed by 2030. Comissioning of the 5th and 6th units are projected to be completed by 2040.

1. **Power Transmission Network**

**Domestic power transmission network:** The operating voltages of the Bangladesh power network system are below 230kV and 132kV, except for the 500MW HVDC link to India that began to be operated in 2014 at Bheramara. The 400kV transmission lines and substations have just recently started to be constructed. Many existing power stations have only a capacity of below 100MW, using domestic gas. They are currently distributed across the whole of the nation.

An efficient power network system, including 765kV and 400kV transmission lines, needs to be studied taking into account the plan for large scale power stations, the high density of power demand in and around Dhaka and Chittagong, and the characteristics of Bangladesh’s power network system. The rapidly deteriorating and inefficient small-scale power stations with capacity below or around 100MW would need to be phased out in sequence. The future thermal power units will mainly use imported fuel such as coal or LNG. Because the locations where suitable seaports can be constructed to receive large scale ships for imported fuel are limited to south Chittagong and Khulna (Pyra and Patuakhali), the large-scale power stations with a capacity of several thousand MW will be unevenly distributed in those areas. In the case of power transmission from hydro power projects in Nepal and Bhutan through India, HVDC interconnections with a capacity of around 500–2,000MW will be required in the north western part of Bangladesh.

1. **Rural Electrification**

Rural Electrification Board (REB) is a government owned and operated corporation of Bangladesh and is responsible for rural electrification. It is one of the major power Distribution Company in Bangladesh. The Rural Electrification Board was formed in 1976 to take up efforts at bringing down changes in rural living patterns. Out of the total shops in Bangladesh an estimated 24% are using rural electricity. In agriculture, average yield per acre under electrified pumps is 24% higher than that of diesel operated ones. Electrified pumps contribute one-third of the food self-sufficiency in Bangladesh. REB through its electrified irrigation pumps covers 4.1 million acres of land for HYV Boro and Aman.

REB is supplying power to residential houses, irrigation pumps and charitable organizations-- which together make up 92% of all its consumers--at Tk. 4.62 per KwH although the cost of that power is Tk. 6.78 per unit. The rest of the consumers, including commercial enterprises and industrial units, pay quite a bit higher tariff rates. The REB purchases electricity from Power Development Board (PDB) and supplies that to the consumers through Palli Bidyut Samity (PBS). There are 80 such associations or PBS in the country. 90% of the REB consumers are residential houses and over half of them are classified as “life-line” who are paying only Tk. 160 for an average consumption of 35 units per month. After the new tariff was announced by the Bangladesh Energy Regulatory Commission (BERC) on September 01, 2015, the REB’s net loss stood at Tk. 511 crore in FY16 and Tk. 880 crore in the FY17. In FY18, the loss is expected to rise to around Tk. 1,400 crore. So far, the REB has laid 351,000 kilometers distribution lines and 799 sub-stations with capacity of 9,020 MVA, supplying electricity to 20 million consumers.

It should be noted that REB made a great improvement in grid extension implementation since 2014, when it substantially increased the grid extension speed compared with the past (between 2003 and 2013). If REB keeps the implementation speed as fast as that observed since 2014, it will in theory reach 100% on-grid extension (in other words, 440,000 km distribution line development) by 2021. On the other hand, if REB lowers its grid extension implementation speed to as slow as that between 2003 and 2013, it would end up far below its target.

# Next Steps Related to Project Financing in Bangladesh

1. **More financing support from the Government of Bangladesh, and Official Multilateral and Bilateral Sources**

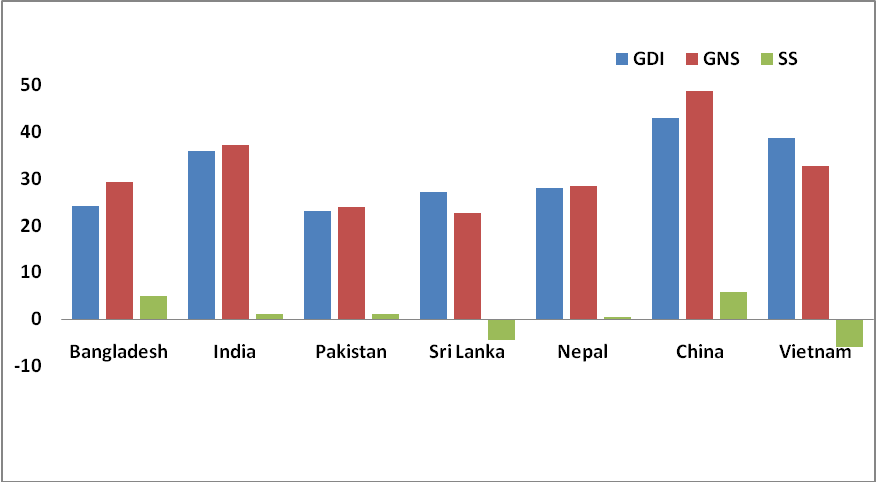
Given the significant funding needs for the PP power sector investment need, the envisaged funding gap and the need to catalyze international commercial bank lending, more multilateral and ECA funding will be required. Partial Risk Guarantee from IDA/ World Bank/ADB for covering risk of the private sector supplying power to less credit-worthy public sector off-takers (BPDB) will be required. Increased funding through budgetary support/ IDCOL and IPFF financing would also be required to make up for shortfall in commercial financing.

1. **A Strategy to Increase Domestic Infrastructure Financing Capacity**

***Over medium to long term, channel national savings into power and other infrastructure investment***

One of the key lessons from the Impact of the Global Financial Crisis on developing economies is the need to have a balance between international and local financing for energy projects. In the case of Bangladesh, gross national savings is generally higher than gross domestic investment, a large part of the financing need for the power and other infrastructure could potentially come from domestic/national sources. A key challenge in addressing Bangladesh’s energy crisis is how to channel this domestic private sector capital into infrastructure financing.

##### Figure 10: Regional Investment and Savings Scenario (In percent of GDP)



***Source: Asian Development Bank 2012***

##### Figure 11: Savings and Investment in Bangladesh

***Source: Bangladesh National Accounts 2017, Bangladesh Bureau of Statistics (BBS)***

A growing number of developing countries have developed their securities markets and long-term savings institutions, allowing them to tap domestic markets while providing infrastructure finance. India, Malaysia and a number of other countries in Asia have made some noteworthy progress in this area, and we believe some lessons are relevant to Bangladesh.

If Bangladesh is to finance the tremendous needs in the power and other infrastructure sector to maintain GDP growth, it will also have to develop the financial institutions and markets necessary to channel domestic savings into infrastructure investment. This would also call for appropriate regulatory, institutional and policy reforms in the bond and capital markets. While a detailed analysis of a strategy for power sector and other infrastructure financing is beyond the scope of this paper, we believe that the following reforms could be part of the solution:

* Insurance and pension reforms are required to direct long-term savings to infrastructure investmentssince insurance and pension funds are long term funds, they can be deployed for infrastructure assets, which are also long term.
* Underdeveloped debt market is yet another key constraint to infrastructure financing which needs to be addressed in order to channeling funds to infrastructural investments. Reforms are needed in government bond market, as the yield curve of government bond could serve as a benchmark for corporate bonds.
* An expansion of securitization of infrastructure revenue stream could free up additional financing for further investment in the power sector. Assets backed securities could be issued by the Government and public entities and also by the private sector against expected/projected future income streams. For example, the revenue stream from Jamuna Bridge may be securitized to mobilize funds for Padma Bridge or any other large infrastructure project.
* An instrument to channel Non-Resident Bangladeshi (NRB) capital into helping solve the infrastructure crisis may be developed in the form of Diaspora Infrastructure Bond. This would need focused marketing and appropriate incentives/commissions for financial institutions in key NRB markets in the US, UK, Europe and the Middle East.
* Infrastructure Development Funds (IDFs) can play an important role by investing in securities (debt and equity) issued by a pool of infrastructure projects. Governments in both developed and emerging market economies have supported the development of infrastructure financing through such funds. Such funds can issue bonds to private investors, guaranteed by the government, to raise core capital. The government can also contribute directly through seed money, as already done by the Government of Bangladesh by transferring resources from the budget to Bangladesh Infrastructure Financing Facility.
* Tax incentives have been provided in many recent IPP contracts and similar incentives can be provided to encourage investors to channel funds towards infrastructure.

1. **Financing Requirements, Financing Mix, and Role of Banks**

***Ensuring Power Sector Project Financing for Both Public and Private Sector Projects:***

The power sector strategy underpinned in the Seventh Plan is based on efficient power supply through large and medium-sized projects rather than reliance on a multitude of small-scale rental plants. But, so far, much of the additional private electricity supply has come from quick rental power plants that supply electricity to the national grid at a much higher unit cost than from other sources owing to the use of liquid fuel. This is a major issue to be addressed by the government and a quick exit from the liquid fuel based high cost generation sources must be secured. With continued dependence on quick rental power plants with high generation cost, financial viability of the power sector will not be achieved, power tariffs would not be affordable to consumers, and competitiveness of exporters and other manufacturers’ may be lost.

Beyond the medium term, the scale of investment in the power sector would need to be boosted significantly so that the net power generation capacity could be enhanced to the levels envisaged under the PP projections. The two electricity demand projections have been prepared using the baseline GDP growth under the PP, and variations in assumptions related to elasticity of power demand over the long term. Scenario1, which we call the baseline scenario, envisages electricity demand to increase by 10-fold to 92.6 thousand MW by FY41. The elasticity assumption under the baseline scenario is quite realistic starting from 1.5 in the base year and thereafter steadily declining to 0.9 by the end of the PP projection period.

#### Table 14: Power Demand Forecast

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fiscal Year | FY16 | FY20 | FY21 | FY25 | FY26 | FY30 | FY31 | FY35 | FY36 | FY40 | FY41 |
| Real GDP growth (%) | 7.1 | 8 | 8.1 | 8.5 | 8.6 | 8.9 | 9 | 9.4 | 9.5 | 9.8 | 9.9 |
| Elasticity of power  w.r.t. real GDP Scenario 1 | 1.5 | 1.4 | 1.35 | 1.15 | 1.10 | 1.5 | 1 | 1 | 0.95 | 0.95 | 0.90 |
| Elasticity of power w.r.t real GDP  Scenario 2 | 1 | 1 | 1 | 1 | 1 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Change in Demand (%) Scenario 1 | 10.65 | 11.20 | 10.93 | 9.77 | 9.46 | 8.90 | 9.00 | 9.40 | 9.02 | 9.31 | 8.91 |
| Change in Demand (%) Scenario 2 | 7.1 | 8 | 8.1 | 8.5 | 8.6 | 8.9 | 8.1 | 8.46 | 8.55 | 8.82 | 8.91 |
| Forecasted Demand (MW) Scenario 1 | 9229 | 14054 | 15591 | 23012 | 25189 | 35371 | 38554 | 54924 | 59881 | 85047 | 92625 |
| Forecasted Demand (MW) Scenario 2 | 8933 | 11940 | 12908 | 17790 | 19319 | 27022 | 29211 | 40221 | 43660 | 60921 | 66349 |

***Source: PRI staff projection.***

We also have prepared a second scenario with extremely low elasticity assumption, starting from 1 currently and coming down to 0.9 by FY41. Electricity demand in Bangladesh has grown by more than 9% in recent years despite compression of demand growth due to generation capacity and transmission and distribution problems. During this period, the real GDP growth was at a healthy pace of more than 6%. Thus, elasticity of 1.5 appears more reasonable given the current state of development in Bangladesh. For a fast- growing economy like Bangladesh, growing out of a very low base, it would be unreasonable to expect that demand for power would be growing at a rate less than the expansion of real per capita real GDP or real income.

The generation requirement of 92.6 thousand MW is much higher than the level of generation projected in PSMP 2016, and reasons for the wide difference is explained in Box 1. Generation cost for this level of power generation, including the high cost Ruppur Nuclear Power project with capacity of 2,400 MW at the cost of $13 billion will take the total investment requirement for power generation alone to more than $100 billion at current prices or equivalent to 40% of 2017 GDP. In addition to generation, massive amounts of investment will be required for power transmission and distribution, and for ensuring the transportation logistics for coal based power plants with imported coal. Thus, the total power sector investment bill may easily approach $120 billion over the PP projection period in constant 2017 dollar.

Mobilization of such a massive financing requirement will require active and broad based private sector participation of domestic and foreign origins. The financing challenges are massive and have been discussed also in Section III.

***Availability of Foreign Currency:*** Higher levels of foreign currency reserves of the central bank usually enhances the country’s ability to finance large infrastructure projects which require external financing. As discussed in the subsequent sections on issues related to project financing, external financing in the form of medium- and long-term equity and debt plays the most important role in financing power sector large projects. External creditors are more assured about Bangladesh’s capacity to repay when they take note of its sovereign ratings and the level of foreign exchange reserves. Bangladesh currently has a very comfortable level of foreign exchange reserve, but the challenge is to sustain the growth of foreign exchange reserves in line with the economic expansion. This will require continued macroeconomic stability along with strong balance of payments position over the long term.

1. **Financing Requirements, Financing Mix**

Plugging the energy gap will require $120 billion of additional investment up to FY41 in terms of generation, transmission and distribution. Bangladesh's power sector will create opportunities for private banks to lend between $20 billion and $30 billion by 2030, as the country struggles to narrow the gap between demand and supply of electricity.

The share of private-sector financing in power projects has already exceeded 50% according to the Power Development Board. Previous large independent power producer (IPP) projects had a debt component of around 60-70 percent, with the rest coming from equity financing. At the initial phase, when new IPP projects were negotiated and efforts were made to secure financing for the IPPs, much of the debt component was obtained through securing of debt from multilateral organizations, GoB guarantee or partial risk guarantee by multilateral organizations. Even for the new IPPs under the PP a similar approach would be needed to ensure financial closure of the projects. Putting together the financing package for IPPs with multiple parties including public, private and multilateral organizations is always a complex and time-consuming process. For example, Summit Power received several contracts for setting up large power projects during 2011-12. However, it was not easy for the firm to put together the financial packages for these projects. In the event, Summit Power could not secure financing for all the projects awarded and had to surrender one or more major project to the government. It also required partial risk guarantee and investment from multilateral organizations like IFC and ADB. Lack of transparency in the bidding process also contributed to initial difficulties and delays in achieving financial closure of the IPP power projects.

Over time, as Bangladesh moves up the income ladder and Bangladesh’s track record in implementing larger power plants is well established, a larger part of the debt financing is likely to come from private (foreign and domestic) lending sources, as the country is likely to become more credit worthy from foreign private investors’ perspective and as it becomes less eligible for multilateral concessional financing. Private sources could provide up to a maximum of 60 percent of project financing over the medium to long term. If we assume a 60 percent private-sector share over the medium term, this suggests that $72 billion of the additional investment required for power projects up to FY41 must come from private sources. On this basis, the analysis sees minimum potential for bank financing of power projects until FY40 at about $20 billion and the maximum potential at $30 billion.

Private commercial banks have already stepped in. Recently, Standard Chartered Bank raised US$190 million from international lenders for the 335 MW electricity plant of Summit Meghnaghat Power Company Ltd in a single largest funding for any private power company in the country. The British bank itself has contributed US$40 million to the fund. The unique feature of the project is that international lenders have come forward with long-term financing for a local project with a local firm. Total project cost was US$ 318 million, of which the US$ 190 million will be long-term debt with 12-year tenure with 18 month grace period. A good part of the loan will be used to repay loans borrowed from the local consortium of banks. The local banks which provided initial short-term financing for the Meghnaghat Power Company include BRAC bank; Dhaka Bank; Dutch Bangla Bank; First Security Islami Bank; ICB; Mutual Trust Bank; Standard Chartered Bank; One Bank; Southeast Bank; Shahjalal Islami Bank; and Trust Bank. Non-resident Bangladeshis and domestic Mutual Funds also participated in the initial financing of the project. This example highlights that local banks have a significant role to play in financing power sector projects.

1. **Infrastructure Project Financing Facility (IPFF)**

Government has taken the Investment Promotion and Financing Facility (IPFF) Project to make available partial debt financing through private sector financial intermediaries for eligible, government-endorsed infrastructure projects, to be developed by the private sector. Projects developed solely by the private sector but identified by the Government to be in the public interest will also be eligible for financing. The objectives of the project are to: a) supplement the resources of the financial markets of Bangladesh to provide term finance for infrastructure investment projects; and b) promote the role of private sector entrepreneurs in the development of infrastructure. Although legally IPFF belongs to the Ministry of Finance, since it is a financial institution, its operations are managed by Bangladesh Bank and it is also physically located in the Bangladesh Bank premise.

The World Bank has scaled up its support for the IPFF for infrastructure development and diversification through leveraging private recourses. The project also helps to build the capacity of the local financial sector for longer term financing to the much needed private-public partnership (PPP) ventures in infrastructure. The project is working in close collaboration with PPP Office and relevant line ministries to develop a pipeline of projects belonging to diversified sectors. The PPP Office, fully operational from January 2012, took the lead in developing the project pipeline. IPFF has successfully completed first phase of its operation by disbursing 100% of its credit line (on-lending component) to seven small power plants through different banks and financial institutions, contributing 178 MW of electricity to national grid.

Considering the continuing demand of IPFF loan, a follow-on project titled "IPFF II Project" has been taken up by Government of Bangladesh (with financial support of the World Bank) with a view to creating sustainable platform for long-term financing in infrastructure and further strengthening skills and abilities of the private sector to fill the substantial infrastructure gap in Bangladesh. The IPFF Project Cell of Bangladesh Bank will continue as the Project Implementation Unit (PIU) for IPFF II. The estimated cost of IPFF II project is US$ 416.70 million. The proposed tenure of IPFF II Project is 5 years, i.e. from July 2017 to June 2022. As of now, IPFF has provided $226.31 million to improve the power capacity of this country adding 589 MW (including Phase I and II). The list of successful IPFF projects in the power sector is shown below:

#### Table 15: Successful Projects in Power Sector under IPFF Financing

| **SL no.** | **Name of** | **Participating** | **Capacity** | **Financing From IPFF** |
| --- | --- | --- | --- | --- |
| **the** | **Financial** | **(MW)** |
| **Company** | **Institutions** |  |
|  | **(PFI)** |  | **In USD** |
|  |  | **(millions)** |
| 1 | Doreen Power | NCCBL | 66 MW (22\*3) | 24.6 |
| Generations |
| and Systems |
| Ltd. |
| At tangail, |
| Feni and |
| Naesingdhi |
| 2 | Doreen Power | DBL, EBL | 11 MW | 2.61 |
| House and | & IIDFC |
| Technologies Ltd. |  |
| At Feni |  |
| 3 | Regent Power Ltd. | EBL, IDLC | 22 MW | 7.96 |
| At Barabikunda, Chittagong | & UFIL |
| 4 | United Power | DBBL | 44 MW | 15.45 |
| Generation & |
| Dist. Co. Ltd. |
| At Chittagong EPZ |
| 5 | United Power | DBL, EBL | 35 MW | 13.2 |
| Generation & | & IIDFC |
| Dist. Co. Ltd. |  |
| At Dhaka EPZ |  |
| 6 | Baraka Patenga Power Limited | UCBL & TBL | 50 MW | 28.97 |
| 7 | Dhaka Southern Power Generations Ltd | NCCBL | 55 MW | 26.9 |
| 8 | Midland Power Company Ltd | EBL, MTBL & TBL | 51 MW | 19.15 |
| 9 | United Ashuganj Energy Limited | DBL,TBL & MTBL | 200 MW | 58.5 |
| 10 | Dhaka Northern Power Generations Ltd | TBL | 55 MW | 28.97 |
| **TOTAL** | | | **589 MW** | **226.31** |

***Source Bangladesh Bank***

Despite a sharp rise in lending in the second phase, the overall lending portfolio under IPFF is rather disappointing compared to what was initially expected. Total lending in the power sector as of now is $226.3 million which is substantially better than the portfolio under phase one. However, it is very small compared with the rapidly growing infrastructure needs of the country. It has not succeeded to tap domestic and international markets for mobilizing long-term financing for infrastructure projects in Bangladesh. It depends solely on official multilateral financing (particularly from the World Bank) for its funding. It has remained as an adjunct institution of Bangladesh Bank and could not establish itself as a strong institution for mobilizing long-term resources for infrastructure financing. If this institution can be strengthened, domestic banking system should be able to depend on it for on-lending to large private and PPP based power and other infrastructure projects in Bangladesh.

1. **Infrastructure Development Company Limited (IDCOL)**

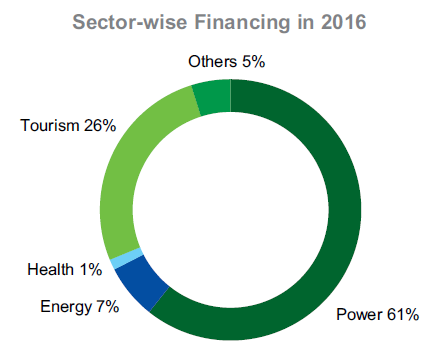
Infrastructure Development Company Limited (IDCOL) was established in 1997 by the Government of Bangladesh with financial support from international multilateral organizations. The Company was licensed by the Bangladesh Bank as a non-bank financial institution (NBFI) in January 1998. Since its inception, IDCOL is playing its role in bridging the financing gap for developing medium to large-scale infrastructure and renewable energy projects in Bangladesh. The company now stands as the market leader in private sector energy and infrastructure financing in Bangladesh.

IDCOL’s mission is to catalyze and optimize private sector participation in promotion, development, and financing of infrastructure as well as renewable energy, and energy efficient projects in a sustainable manner through public-private-partnership initiatives.

In 2001, IDCOL Financed the first Independent Power Plant (IPP) Project- 450 MW Meghnaghat Power Ltd. IDCOL is the largest local financier in the power sector of Bangladesh and has co-financed Tk. 1.5 billion for installation of more than 1500 MW of power plants. Following are the major projects financed/approved by IDCOL:

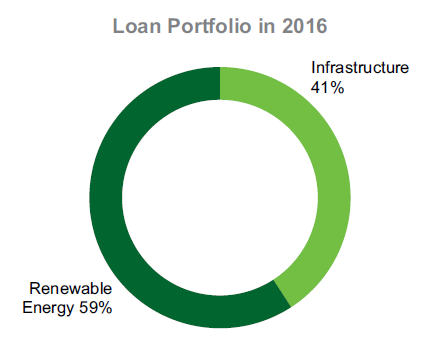
IDCOL is implementing and financing several renewable energy programs which include Solar Home System (SHS) Program, Biogas Program, Improved Cookstoves (ICS) Program and other renewable energy projects such as solar irrigation pump, solar minigrid, biogas/biomass based power plant etc. By 2016, 4.1 million Solar Home Systems (SHS) were installed under IDCOL SHS program providing clean electricity solution to 18 million rural people living in the off-grid areas of Bangladesh and expects to create a green revolution in the agricultural sector of the country through its solar irrigation program. The sector wise financing and loan disbursement for FY 16 show the vital role IDCOL plays in the infrastructural development of the power sector and renewable energy projects.

##### Figure 12: Sector Wise Financing by IDCOL for FY 16

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***Source: IDCOL Annual Reports***

##### Figure 13: Loan Portfolio of IDCOL for FY2016

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***Source: IDCOL Annual Reports***

# Concluding Observations

Bangladesh has certainly made significant progress in adding power generation capacity to meet the growing demand for power in Bangladesh, despite growing shortage of natural gas supply as the primary fuel. Starting from an initial situation of massive shortage of power due to lack of investment in the sector over a prolonged period, the progress on the generation side has been impressive. Simultaneously, the gains made on access to electricity, per capita consumption of electricity, and reduction of system loss are commendable achievements. If the pace of new electricity connections in recent years is sustained, the government objective of providing electricity to all households across Bangladesh will be realized by FY21. The rapid expansion of the role of private sector in electricity generation and the success in mobilizing financing for the new power generation projects are also praiseworthy.

At the same time, there are important issues that have emerged and need to be addressed in order to sustain the progress that has been made since 2010 and support the ambitious growth targets envisaged under the PP. At a broader level, sustaining the progress and supporting the PP growth objective will require providing quality electricity supply in abundant quantity and at affordable and competitive prices. The key challenges are in the following areas:

* Making electricity available at affordable prices for the business, industry and households and at the same time eliminating subsidies from the budget will require substantial efficiency gains at every level of operation, which will also ensure long-term sustainability of the power sector. The rapid increase in power tariff experienced in recent years cannot continue for long without making Bangladesh industry uncompetitive in the export and domestic markets.
* Achieving the 10-fold increase in generation capacity to more than 90,000 MW by FY41, as envisaged under the PP baseline scenario described above, will face many major challenges in terms of sourcing of primary energy mix, overcoming the shortage of natural gas supply, investing in logistics for handling/import of coal and LNG, cross-country transmission networks and trade in electricity with proper regulatory regimes in place.
* Mobilization of the associated massive amounts of financing for investments in power generation, transmission and distribution, handling of coal and LNG imports will remain a major challenge, despite the recent success in financing many private and public sector power plants.
* Bangladesh lies in the midst of a sub-region that is well endowed with hydropower with huge production potentials in Bhutan, North-Eastern India, and Nepal. Furthermore, there are huge trade potentials for importing power from solar and coal based sources in India at more competitive prices. Long-term investment with the sub-regional partners in power distribution and transmission network, and allowing import of power from government to government (G-to-G), business to business (B-to-B) or business to government (B-to-G) level should be more actively considered to promote trans-boundary power generation and free flow of electricity across the South Asian sub-region through market mechanism.
* Liberalization of domestic power generation, domestic trade/distribution of power, and marketing of electricity power at the retail level with a view to improving efficiency and enhancing competition will require putting in place proper regulatory regimes.

The PSMP 2016 has appropriately identified many of these challenges, but it appears that the government has to go well beyond the generation, transmission, and investment targets established under the PSMP 2016 since the growth objectives under the PP are much more ambitious with a view to transform Bangladesh into a high-income country by FY41. The growth objectives under the PP is almost twice the growth targets assumed under the PSMP 2016, thus essentially entailing huge mismatch in demand and the required generation capacity between what the government aims to achieve under the PSMP 2016 and what would be required under the PP. Since the PSMP 2016 objectives are less ambitious and not compatible with the ambitious PP objectives, in order to ensure compatibility, the PSMP 2016 should be appropriately revised/updated following the approval of Perspective Plan by the Government.

PSMP 2016 envisages a bigger role of the private sector, but the coverage of potential roles for the private sector was limited primarily in terms of investment and ownership of power plants for generation purpose. Private sector risk is mitigated through power purchase agreements (PPA). Under the current system where transmission and distribution are handled by state monopolies, which is perhaps a sensible way to mitigate private sector risk. However, in the process public sector is essentially taking almost all risks on to its shoulder and made private sector investment in the power sector virtually risk free. This modus operandi is fine in the short to medium term, but will be very costly and inappropriate over the long term. In order to foster private sector participation and competition at all or most stages/segments of the power sector, Bangladesh needs to encourage private sector participation at the retail end, as commonly practiced in European countries. If the private sector can be allowed to participate in all three stages of operation—generation, transmission and distribution at the retail level—public sector cag gradually get out of its monopoly position in the transmission and retail distribution/sale. Such liberalization would increase efficiency through enhanced competition and will enable the business risk sharing by the private sector. Over the long term, the government role should primarily be limited but focused on market regulation with an eye to protecting public/consumer interests and fostering sustained growth by maintaining environment for increased private investment in the power sector.